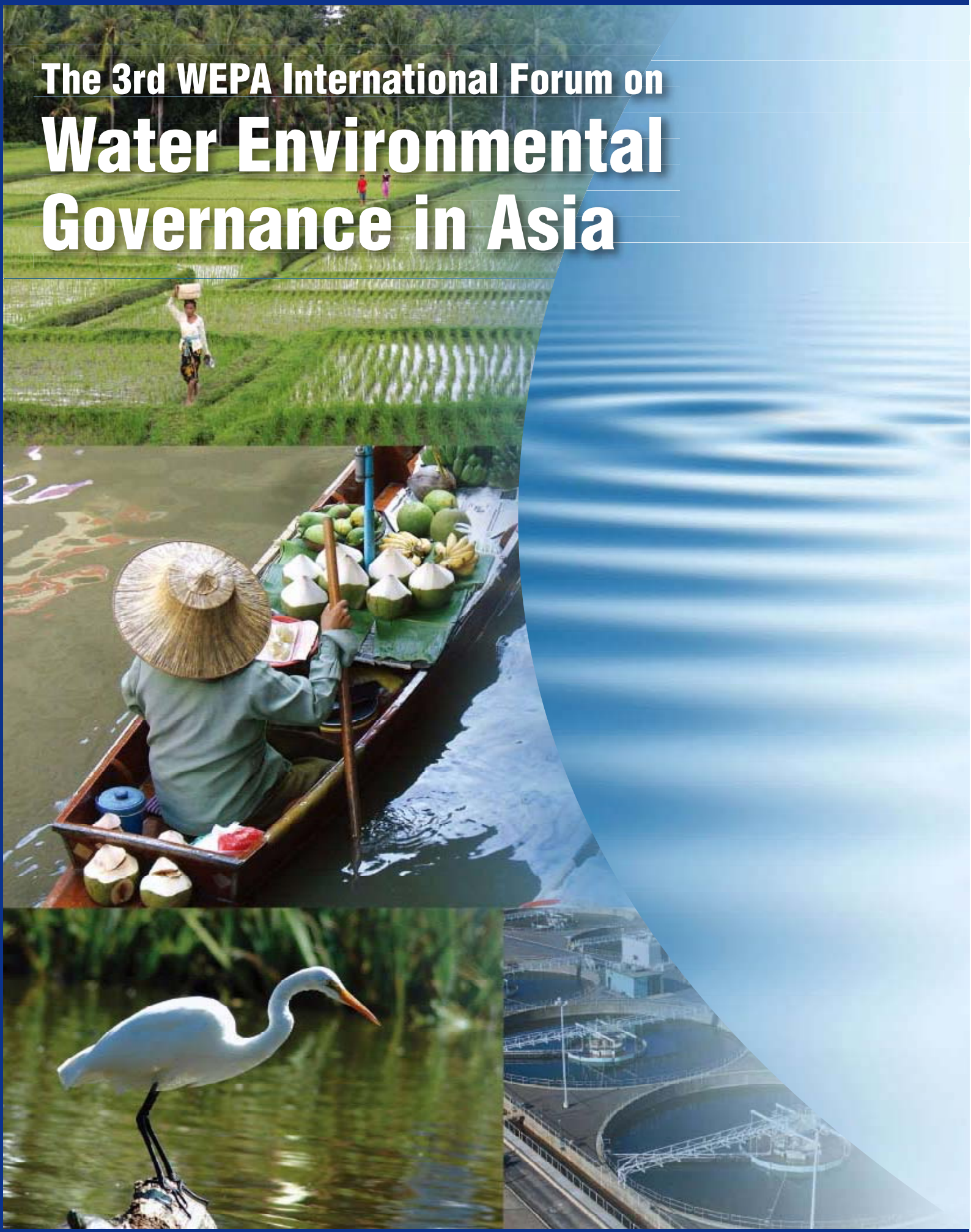
Oral Presentation Proceedings



The 3rd WEPA International Forum on Water Environmental Governance in Asia

23-24 October 2008 Putrajaya, Malaysia

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This publication is made as part of the Water Environment Partnership in Asia (WEPA) project and published by the Institute for Global Environmental Strategies (IGES).

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Copper and Lead Depuration in Nila Fish (*Oreocromis niloticus* L.)

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Abstract
Fresh water fish consumption in West Java Indonesia is high. There are two popular fresh water fish in Wst Java community namely Nila Tilapia or *Oreocromis niloticus* and carp or *Cyprinus carpio*. Most of the fresh water fish for West Java consumption was supplied by Saguling and Cirata reservoir fisheries. According to water quality monitoring, it was reveal that water quality in Cirata and Saguling were categorized Poor based on water standard Class I of Government Decree No. 82 Year 2001. Parameter that tends to be increased is heavy metal such as copper and lead. Fish has capability to uptake and depurate copper and lead from water which depend on the concentration and time of exposure. This study was aimed to investigate depuration time of copper and lead in Nile tilapia or *Oreochromis niloticus*. Uptake process was conducted in laboratory and followed by depuration process. Copper and Lead concentrations that used in uptake process were based on water quality standard and higher concentration in reservoir water quality monitoring. Copper and lead concentration in fish was calculated every 7 days during uptake process until 28 days and every day in depuration process for three days. For depuration process, additional samples of fish from Cirata and Saguling reservoir also analysed. According to the result, depuration process could not always decrease the Cu concentration because it was depend on several factors such as Cu concentration in the organ target, time of depuration, and the abnormalities of organ after accumulation process. Therefore Cu depuration need time more than three days. On the other hand lead concentration in depuration process decreased significantly in three days.

Keywords: *Oreochromis niloticus*, depuration, copper, lead

Introduction
Indonesian people love to eat a fresh water fish for their daily consumption. In West Java, the most popular fresh water fish are Nila Tilapia or *Oreocromis niloticus* and carp or *Cyprinus carpio*. These species were cultivated in several type of aquaculture such as private aquaculture or the reservoir. There are three reservoirs in West Java namely, Saguling, Cirata, and Jatiluhur. Most of the fresh water fish for West Java consumption was supplied by Saguling and Cirata reservoir fisheries (Oktaviatun, 2004). Previously these reservoirs were built as hydroelectric power supply, but later on they were used as tourism and fishery activities. Local community whose area was drowned by the built reservoirs allowed using the reservoir as aquaculture farming as compensation. As results, in these reservoirs many floating caged-fish aquaculture are occupied. This activity has change water quality of Saguling and Cirata reservoirs. In addition, these reservoirs also receive water from Citarum River which has polluted by industrial, domestic and agriculture activities.

According to water quality monitoring it was reveal that the quality of water in Saguling and Cirata reservoirs were categorized Poor based on water standard Class I of Government Decree No. 82 Year 2001. Parameters that tend to be higher are heavy metal such as copper and lead. In 2004, concentration of copper and lead were still below the standard but it was increased every year. According to Kompas Newspaper (2008), copper concentration reach 0.04 and 0.11 mg/L in several sampling point of Cirata reservoir, this concentration above the standard which should be below 0.02 mg/L. On the other hand, Lead concentration also reached permission limit which is 0.03 mg/L.

Fish has capability to uptake Cu and Lead from the water and bioaccumulated. This process depends on several factors such as the concentrations and time of exposure. Cu and lead are lipophilic so can be easily bound in fatty tissue of fish even though fish has capacity to depurate (transfer or remove) the metal to surrounding environment (water) (EPA, 1996). Capability to accumulate the metal, especially Cu and Lead, has potential risk to upper tropic level such as human. Higher Cu accumulation could affect human health such as in homeostatic control (Harris, 1991). While lead accumulation could effect gastric and will accumulate in bone for 30-40 years (US EPA: 2004, Darmono: 1995)

The aims of study are to investigate time of *depuration* of copper and lead concentration from the most dominant fish in Saguling and Cirata reservoir. Fisherman in Saguling and Cirata reservoirs grow Nila Tilapia or *Oreocromis niloticus* and carp or *Cyprinus carpio*. The research was conducted in several studies. The first study investigate lead and copper depuration in laboratory while the second study investigate lead depuration process in Cirata and Saguling fish. The results would be use as recommendation for community and further studies.

Material and Methods

The research was conducted in laboratory and consists of two step, firstly, metal uptake process than continue with the depuration process. *O. niloticus* were obtained from Ciherang fish hatchery both male and female at 4-5 weeks. Acclimatization was conducted for 15 days and 28 days for uptake process. For copper depuration studies, the fish were divided into three groups, one group for control and two groups for treatment (duplo). Each group was placed into flow-trough tank with flow rate 60ml/min. Stock solution was made using $CuSO_4.5H_2O$ (SMEWW, 2001) and dechlorinated watertap for the dilution water. Cu concentration observed were 0.002;0.02; and 0.04 mg/L. In the other hand, lead depuration process used semi static tank and stock solution was made using $Pb(NO_3)_2$ (US EPA, 2001). Pb concentration observed were 0.03 mg/L and 1 mg/L according to Government Regulation No. 82/2001 for water quality standard.

The studies also conducted in field scale using *O. niloticus* from the Saguling and Cirata reservoirs. The fish that ready to harvest (3-4 month) were collected and move in to aquarium supplied with aerated dechlorinated tapwater from PDAM, Bandung. There were to different volume of water that was used in depuration process, 9 liters and 18 liters of water. Lead concentration of fish in depuration process was observed in day 0 and day 3.

Indonesia National Standard (SNI) 01-2362-1991 and 01-2368-1991 were used to analyse Cu and Pb concentration in fish and water samples. Wet and dry weight of fish sample was

calculated, using 2-3 grams of fish sample (dry weight) which was destructed using H_2NO_3 pa, added with H_2O_2 and aquadest until 25 ml of volume. All sample was analyzed by AAS and calculated to obtain copper and lead concentration in fish.

Results and Discussion

Cu concentration in fish can be show in Fig.1. For Cu concentration of 0.002 mg/L, Cu uptake into total body concentration was increased at day-7, declined at day-14 and raised again in day-21 and 28. Different pattern was found at 0.02 mg/L and 0.04 mg/L Cu concentration which total body concentration rose at day-14 and 21 and declined at day 21 and 28. Even though Cu concentration in total body fluctuated every week for each concentration of treatment, at the end of process (day-28) Cu concentration was increased from day-0 during accumulation process. The concentration of Cu uptake followed an order as : 0.04 mg/L > 0.02 mg/L > 0.002 mg/L.

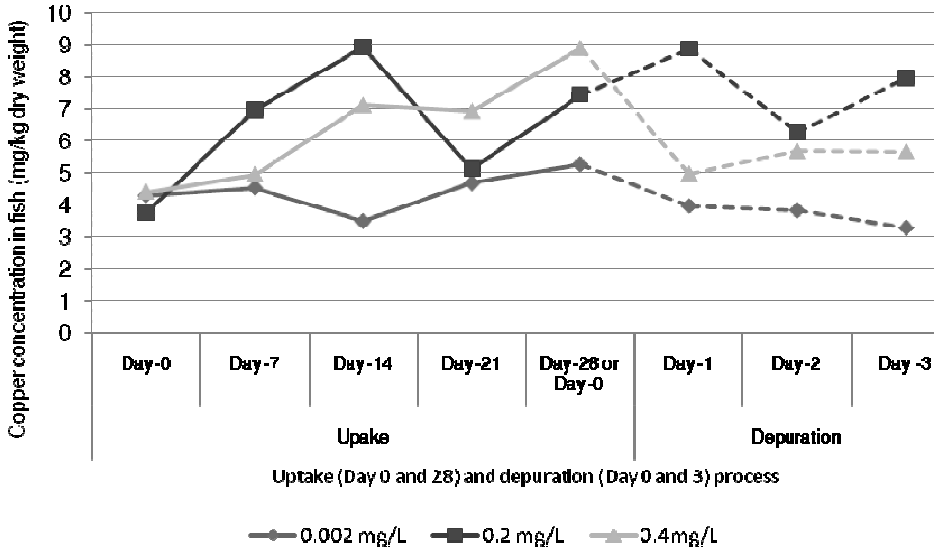

Figure 1. Uptake and Depuration of copper in fish with different copper concentration in water

In depuration process, 0.002 and 0.04 mg/L treatment have similar pattern. Concentration of copper in fish in first day significantly decreased but increased in second day and finally decreased for 0.002 mg/L treatment and increased for 0.04 mg/L. Generally copper concentration in fish in 0.002 and 0.04 mg/L treatment decreased on day-3. On the other hand, 0.02 mg/L treatment had fluctuated pattern, copper concentration on day-3 higher than copper concentration on day-0

Fluctuated of Cu concentration in fish during depuration process interfered by several factors. Cu concentration measured was the total concentration which consist of Cu concentration each target organ. Kristijarti (2006) state that Cu concentration in liver and gill during depuration process (day-1 and day-3) still high, but in the muscle was relatively stable. Arellano et al (2000) conducted his research exposed *Solea senegalensis* and *Halobatracus didactylus* with Cu 100µg Cu+/L on the organ target and the results showed that there was decrease in copper levels in liver on day-2 and 4 and day-4 in gill during depuration process,

but in the muscle there was no significant differences between accumulation and depuration process.

The other factors that influenced depuration process were detoxification of Cu by liver and gill that plays role in detoxifications as well as storage (Kotze et all, 1999). This organ could be dysfunction because of internal Cu concentration exceeded the capacity and capability of the liver and gill to detoxicate the metal. According to Kristijarti (2006) there were abnormalities of organ tissue especially in liver and gill tissue at the end of accumulation process. Depuration process cannot always decrease and recover this abnormality. This condition also found in Cerqueira dan Fernandes (2002) research, which investigated the changed in *Prochilodus schofa* (tropical fish) gill tissue and in blood responses after 96-h Cu exposure and transfer to clean water. Restoration of gill structure was slow, with no tissue improvements in the first 2 days in clean water from the 7th to the 15th days. The recovery of gill tissue began to become evident, with complete recovery occurring on the 45th day in clean water.

Uptake process for lead in fish show different pattern than copper uptake (Fig.2). Lead uptake in 1 mg/L significantly increased every 7 days until 28 days while in 0.03 mg/L treatment lead concentration in fish increased slowly. In depuration process, lead concentration was significantly decreased in both treatments on day-1 and slowly decreased until day-3. Lead concentration in depuration process on day-3 was decrease more than 90% for 0.03 mg/L treatment and 86% for 1 mg/L treatment.

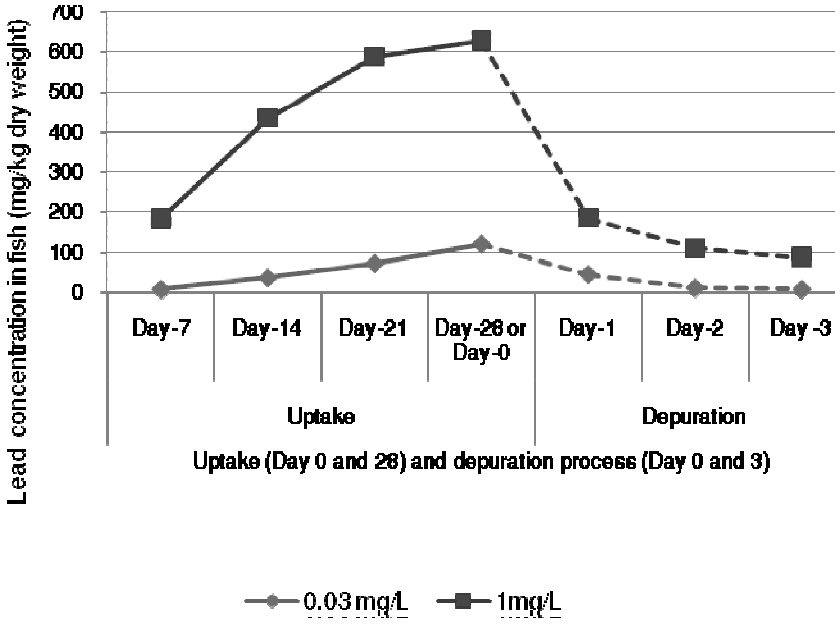

Figure 2. Uptake and Depuration of lead in fish with different lead concentration in water.

Fish from Saguling and Cirata was taken as a sample for uptake process. Lead concentration in Saguling fish was higher than Cirata Fish because Saguling reservoir water quality was poorer than water quality in Cirata reservoir. Depuration process was conducted in laboratory using un-chlorinated tap water. Lead concentration in fish during depuration process can be showed in Fig.3. Lead concentrations in fish were slowly decreased during depuration process

in 9 liters tank for both Saguling and Cirata reservoir. In the contrary, lead concentration in fish at 18 L tank tend to increased on day-1 and significantly decreased on day-2 and unmeasured in day-3.

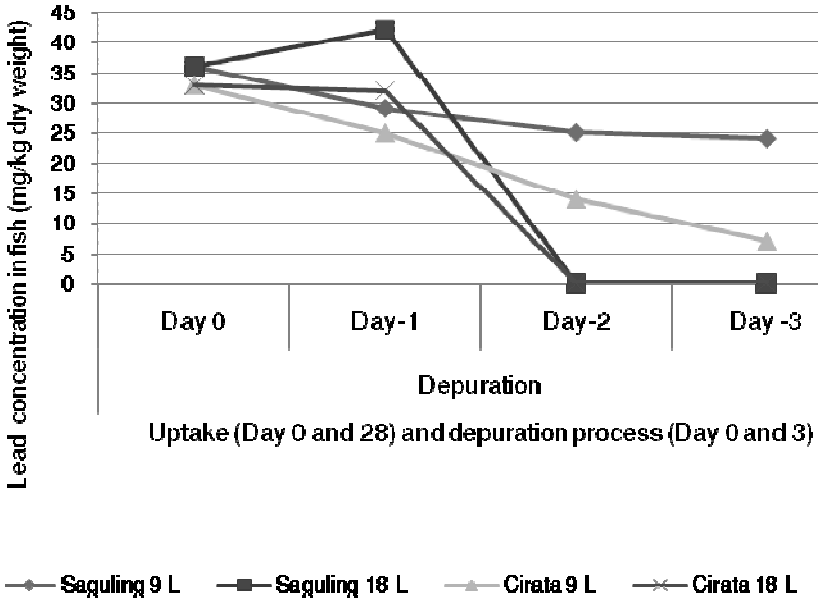

Figure 3. Lead Depuration in Saguling and Cirata fish.

Both studies showed that Copper and Lead has different mechanism in uptake and depuration process for *O. niloticus*. Copper concentration in fish tends to has fluctuated pattern during uptake and depuration process with different concentration of treatment. On the other hand lead has typical pattern in different treatment. In depuration process day-3, copper concentration still high and the efficiency of depuration below 50% while lead depuration has higher efficiency (above 80%). As mention before, depuration process for Cu depend on several conditions such as Cu concentration in the organ target, time of depuration, and the abnormalities of organ (liver and gills) after accumulation process. The studies also showed that copper need longer time than lead in depuration process. Therefore, community should keep the fish more than 3 days in unpolluted water to reduce copper concentration in fish before they consume it while time to reduce lead concentration in fish 3 days would be effective.

However, even though fish has capacity to depurate copper and lead by replace it to the unpolluted water, further research should be conducted especially in field scale and find out water parameters such as pH, hardness, combination pH-hardness or other combination of parameter that could effectively reduce Cu concentration in fish during depuration process

Conclusion

Copper and lead has different mechanism in uptake and depuration process. Copper concentration in fish tends to has fluctuated pattern while lead has typical pattern in different concentration of treatment.

Depuration process could not always decrease the Cu concentration because it depend on several condition such as Cu concentration in the organ target, time of depuration, and the abnormalities of organ after accumulation process. Therefore Cu depuration need time more than three days.

Depuration process can significantly decrease the Pb concentration in fish in three days for both in laboratory studies and Sastudies (laboratory and field)

Acknowledgements
This research was sponsored by Research of ITB 2006

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An Initiative for Community Participation and Rehabilitation of a Watershed Ecosystem in a Mountainous Area in India

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Abstract
Globally, due to competition for economic development, the per capita demand for natural resources is increasing. This requires community participation for resources conservation, based on a value system that they understand and appreciate. In this context, an initiative taken by Divya Jyoti Jagrati Sansthan (DJJS), New Delhi is presented here, with aim to generate public awareness and induce community participation, especially of women and youth, in Sheri Kanda, Pithoragarh District, Uttarakhand. Door to door survey for collection of information, Community Awareness Campaign, Pre-Training Session, Training of Trainers, and Pilot Level Technical Survey were undertaken. Pre- and Post- initiative situation analysis was done. A drastic change was seen in the attitude of the people especially women with growing participation and cooperation. The Community showed growing awareness of the water related issues and willingness to implement rainwater harvesting. The initiative provided strength in a wide range of areas, through community mobilisation and women's empowerment, promotion of education and culture, community health management by improvement in water and sanitation aspects.

Keywords: Community participation, rehabilitation, ecosystem, mountainous area, India.

Introduction
In India, the Himalayan Mountain region has a large number of ethnic societies having their own social, economic and cultural attributes, and thus, presents a unique socio-ecological richness with traditional knowledge and experience, and forms a powerful link between the nature and the social systems. Due to competition among the local communities for earning their livelihood, the per capita demand for natural resources especially water is increasing. Hence, any nature conservation linked initiative has to be based upon a value system that they understand, appreciate, and feel interested to participate. However, the task of development and management of human resource, water, land, soil, crop, livestock, pasture, etc. requires great care, seeking community participation at each step. Therefore, an analysis of the socio-ecological systems with watershed concept, integrating technical, physical and social dimensions in a synchronized manner, can be helpful for resources management, and can provide long-lasting replicable solutions to the problems of socio-ecological rehabilitation. But, generally it is observed that the biophysical dimensions are better understood than issues of socioeconomics, community participation, people's empowerment, institution building, and equity and gender considerations.

In this context, Divya Jyoti Jagrati Sansthan (DJJS), New Delhi took an initiative during May-October, 2007 for socio-ecological transformation to tackle the problem of water scarcity, and generate public awareness, community participation and capacity building, especially of

women and youth, in Sheri Kanda (Long.: 80°09.766'E, Lat.: 29°31.120'N, altitude 1721 amsl), at a distance of 17 km southwest of Pithoragarh (29.58° N 80.22° E; altitude 1650m amsl). The area is underdeveloped and naturally landscaped in an undulated rocky and rubbled terrain on a tubular ridge of slates, limestones and greenstone, surrounded with snow capped mountains, valleys, forests, perennial rivers, springs and waterfalls. Water sources are located about 1.5 km down hill. Annual average rainfall is 36.7 cm, of which 80% occurs during the monsoon period June to September and 20% during winter (December–March). In December- January, mountain ridges receive snowfall and have 5.5°-8°C temperature. Flora and fauna has rich ecological diversity. Chir forests occur at 500-1800m altitudes and Sal forests up to 1,220 m.

Initiatives for community participation

A meeting was held with the villagers in May, 2007 to consider the following activities, and representative members were selected for workshop on Training of the Trainers (TOT):

1. **Physical:** Ninety seven households in the village and nearby hamlets were surveyed with questionnaire and baseline information on socioeconomic structure, education water resources in and around the hamlets and water usage was collected, to get a picture of the prevailing water problem. Assessed the knowledge and awareness level of local people.
2. **Outreach:** Each and every household was reached door-to-door and was given the introduction of the programme through community meetings. Well-planned pre-training communication programs were undertaken to plan the training to reach the people.

The key issues of concern and the causal factors were: (a) Under developed Area, (b) Environmental ignorance, (c) Improper management of natural resources, (d) Absence of Pucca road and mode of transport, (e) Water Scarcity, (f) Inadequate facilities for health, sanitation and hygiene, (g) Alcoholism and drug abuse, (h) Vulnerability and drudgery of Women, (i) Poor economic condition (j) Lack of education, (k) Unemployment, and (l) Forest fire. The impact of the first meeting on the villagers was significant and they showed interest to participate in the scientific campaign, accompanying the survey team door to door for collection of data.

(A) Pre-Training Session: The session was held in July, 2007, with participation of fourteen persons including four DJJS volunteers and two women. A Focused Group Discussion was also organised, where the representatives from Sainio Ka Sangathan (SKS), a local organisation in the Uttrakhand working on environment and community welfare issues, and the Project facilitator explained the villagers about the incentives of training and knowledge, which included: (1) importance and benefits of the training, and (2) the responsibilities and work of trainers. Their work after the training included: Community mobilization, consensus building, promoting coordination, awareness generation, and assisting the execution of the programme. Focused Group Discussions, Community Meetings, and Women Group Meetings proved most effective in reaching the people, understanding them, explaining them the programme concept, motivating them for participation and taking their inputs for planning and executing activities.

(B) Training of the Trainers: The workshop, facilitated by SKS, was held in July, 2007, to impart training to the volunteers on the concepts of watershed management and collective action, through lectures, demonstrations, questionnaires and field site visits. Fourteen persons were trained, and this group and DJJS volunteers led all the training and awareness programs, and also carried out door to door household and general survey with the questionnaire. Workshop included the following activities, to equip the trainees with information on various concerns:

Activity–1 Theoretical/ system training about the Watershed Concept: General information were provided through lectures, diagrams, maps, charts, etc. on various biophysical features of watershed and hydrological cycle; the existing water resources and reserves, plantation and vegetation, importance of soil and water conservation; socio-economic aspects, major problems and unmet needs; economic livelihood, needs to manage a watershed efficiently, insight to alternate scenarios of income generation and watershed management, etc.

Activity–2 Planning for minor Watershed Management: Training was imparted on PRA, watershed management procedures, creation of advisory committees for awareness generation, management and regeneration of forest, other land, natural resources, and control of forest fires.

Activity–3 Collective Protection and Maintenance: Insight was given into how to plan and implement different collective action and strategies for maintenance and conservation of natural resources, particularly water, by creation of institutional setups like 'Pani Panchayats' that can serve as tool of decentralization, devolving power and responsibility onto the community.

Activity–4 Role of communication in village perspective for scientific practises: The trainees were taught effective ways of communication to awaken and sensitize the local community to the issues of water management, sanitation and hygiene, land and forest conservation etc.

Activity – 5 Development of future perspective for: Preparation and implementation of awareness campaign. The various aspects dealt under this activity were development of survey formats; need assessment and need based planning as well as methods of planning.

(C) Community Awareness Implementation Programme:

(a) Preparatory Phase: The following activities were planned and works assigned in teams:

1. Visit to forest area to collect information on resource infrastructure, water sources, their numbers, capacity and distance from village and rainfall by direct measurement.
2. Develop communication material: (i) Making Puppets for thematic show, (ii) Writing scripts and songs for play/skits, and (iii) Making slogans, posters, etc.
3. Develop Communication teams involving villagers to (i) interact with the community; (ii) talk to women specially, and (iii) prepare puppet shows, drama and skits.
4. Prepare presentations on: (i) History and future of water; (ii) Water cycle; relation among water, forest and soil, (iii) Health, water and over all wellbeing, (iv) Biodiversity and community, (v) Adverse impacts if issues are not addressed in time.

Supervision meetings were also held to take feedback on (i) work completed by teams, (ii) activities which could not be carried out, problems faced and finding solution to the problems. Subsequently, the following activities were undertaken:

1. Community meetings were conducted and a well-structured plan for the community awareness programme was formulated by fourteen trainees, resource persons, along with Project Facilitator, wherein people expressed their problems and volunteered to cooperate. The community provided important inputs in deciding the timings and scheduling of activities in a manner when villagers would be free from fields and can participate. A Women Group was formed.

2. Internal community meetings were organised by the trainees of TOT to appraise the community members regarding existing problems and possible solutions. Villagers were encouraged to participate in programme. Communication teams were formed.

3. The trainees visited door-to-door and counselled people on water, health sanitation and education issues. They were told the importance of community participation in solving the problems, through banners, posters, slogans, etc.

4. The formats containing questions on basic information on number of family members, agriculture, irrigation, health and hygiene, and water conservation were designed to assess the social and economic conditions and awareness level in the community. The trainees distributed the survey formats through different groups, and filled these forms.

5. Plays, skits, songs, puppet shows, speeches, etc. were organised.

(b) <u>Execution Phase</u>:

I. Public Mobilization: A three days awareness generation camp was held in Sep, 2007. Various communication instruments like posters, skits, speeches, plays; puppet shows etc. were used, to sensitize people towards the issues on water sanitation, health and hygiene, water borne diseases and its prevention. The villagers also presented plays and skits on relationship between water, soil and forest, how to save water, different problems faced in daily lives, social evils like growing drug addiction, its socio-economic impacts, etc., showing their increased participation. Speeches were conducted on issues like agriculture, dairy farming, importance and conservation of water resources, etc. Other activities included: (a) Formation of a youth group; (b) Formation of Pani Panchayat, and (c) Planning of technical demonstration.

II. Technical Demonstrations included (1) Developing Poly Tanks and collection of rain water; (2) Recharge Pits to maintain water level in water sources; (3) Cleaning & maintenance of existing water sources; and (4) Creation of culverts at upper reaches of the hills for temporary storage of water and thus promoting ground water recharge.

(D) <u>Pilot Level Technical Survey:</u> The survey was made in October, 2007 covering 25 km^2 area at 1568-1832m altitudes by non-stop 15 km trekking on steep slopes up and down the hills, with GPS measurements on longitude, latitude and altitude. GIS was used to integrate, visualise and manage the data, with the aim to survey the natural drainage system, for identifying the possible locations of high flow water channels, and water harvesting. The team worked closely with local communities, using participatory methods, and made efforts of introducing new technologies to suit different locales and needs. Seven spots were located for exploring the possibilities of soil-water conservation: Nanda Dhara **(**Altitute: 1568m, Long.: 80°09.749'E, Lat.: 29°31.245'N); Kanda **(**Alt.: 1721m); Kanda School (Long.: 80°09.766'E, Lat.: 29°31.120'N, Alt.: 1690m); Sheri Kanda **(**Alt.: 1720m); Bhamkanigar **(**Alt.: 1738m); Vinayak **(**Alt.: 1832m; Long.: 80°10.201'E, Lat.: 29°30.657'N); and Latkhola Moruadha

(Alt.: 1673m). Samples were collected for determination of water quality, soil structure and water holding capacity; and locating fields for soil/water management.

The survey indicated that the cultivated lands have 3-6% topographical slopes. The soils are neutral to alkaline, mostly calcarious, dark in colour, gravel or single grained and highly vulnerable to erosion. Soil structure is non-spherical sub-rounded; spherical sub-rounded; and spherical angular. Soils water holding capacities are 34.7-61.93%. Soils Organic Carbon contents range from 0.001% to 1.9%. The flora is beautifully distributed and most plants have some medicinal value. Natural vegetations are Buj, Chir, Tuni, Timal, Malta, Santra, Anar, Burash, Aru, Naspati, Ritha, etc. Farmers grow Wheat, Rice, Urd, Masoor, Makka, Arbi, Haldi, Khira, Adrak, Potato, Rajma, Soybean, Tori, Brinjal, Tomato, Cabbage, Chilli, etc. Farmers use traditional/wild seeds for vegetables and food grains, and use conservation measure like growing crops in the lower slopes.

Questionnaire survey based situation analysis

Status Indicators - Socio-economic status: Almost 90% of villagers stay in 'pucca' houses. A family generally has 5-7 members, with average monthly income Rs. 500-7000/-. Around 72% households depend on subsistence oriented underdeveloped small scale rain-fed agriculture on 61ha area, characterised by low productivity. People generally spend 4-6 hours in agriculture. Unawareness about scientific and modern methods, conventional method of agriculture, and no irrigation facilities gives poor yield. Women are the major workers both in fields and household chores. Men opt for uncertain labour jobs, with disguised and seasonal unemployment. Few people who join Army take Voluntary Retirement to get pensions, which are used in paying back the debts, or in unplanned economic activates like opening up shops, putting up taxis etc. Water scarcity does not permit promising interventions like dairy farming, herbal gardening, organic farming, etc. Animal droppings are used along with leaves and grasses, and stored in livestock sheds for soil organic manure. 85% households use wood fuel and 36% have LPG but use rarely.

There is an acute water shortage, which becomes severe during summer. Average water requirement per family is 10-200 lpd, depending on the family size and number of animals owned, while available water is 40-120 lpd, depending on number of trips taken to fetch water. On an average 1-4 hrs/day is spent by women in fetching 15-20 litres water from a source 2 km downhill. 60% of fetched water is used for livestock and the remaining for other purposes such as, drinking, washing, cooking, etc. There is no certainty of portable water, and the area depends on groundwater sources, which is odourless and of very good quality by and large. Scarcity of water resulted in competition for water resources, especially drinking water, and hence, there is high conflict potential. The problem is from the distribution point. Out of 65 water connections, 50 percent of villagers avail water without any official connection, as no water meter provided by the authority. 29% of people have traditional knowledge of soil and water conservation, but implementation is rare, but, they are interested in participating in such activities. 79% people have some land around their house and are willing to use this land for rainwater harvesting.

According to the Census 2001, 74% males and 56% females are literate. There is only one primary school built in 1985 with no proper facilities, and the teachers don't come regularly.

Students are unable to acquire the knowledge of standard, and for further study go to another village, 5km down hill. There is no avenue for advance education and employment for girls. A majority of youth is not matriculate. Due to absence of Government technical or vocational training centre, over 90% of the youth is unskilled and lack technical education of any kind. No awareness of proper sanitation and hygiene exists. 92% of the households do not have toilets and drainage system. No health or first aid facilities available. The nearest health centre is at 4 km downhill. During emergency, it is difficult to reach the health centre in time due to absence of any mode of transportation and pucca road. There are total 310 animals, of which 43% are goats, 17% buffalos, 16% bulls, 12% calf and 11% cows. Pine tree plantation have added new dimension to the drudgery as falling pine needles cover the ground and prevent growth of grass. The villagers also cause Forest fire as they burn the fallen pine needles to get rid of it.

Pressure/Vulnerability Indicators: Stratification, quarrelling with each other and absence of community feeling over issues related to water, etc. is prevalent. People belonging to upper castes having affluence and political influence suppress and ill-treat the lower caste people and try to dominate and command the rest. Drudgery of women exists due to unavailability of water, fodder, and firewood in close vicinity; women need to go to far off hillocks. Women are vulnerable, because they feel that they cannot participate in any developmental activities as they are illiterate or uneducated. In the absence of avenues for advance education and employment, girls are vulnerable to early marriages. Being unaware of free health services and facilities available, the people (especially women) are vulnerable to paying money to doctors at Government Hospitals. Men folk and youth are vulnerable to drug abuse and alcoholism. Animal sacrifice also exists, which indicates prevalent superstitious beliefs. People are more concerned with the hamlets where they reside and wish that all the development must take place there.

Response Indicators: During preliminary meetings, village community mentioned many of its current and future problems and expressed that if water is made available they could take up promising livelihood options like dairy farming, herbal and organic farming, and vegetable cultivation etc. Most of them had no knowledge about developed varieties of seeds etc. These factors have been the cause of migration of men from the village to the cities in the search of job.

Output Indicators: Initial surveys and observations revealed that in the past public participation was nil for any developmental activities. Village community had neither any role nor were they aware about them. There existed no Self Help Group or other assemblage for addressing the community issues. There exists absolute environmental ignorance and no maintenance and management of existing water sources despite acute water shortage in the area.

Context Indicators: The facilitators used visual aids to motivate the villagers and give equal opportunity to each to voice views; guided the villagers with relevant questions in order to analyse the situation thoroughly; created awareness on the importance of resource conservation and Land Use Planning; and promoted self-help spirit as a means to develop, involve and empower the villagers to address their problems and to find their own solutions.

Post-initiative visible impacts/success stories

- A drastic change was seen in the attitude of the people especially women with growing participation and cooperation in the meetings.
- Development of analytical perspective in women enabling problems identification.
- Importance of unity has been understood, as a result of which women have come together to take lead in the developmental activities. First women group fund has been collected.
- The Community understood the importance of education and demand for a well-structured and functional education system is growing.
- The Community has growing awareness towards the water related issues and willingness to implement rainwater harvesting, if efforts are made to provide them technical know-how and infrastructural support for adopting advance techniques for water harvesting.

Future scope and recommendations

The initiative provided strength and future scope in a wide range of areas: community mobilisation and women's empowerment, promotion of education and culture, community health management by improved water and sanitation dimensions, natural resource management and 'Panchayati Raj' system. The following activities are recommended:

- Rainwater harvesting from slanted rooftop of buildings and laying the infrastructure for conserving water in storage tank, farm ponds, depression, etc. A technical demonstration of the rainwater harvesting with low cost measures and involvement of the community.
- The individual farmlands being too small and highly fragmented, group farming or cooperative system may be encouraged.
- Stone concrete check dams and contour bunds can be constructed to protect soil erosion.
- Soil maintenance and regeneration can be accomplished covering the soil with crop residues, fertilization with animal wastes, and reduced tillage.
- To arrest illicit felling for fuel and timber, adopt approaches, such as, afforestation with suitable species, comprising various species of fruit, fodder, fuel wood and timber plants.
- The villagers should be provided higher yielding hybrid varieties of good seeds of vegetables and food grains suitable for hilly environment.
- Existing agricultural practices can be modified through the adoption of an ecological approach with emphasis on reducing the energy and resource-intensive inputs; cultivation of pest-resistant plant, etc.

Acknowledgements

The kind help and cooperation of Swami Narendranand, Vidushi Anju Bharati, Bhagirathi Bharati, Aditi Mehendiratta and other representatives of the DJJS, Mr. S.K. Tyagi (NRL) and Mr. U. Sen (NRL), is thankfully acknowledged. Thanks are also due to Sainio Ka Sangathan for facilitating the TOT workshop. The initiative could not have been successfully implemented without the kind help and cooperation of the village community. The initiative was funded and supported by the NCSTC, DST, Govt. of India.

The Development of New Fish Monitoring Methodology and Its Application for National Stream Health Assessments in Korea

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Abstract
The objectives of the study were to develop national stream health assessment model (NSHA) using fish assemblages in Korea during 2003- 2005 and apply the NSHA model to 80 stream and rivers of national major watersheds for the model tests. The NSHA model was based on the metric index of biological integrity (IBI), which was established as a Rapid Bioassessment Protocol (RBP) in the US EPA. For the national model developments, regional trophic guilds and tolerance guilds were analyzed in the four major watersheds in Korea and 39 national reference streams were selected for developments of the maxim species richness line (MSRL). Also, metric numbers and metric attributes of the NSHA were modified and corrected for the regional applications along with establishments of the scoring criteria. In the initial stage we selected 10 metric model and corrected as 8-metric models as a cost-effective strategy. Also, we tested the fitting of the model on the national ecosystems in the relations with habitat health, based on Qualitative Habitat Evaluation Index (QHEI) and conventional water quality criteria. We identified impaired vs. healthy systems by the national biological criteria in nationwide streams and rivers in Korea. The new national biological monitoring methodology would be used as a key tool for ecological restorations and species conservations in Korean aquatic ecosystems.

Introduction
Recently, effective management strategies for aquatic ecosystems are developing in many developed countries (Barbour et al., 1999) and the paradigm is changing from the chemical-based to biological approach (Davis and Simon, 1995). During the last several decades, stream water quality has been frequently evaluated by chemical monitoring such as nutrients, biochemical oxygen demand, and hazard chemicals. However, health assessments of aquatic ecosystems, based on various types of aquatic taxa, have been a hot central issue for effective water quality monitoring and this approach has been considered as a surrogate for achieving the goal of ecological integrity in aquatic ecosystems (Karr and Chu, 2000). In fact, Judy et al. (1984) pointed out that simple chemical measurements may not detect an integrative health condition of water environments due to dynamic spatial and temporal variations as well as various habitat degradations (channel modifications) and modified hydrological regime. This fact is supported by various quantitative habitat evaluations (Terrell et al., 1982) and instream flow incremental methodology (Stalnaker, 1982).

Multi-metric models, based on various biological indicators and physical habitats, have been widely applied for evaluations of integrative ecological health in aquatic ecosystems. One of them is a concept of "index of biological integrity (IBI) using fish assemblages and this

concept was originally introduced by Karr (1981) for evaluations of water environment reflecting physical habitat, chemical, and biological conditions in small mid-western streams, USA. Since then, 35 states in the USA applied the IBI to wadable streams and rivers (Karr and Dionne 1991) and many other countries. The reason why the IBI is applied to world-wide is due to cost-effective, quantitative, and multi-metric approach (Ohio EPA 1987, Karr and Dionne 1991, Barbour et al. 1999 Karr and Chu 1999) that evaluates various aspects of fish community structures and functions in a specific region. In this study, we developed national stream health assessment (NSHA) model using fish assemblages, and applied to various streams and rivers in Korean watersheds. Also, we compared the model values to conventional water quality (such as BOD) and physical habitat index.

Material and Methods

Field survey was conducted in 80 temperate stream and river locations during April - June 2005 and fish sampling followed after the wading method (Ohio EPA, 1989). The sampling locations were same as the chemical monitoring sites designated by the government. At the all sites, fish collections were conducted according to the method of the catch per unit of effort (CPUE; Ohio EPA 1989); all habitat types including riffle, run, pool were sampled for a distance of 200 m during 60 minutes. Chemical data such as conductivity, BOD, and TP were obtained from the Ministry of Environment, Korea. Also, fish samples were collected from 39 reference streams and river sites in the Korean major watershed during 2003 - 2005 to derive maximum species-richness lines against the stream order. In selecting the regional reference sites, we followed the approach of Hughes (1995).

For the ecological stream health assessments, eight - ten metric model system was determined and the model based on the 3 major attributes of species richness, trophic and tolerance guild analysis, and individual health (Barbour et al., 1999). National ecological stream health, based on ten-metric models, was initially categorized as five integrity classes of excellent, good, fair, poor, very poor, and worst conditions. We also analyzed the habitat quality, based on the Qualitative Habitat Evaluation Index (QHEI; Plafkin et al., 1989). Seven habitat parameters were selected for the assessment of QHEI, based on the references widely used (U.S. EPA, 1983). The physical habitat health conditions of the habitat were categorized as 4 ranks of "comparable to reference", "support", "partially support" and "non-support".

Results and Discussions

Preliminary metrics of NSHA model, based on the Index of Biological Integrity (IBI), were composed of three components of species compositions (M_1: number of Korean native species, M_2: Number of riffle benthic species, M_3:Number of sensitive species, M_4:Number of tolerant species), trophic compositions (M_5: % omnivores, M_6: % insectivores, M_7: % carnivores) and fish abundance and individual health (M_8: total number of native fish, M_9: % exotic species, M_{10}: fish anormalities). In the mean time, metrics of M_7 and M_9 were removed from the analysis for 8-metric models.

The values of NSHA model averaged 16.7±9.9 (n=36) in Han-River, 21.0±9.0 (n=40) in Geum-River, 20.6±8.7 (n = 40) in YeongSan/SumJin-River, and 18.4±6.6 (n=36) in Nakdong-River watersheds (Fig. 1).

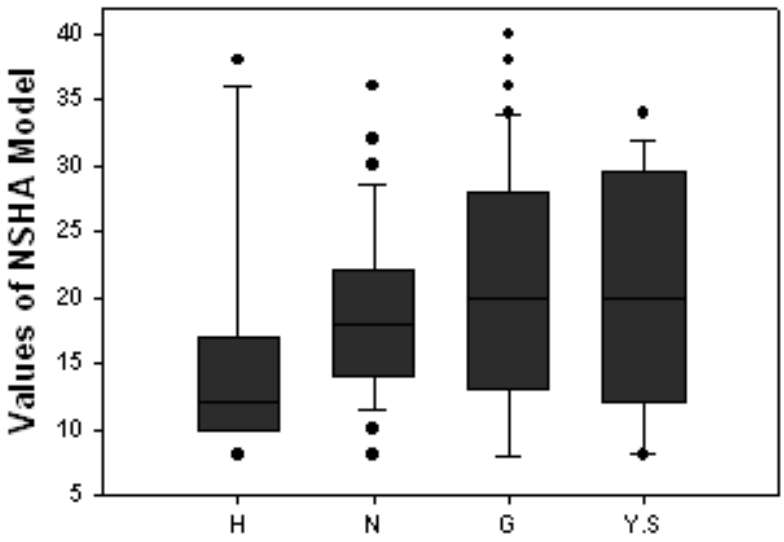

Figure 1. Values of national stream health assessment (NSHA) model, based on the IBI, in the four Korean major watersheds (H = Han-River, N = Nakdong-River, G = Geam River, Y.S. = YeongSan/SumJin River).

The overall values of NSHA, 152 observations of Korean stream and rivers, averaged 19.3 ± 8.7 (n = 172). Thus, the ecological health in Korean watershed was identified as a "*good condition" according to the modified criteria of Karr (1981) and US EPA (1993), but there were large spatial variation depending on the locations and seasons sampled. Pearson's correlation analysis showed that values of NSHA model, based on IBI, were not correlated ($p > 0.05$) with BOD, COD, TP, and TSS. However, when we removed the data during the high-flow (ex, IBI values of > 35 when BOD were > 2.7 mgL^{-1}), IBI values had high negative correlations ($r = - 0.890$, $p < 0.05$) with BOD values. Also, TP, COD and TSS had strong correlations with IBI when the data were removed from the analysis.

The index of biological integrity (IBI) also had strong correlations with indicator species (Fig. 2); the abundance of sensitive species increased with high values of IBI, while percent tolerant species decreased with high IBI values. Similar pattern on IBI was shown in the number of individual and the number of species, as shown in the sensitive species. These results indicate that high nutrient enrichment or organic pollution resulted in reduced the model values and this condition modified the relative proportions of ecological indicator species (sensitive vs. tolerant species).

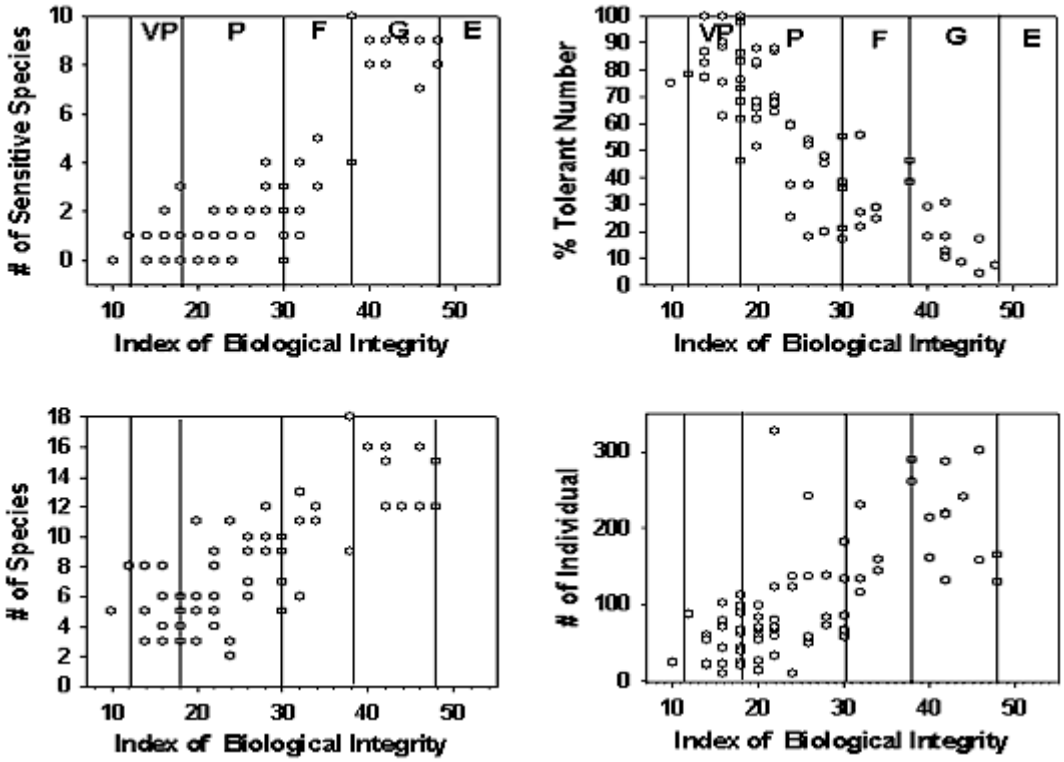

Figure 2. Relations of the Index of Biological Integrity (IBI) on the sensitive and tolerant species, the number of species and the number of individuals.

As shown in Fig. 3, values of IBI had high variations when the BOD values were low (1 - 2 mg L^{-1}), and the values had low variations when the BOD values were high (4 - 5 mg L^{-1}). In other words, when water quality, based on BOD, was good (1 - 2 mg L^{-1}), the stream health was judged from 1st rank (excellent condition) to 4the rank (poor condition), indicating a high variation. In contrast, when the water quality was bad (4 - 5 mg L^{-1}), IBI was judged as poor - very poor conditions, indicating that the stream health, based on IBI, reflects directly the organic matter pollutions.

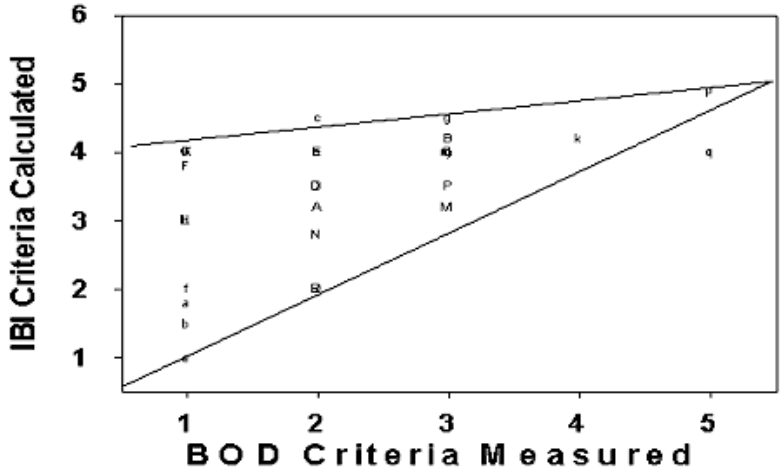

Fig. 3. Relations of the criteria IBI calculated vs. BOD criteria measured. The alphabets indicate the streams sampled.

Also, case study in the SumJin / YoungSan Rivers showed that when the BOD values were > 2.5 mg L^{-1}, IBIF values (Index of Biological Integrity using Fish) were low, even if the QHEI values were > 50 (Fig. 4). In contrast, when the BOD values were < 2.0 mg L^{-1}, IBIF values had linear functional relations with QHEI. These outcomes indicate that when the chemical water quality is good, the health conditions in the streams and rivers are directly determined by the habitat health as shown in the Fig. 4. Overall, our results suggest that the ecological stream health in this study was due to combined effects of chemical degradations and habitat degradations. Especially, when the chemical water quality was very good (< 2.0 mg L^{-1} as BOD), still the ecological health showed large variation, so that simple chemical measurements may not detect actual conditions of the ecological health.

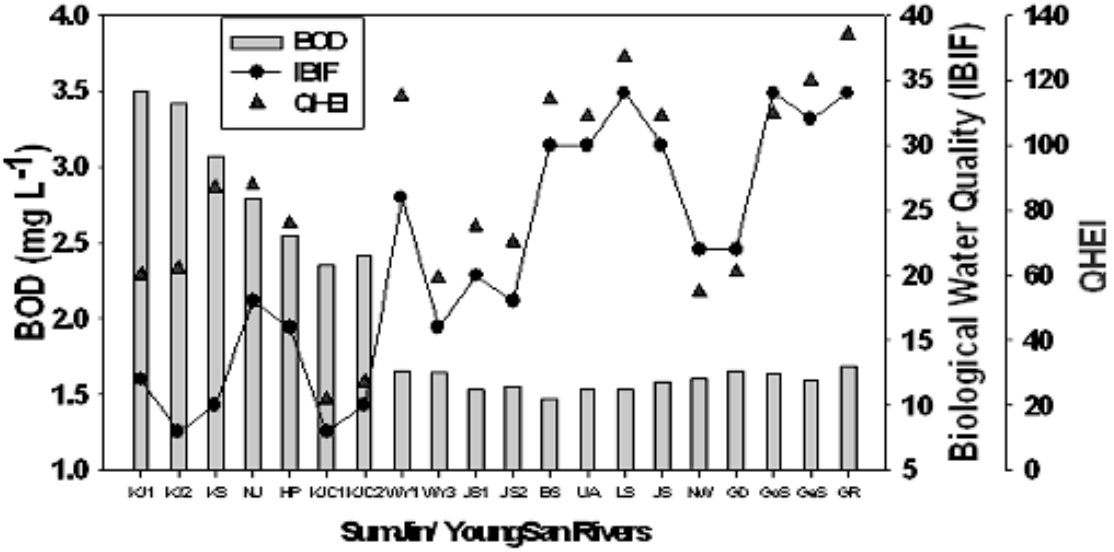

Figure 4. Case study of SumJin/YoungSan Rivers on the relations of BOD, biological water quality, based on IBIF (Index of Biological Integrity using Fish), and Qualitative habitat Evaluation Index (QHEI).

This assessment could diagnose the currents health conditions in Korean watershed, so this new monitoring approach may be used as an important management tool for efficient ecosystem managements and restorations.

Acknowledgements
This work was supported by the "Development and Survey Research on Integrative Water Environment Assessment Methodology", the Ministry of Environment, Korea.

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School Network for River Conservation and Ecosystem Monitoring in Northern Thailand

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Abstract
Depletion of water quality in Thailand has become a serious problem in recent years. The objective of this study was to mobilize river conservation and monitoring activities in Ngao River, a Mekong tributary in northern Thailand by involving elementary and junior high schools. The project was divided into four activities: i) field survey, ii) illuminating workshop and network stimulation, iii) students activities on river conservation, and iv) presentation of school and student activities.
The research found that use of actual situations in the district and outdoor training programs are effective to educate children and increase their awareness on river water quality issues. Students are keen to participate in the project; many of them investigated simple water quality indicators such as temperature, water velocity, transparency, total solids and diversity of aquatic life. Some schools arranged an awareness raising program to promote river conservation in the community. Some volunteered to dredge and collect waste from the river. The results clearly revealed that the schools and the students can play a major role in measuring simple water quality indicators and monitoring the river ecosystem. Further, they can convince other children, residents and local organizations to be more interested in and responsible for conservation and monitoring of the river environment. This could eventually establish a strong community network, driven by the schools, for rehabilitating and monitoring the river and ecosystem in this watershed.

Keywords: School Network, River Ecosystem, Monitoring

Introduction
Wiang Kaen District, Chiang Rai, Thailand, is a landlocked area adjacent to Lao People's Democratic Republic. The north is bordered by the Mekong River and the east by the Doi Prae Muang and Doi Pha Mon mountains. The land is mountainous with an elevation ranging from 310 to 1,625 meters above mean sea level (Sang-Arun et al., 2006). The area has one main river called the Ngao River which flows from the high land in the south to the Mekong River (***Fig. 1***).

Local people have had a close relationship with the river for a long time. Most of them use the Ngao River as the main source of water for their daily consumption, crop cultivation, and so on. However, the ecosystems of the Ngao River have changed a great deal in more recent times. Many organizations in the Wiang Kaen District now pay close attention to the river

ecosystems; however, the problems of low water quality and degradation of the ecosystem have not been solved. The government tried to dredge the river, though this can also impact the ecosystem negatively, and organized an event to promote the use of traditional practices to conserve the river.

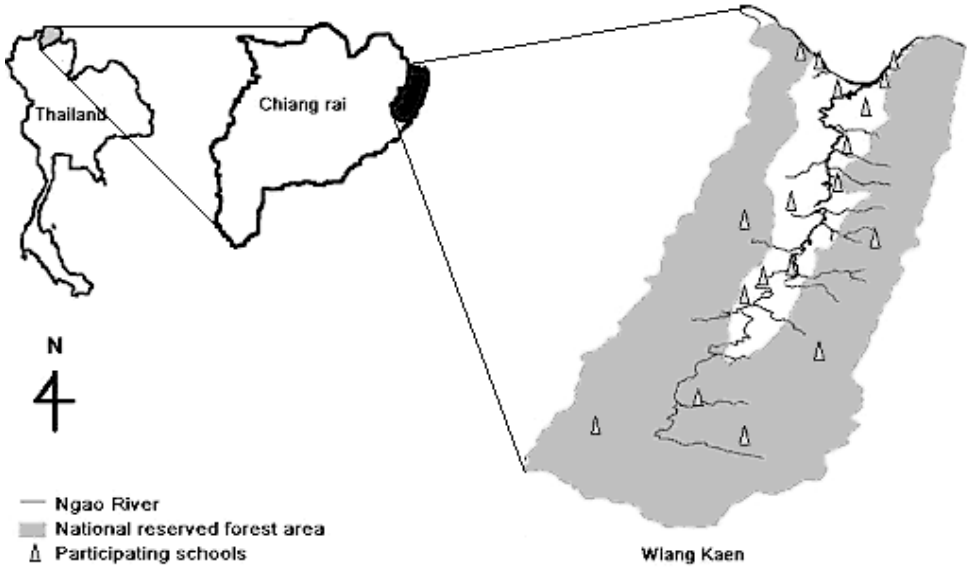

Figure 1. Study area in Wing Kaen District, Chiang Rai Province Thailand.

The objective of this study was to mobilize river conservation and monitoring activities in Ngao River, a Mekong tributary in northern Thailand by involving elementary and junior high schools.

Project activities

The project comprised four activities: i) field survey, ii) illuminating workshop and network stimulation, iii) students and school activities on river monitoring and conservation, and iv) presentation of schools and students' activities. The field survey was conducted in June 2006. An investigation into local practices which affect water quality was carried out. The illuminating workshop was organized in August 2008. The workshop invited dialogue on the role of each sector in solving the problems of the river. The target groups were elementary and junior high school students in the district. These schools are located not so far from the river's tributaries thus there is high potential for them to monitor the river quality and its ecosystem. Also there is a high potential to encourage them to build up an active river monitoring network. Relevant stakeholders and Government officials were also invited to participate in the workshop. This workshop aimed to improve the communities' knowledge and understanding of the current environmental situation, natural resource management principles and the positive role that local communities can play in environmental management. The workshop activities included i) a presentation of water quality and the river ecosystems of the Ngao and Mekong River, ii) identification of factors inducing degradation of river quality and ecosystem, iii) outdoor training of simple water quality measurement and ecosystem observation, and iv) brainstorming session and drawing activities. The workshop involved school teachers and trained junior-high school students to facilitate the workshop.

After completion of the workshop, each school was given responsibility for monitoring water quality in their area. Equipment was distributed for students to conduct the measurements. After six months, in February 2007, a program to evaluate the success of the project was undertaken. Students were requested to present and share experiences.

Results and discussion

Impacts of activities on river ecosystems

The results of field surveys showed that there were four main activities that induced degradation of water quality and river ecosystem in Wiang Kaen District. These activities were identified as the main causes for poor water quality, drop in river depth, high river bank erosion rates, and water scarcity even in the rainy season due to high turbidity of the water.

i) Deforestation and land use change

An increasing population has directly affected land use and deforestation rates. In Wiang Kaen District there are at least nine minority groups: Lanna, Lue, Mong, Lahu or Muser, Myan, Khmu, Chinese, Akha and Yao. Most of them base their farming practices on shifting cultivation in mountainous areas which is well recognized as a cause of deforestation. Another cause is land use change from forest to cultivated land for staple and cash crops. This pressure has an affect on the headwater forest area and the water quality in the Ngao River. Sang-Arun et al (2006) estimated that over 40% of the reserved forest area in Wiang Kaen was encroached for the cultivation of annual crops and the planting of orchards (***Fig. 2a***).

Figure 2. Main causes of degradation of water quality and river ecosystem of the Ngao River Watershed and their impacts: (a) unsustainable farming practice in high mountainous area, (b) river bank erosion, and (c) gold mining in the river.

ii) Unsustainable farming practice

Thai farmers use a number of agricultural practices which were found to have negative environmental impacts. The farmers in the Ngao River watershed prefer to plant monocrops such as corn and ginger. The cultivation of such crops can readily cause soil erosion because their root systems are weak and shallow. Further, overuse of herbicides and pesticides polluted the river.

iii) Non-ecological friendly riverbank management practice

Due to high erosion rates, the depth of the river has decreased. The Government decided to increase the depth and width of the river by dredging. The riverbanks ecosystems were destroyed by the dredging and there were very few restoration programs. Further, surrounding

the river and the headwaters is an area where slash and burn agriculture practice is common. Therefore, every time it rains there is a high level of sediment in the river turning it red in color. Additionally, the river bank suffers from high erosion rates (***Fig. 2b***). The result is that infrastructure such as roads and bridges and cultivation areas adjacent to the river were destroyed.

iv) Gold mining

A part of the district in the hilly area has gold deposits. Local residents conducted traditional gold mining in the river (***Fig. 2c***). This practice caused high turbidity of the river and increased the accumulation of downstream sediment.

The students' awareness of river ecosystem problems

Nineteen schools located in the district participated in the workshop which included presentation of the results of field surveys on river quality, river ecosystems, and practical field training on simple river quality monitoring techniques (***Fig. 3***). The results of the workshop show that the participating students could understand simple water quality measurement techniques using local materials available in the district. They were also able to identify the current problems of the Ngao River such as high sediment load, river bank erosion, and potential chemical contamination.

Figure 3. Outdoor training activities for simple river quality measurement and monitoring techniques.

After a brainstorming session, several methods were identified to solve the many problems facing the river ecosystem, for example, reduction in the use of chemicals and pesticides during cultivation, the planting of more trees in the highland areas to reduce soil erosion and subsequent sediment loads in the river. To encourage the children to understand the need for a clean and healthy river they were asked to imagine the river as it was in their dreams and to sketch what they imagined.

The parameters and the condition of the river that schools are observing and measuring are average rainfall, types of land utilisation near the river, river colors, smells, water level, river velocity, temperature, transparency, total solids and aquatic life. The students proved to be very active and enjoyed using the equipment for the monitoring of the river (***Fig. 4***). Huay Han School, Ban Muang Yay School and Ban Thakham School actively introduced the simple water quality measurement into their science education program. A preliminary study on water quality in river and reservoirs was carried out by students who investigated the causes of water pollution. Khunkwak Pittaya School, Ban Saithong School and Ban Thakham School were very keen to monitor aquatic life in the river. Students in Ban Huay Ian School monitor

the Mekong Riverside ecosystem regularly and have protested illegal rock trafficking. Ban Thakham School, Poh Wittaya School and Pang Hud Sahasad conducted an awareness raising program to promote river conservation in the community and organized an event to clean and collect waste from the river.

Figure 4. Student activities for monitoring water quality and river ecosystems.

The school network for water and river monitoring

In February 2007, eleven schools presented their activities on river conservation and ecosystem monitoring at Khunkwak Pittaya School (***Fig. 5***). This activity provided evidence that the schools and students can be effective in monitoring the river quality and its ecosystems. They are able to use simple equipment effectively and carry out basic scientific observation reliably. They are able to identify correctly the many land use types which have an impact on the river. Further, they can convince other children, residents and local organizations to be more interested in and responsible for conservation and monitoring of river environment. This could eventually establish a strong community network, driven by schools, for rehabilitation and monitoring of the river and ecosystem in this watershed.

Figure 5. School exhibitions.

Another result of the student presentation and school exhibitions is that schools can help plan the monitoring and future restoration of the river. Through collaboration with all stakeholders in the area, it has been agreed to set up a schools' river and environmental monitoring network which will be supported by local government and the private sector. Ban Saithong School volunteered to coordinate this network to ensure momentum of these activities in the district.

Community environmental management by school network mobilization

Inspired by the outcome of students' activities, Ban Saithong School proposed to build a river conservation network and continue the activities. The School Principal volunteered to coordinate the network. The schools' network will prepare the local environmental curriculum

in Ngao watershed and mobilize the development of the local community plan which is to be set up by local government. This could help convince related stakeholders in the area to pay more attention to river conservation from a broader perspective than merely dredging the river channel. The research indicates the benefits of involving students in measuring and monitoring river water quality and ecosystems. The students are a valuable and important resource that can make a vital contribution to conservation and restoration of the river and its watershed. The students can serve as a catalyst for participation from other sectors in the community for the creation of a strong network for conservation and monitoring of water quality and river ecosystems in the watershed.

Conclusion

The participation of local schools in water quality and ecosystem monitoring in Wiang Kaen District was a successful and novel way to make them aware and understand the values and importance of environmental conservation. In addition, students provided a service to the community as a monitoring group. They can further pass on this knowledge to their families and broader communities.

Schools proved resourceful in soliciting funding and formulating proposals for river conservation to the relevant stakeholders, government and private sectors. The initiative of these schools can lead to further collaboration, development of monitoring plans, and mobilization of community involvement in river conservation. Other sectors can play an important role by setting up planning and policies to support the required budget and equipment needed.

Acknowledgement

The authors would like to express their gratitude to the Japan Society for the Promotion of Science which provided financial support to this project. We are also grateful to Dr. Henry Scheyvens of the Institute for Global Environmental Strategies for his kind advice and proof reading of the manuscript.

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Overview of MBR on Research and Application in China

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Abstract
During the last few years, MBR (membrane bio-reactor), a promising process combination of activated sludge treatment and membrane filtration, came through remarkable progress in China, both in academic research and commercial application. This paper provided an overview of the research and application of MBRs in wastewater treatment and reclamation in China. Particular attention was paid to the research progress related to membrane fouling and control, new MBR processes, and target wastewater types. Some case studies for MBR commercial application and main organizations related to MBR in China were provided at the end of this paper, followed by the challenges and future visions of this technology.

Keywords: membrane bioreactor (MBR), wastewater, treatment, reclamation, China, review

Introduction
Since 1966 when Smith, et al. first employed membrane bioreactor (MBR) for wastewater treatment, this technology has received increasing attention around the world. MBR is operated similarly to a conventional activated sludge (CAS) process, with the exception that membrane filtration is employed to separate effluent from activated sludge instead of secondary clarification. This substitution eliminates the sludge settling challenges associated with a clarifier, coupled with many other advantages including reduced footprint, low sludge production, stable and high quality effluent, easy automation, etc.

In China, research on MBR started from 1991 when Chen (1991) published the first paper in one Chinese journal on MBR application for wastewater treatment in other countries. From then on, many universities and research institutes had involved in research on MBR process. These included Tsinghua University, Tongji University, Chinese Academy of Sciences (CAS), Tianjin University, Zhejiang University and Harbin Institute of Technology, etc. To promote development and application of MBR, Ministry of Science and Technology (MOST) of China successively funded MBR project from 1996 under the national 9th "5-year-plan" and from 2002 under the national "863" project. A number of companies, both domestic and overseas-funded, emerged during this period and dedicated their efforts to MBR development and application in Chinese market. To date, remarkable progress has been achieved both on academic research and commercial applications of MBR in China. With the increment of treatment capacity and the reduction of operation cost, MBR is anticipated to be a very important technology for water treatment and reuse.

This paper presented the recent research and application progress of MBR in China by critically reviewing the research achievements and specifically presenting commercial applications in China. Main domestic organizations involved in MBR research and application were also provided. At the end of this paper, challenges and future development

trend of MBR technology were analyzed.

Overview on MBR research in China

This section provided a review of the past academic research progress in China, which was divided into the four sub-sections as followed.

Increment of papers and organizations on MBR research

According to the statistics by Huang et al. (2008) and Wang et al. (2008), during 1995~2006, over 700 scientific papers written by Chinese authors were published, in which over 80% were Chinese papers. Meanwhile, more and more organizations had dedicated their efforts to MBR research. The detailed information for chronological distribution of Chinese papers and domestic organizations were presented in Figure 1. As demonstrated, the numbers of papers and organizations involved in MBR research saw a continous increase during the 12 years, especially from 2001 to 2006. Among the published papers, about 76% were original research papers, while the residual were review papers. Universities were the dominant organizations for MBR research all along, though after 2000, especially during 2005 and 2006, a number of companies and institutes joined in the research, such as Tianjin Motimo Membrane Technology Co., Ltd., Tianjin Tsinghua Daring Co., Ltd., Beijing OriginWater Technology Co., Ltd., and CAS. This increment of papers and organizations indicated that MBR technology had drawn more and more attentions of individuals and research organizations in China in recent years.

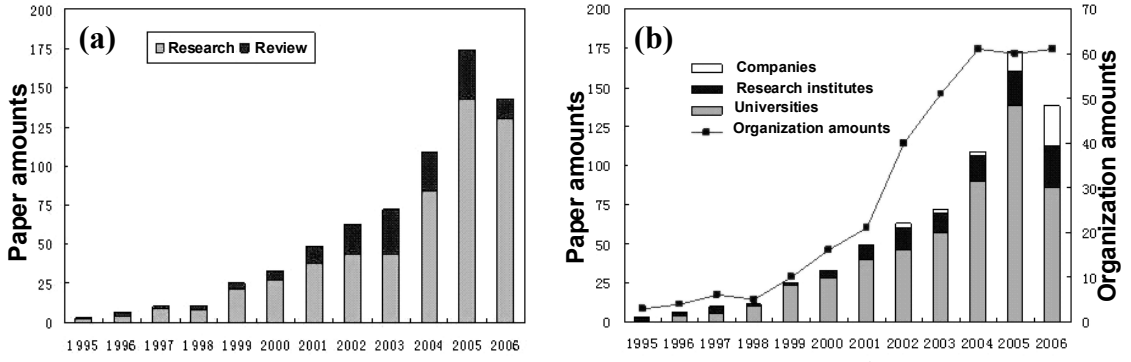

Figure 1. Chronological distribution of (a) Chinese papers and (b) domestic organizations involved in MBR research during 1995~2006.

Fundamental research on basic information of MBR

MBR configurations

MBRs are composed of two primary parts, i.e. the biological unit responsible for biodegradation of the waste compounds, and the membrane module for physical separation of the treated water from mixed liquor. According to their configuration, MBR systems are classified into two major groups: integrated (submerged or immersed) and recirculated (side-stream or external) MBRs. As demonstrated in Figure 2(a), recirculated MBRs was the dominant configuration in the early studies. Though Yamamoto et al. (1989) put forward the concept of integrated MBRs in as early as 1989, they were not popular in China until 2001. For example, in 2000 less than 50% of the published papers were related to integrated MBRs. However, in 2004, the ratio increased to over 95%. As compared with recirculated MBRs, integrated MBRs consume much less power due to the absence of a high-flow recirculation pump. This was the main reason for the popularity of integrated MBRs in wastewater

treatment after 2001.

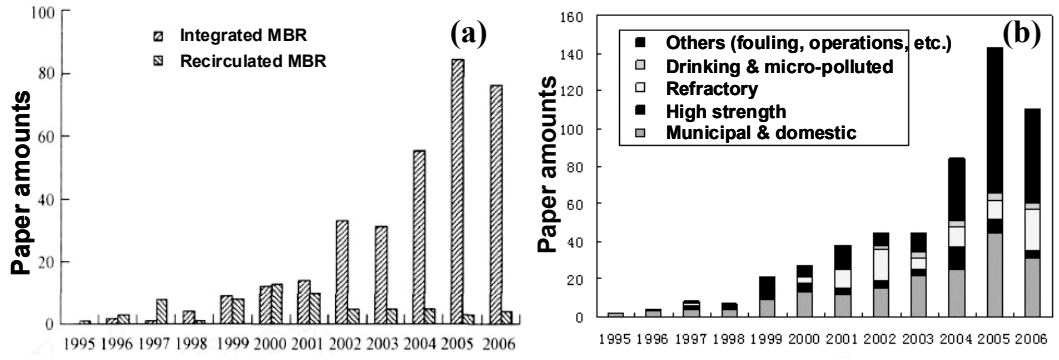

Figure 2. Papers distribution in (a) MBR configurations and (b) research contents (target wastwaters and others) during 1995~2006 in China

However, integrated MBRs also had their disadvantages. Because of the direct contact between membrane module and wastewater with high organic load, membranes used in integrated MBRs were more apt to be fouled. To solve the problem, several modified configurations were proposed by Chinese investigators. For example, Fan et al. (2003) from CAS developed a modified recirculated MBR (also called as airlift external circulation MBR, AEC-MBR), combining the advantages of integrated MBRs with recirculated MBRs through replacing the recirculation pump by H-type recycling pipe, for the treatment of toilet wastewater and municipal wastewater. Another innovative MBR, named as submerged anaerobic membrane bioreactor (SAMBR), was developed by Wu and Wang in 2004. In this new MBR, fouling was controlled by recirculating the biogas produced by the bioreactor to induce mixed liquor turbulence. Detailed information for other new MBR processes would be provided in section 2.4.

Membrane materials and modules

Three membrane modules most often used in the past studies included hollow fiber, flat sheet and tublar membranes. The main domestic suppliers and typical product parameters for membranes were summarized in Table 1. Several overseas suppliers were also listed for comparisions. As demonstrated, the demoestic hollow fiber membranes were mainly produced by Tianjin Motimo Membrane Technology Co., Ltd. and Zhejiang University Kaihua Membrane Technology Co., Ltd. And their main-stream products were polyvinylidene fluoride (PVDF) fibers with 0.2 μm pore size and polypropylene (PP) hollow fibers, respectively. Besides, several other membrane materials including polyethylene (PE), polyethersulfone (PES), polyvinylidene chloride (PVC), and polysulfone (PS) produced by overseas or Chinese organizations were also applied in these studies and their characteristics of wastewater treatment in MBRs were well investigated. As compared with hollow fibers, flat-sheet and tublar membranes were much less supplied, with their main suppliers as Shanghai Institute of Applied Physics and Kubota, Toray (Japan) or Nanjing University of Chemical Technology and X-Flow (Netherland), respecively. Among the published original research papers, the vast majority focused on the study of hollow fiber membranes for wastewater treatment while flat-sheet membranes were only intensively studied by Tongji University and few institutes in China. Ceramic membranes, as shown in Table 1, were also researched in China due to their special qualities including the resistance against extreme pH, temperature and pressures and the tolerance of rigorous cleaning with acid, alkali and hot water.

Overall, domestic membrane modules had the advantage of low cost as compared with that from overseas. However, their performance still needed to be promoted. In the future, membranes with high performance and low cost should be developed to expand the market for domestic membranes.

Table 1 Main membrane suppliers in China and comparisions of product parameters between domestic and overseas membranes.

Membrane supplier	Module	Configuation	Material	Pore size, μm	Flux, $L/m^2 \cdot h$
Tianjin Motimo	Hollow fiber	Integrated	PVDF	0.2	10~15
Zhejiang U Kaihua	Hollow fiber	Integrated	PP	0.1~0.2	5~10
Shanghai Inst Appl Phys	Plate sheet	Integrated	PVDF/PES	100,000 Da	10~20
Hainan Lisheng	Hollow fiber	Integrated	PVC/PVDF	0.01	5~10/10~15
Nanjing U Chem Techn	Tublar	Recirculated	Ceramic	0.2	40~80
GE Zenon	Hollow fiber	Integrated	PVDF	0.04	15~30
Kubota, Japan	Plate sheet	Integrated	CPE	0.4	15~30
Mitsubishi Rayon, Japan	Hollow fiber	Integrated	PE/PVDF	0.4	10~15/15~30
Toray, Japan	Plate sheet	Integrated	PVDF	0.08	15~30
X-Flow, Netherland	Tublar	Recirculated	PVDF	150,000 Da	30~60

Research contents

According to the previous studies as demonstrated in Figure 2, MBR research contents were focused on two aspects: membrane fouling and control, and application of MBR for treatment of different water and wastewaters.

Membrane fouling and control

Membrane fouling is a major obstacle for wide application of MBRs. It results in severe flux decline, high-energy consumption and frequent membrane cleaning or replacement. For the better operation of a MBR, causes, mechanisms, and control of membrane fouling should be throughly investigated.

A number of investigators in China had dedicated their efforts to the study of causes and mechanisms of membrane fouling. They suggested that membrane fouling was significantly influenced by the feed water characteristics, membrane type, and hydrodynamic conditions. Based on these studies, a general understanding of membrane fouling could be established: 1) Sludge cake layer, formed mainly by bioflocs, has strong effects on membrane permeability; 2) Soluble microbial product (SMP) and extracellular polymeric substances (EPS), which are easily adhered to membrane surface to form “gel layer”, have significant correlations with membrane fouling; 3) A proper sludge concentration (TLSS) should be maintained to facilitate MBR performance; 4) Other parameters like feed water characteristics, sludge components, operation conditions, etc. all have correlations, to some extent, with membrane fouling.

Several methods were employed for the detection of membrane fouling. Typical methods were by the increase of transmembrane pressure (TMP) or by the decline of permeate quality or flux. However, these methods had the disadvantages of delayed response and long time

needing, etc. To solve this, instrumentation techniques including SEM, AFM, and FTIR were also used for fouling identification. Besides, Li et al. (2005) from Tianjin Polytechnic University proposed a new technology, i.e. ultrasonic sensors (UTDR, Ultrasonic Time-Domain Reflectometry) for fouling detection. This approach had the advantage of aquiring information for the extent of biofouling in real time.

On the basis of the understanding of fouling mechanisms and characteristics, many effective and applicable measures had been studied and developed to control membrane fouling. Four following aspects of attempts were the focus of research on MBR fouling control.

1) Feed adjusting. Experts from Tsinghua Univerty developed several feed adjusting processes for control of membrane fouling. In their studies, powdered and porous materials such as powdered activated carbon (PAC) and zeolite, and coagulants including $Al_2(SO_4)_3$, $FeCl_3$, polymeric aluminum chloride and polymeric ferric sulfate (PFS) were added into MBRs to modify the filterability of mixed liquors. It was found that membrane fouling was reduced after PAC or coagulant addition among many studies. Besides, a lot of other innovative attempts were also made in Tsinghua University for membrane fouling control, such as MBRs seeded with granular sludge and MBRs coupled suspended carriers. The main goal was to reduce the fouling caused by fine particles in the system or to obtain better hydraulic conditions through the carrier's movement induced by aeration.

2) Fabrication of membranes. Characteristics of membrane materials, including wettability, pore size and surface charge, were reported to have close correlation with their fouling capabilities. Among them, surface wettability was deemed as the dominant factor. Generally speaking, the more hydrophilic membrane always resulted in less fouling. On this principle, several membrane fabrication methods were proposed by some authors. For example, Xu and Yu (2005a, b) from Zhejiang University modified PP hollow fibers by plasma-induced immbolization of poly(N-vinyl-2-pyrrolidone) (PVP), plasma treatment with air, O_2, Ar, CO_2, and H_2O or UV-induced graft of acrylic acid. While Lu et al. (2005) from Harbin Institute of Technology prepared the organic-inorganic composite membranes by addition of nano-sized Al_2O_3 during the PVDF membrane preparation procedure. After these fabrications, antifouling properties of the membranes were demonstrated to be significantly enhanced.

3) Optimization of operational conditions and parameters. Operational conditions play a key role in MBR process, and optimized conditions and parameters are very conducive to reduce and control membrane fouling. It has been well recognized that critical flux is an important concept in integrated MBRs, below which the increase of TMP or the decline of flux with time does not occur, while above that level fouling is observed. Many researchers focused on the study of critical flux in MBR and identified that sub-critical operation was suitable for the integrated MBRs. Under sub-critical operation, MBRs could achieve long-term, stable operation without frequent membrane cleaning. Besides, other operational parameters including dissolved oxygen (DO) concentration, aeration intensity, the ratio of suction and non-suction time during intermittent filtration, sludge retention time (SRT), hydraulic retention time (HRT), filtration modes, sludge concentration, and temperature were suggested to be optimized for reducing membrane fouling.

4) Surface Cleaning. Although the above-mentioned measures could control membrane fouling to some extent, the decrease of membrane permeability is inevitable attributed to pore clogging, biofouling, etc. Once operational pressure increases dramatically to a certain value,

membrane cleaning procedure is needed to recover the membrane permeability.

Physical cleaning is one popular method for such purpose, aiming at the reversible fouling caused mainly by deposition of bioflocs and pore clogging. Typical physical methods include aeration, water back-flushing, and sonication, etc. Among them, back-flushing is an effective way for high-pressure-resistance membranes, such as hollow fiber and ceramic membranes. Other physical cleaning methods were also studied and developed in China. For example, Xu and Fan (2004) developed a hollow fiber membrane module with enhanced self-mechanical-cleaning function which was suitable for high sludge concentration and flux operation. Sun et al. (2003) adopted sponge scouring to remove the fouling in a submerged flat-sheet MBR. It was also found that application of ultrasound could effectively reduce membrane fouling in a side-stream anaerobic MBR for high-strength synthetic wastewater treatment (Sui et al. 2006).

However, for irreversible fouling caused primarily by surface gelation, some chemical agents should be applied for membrane cleaning, such as acids (hydrochloric acid, sulfuric acid, citric acid, etc.), alkali (sodium hydroxide), and oxidants (sodium hypochlorite, perhydrol, etc.). Their effects on foulants removal were extensively identified. A general conclusion could be drawn from these studies that acids can effectively remove inorganic foulants while alkaline solution and oxidants perform well in removing organic substances and biofouling. Much higher cleaning efficiency could be reached by employing multi-step chemical cleaning, for instance, sodium hypochlorite cleaning followed by acid and/or alkaline cleaning.

Overall, membrane fouling and control strategy are two closely interrelated hot topics of the research on MBR technology. The ultimate goal is to propose corresponding fouling control methods and to facilitate MBR stable operation. With the deep understanding of membrane fouling mechanism in MBRs, more efficient and convenient control strategy would be developed in future. Another issue that should be addressed is that the fouling control strategies in full-scale MBR plants, especially large-scale MBRs, are insufficient in China. Fouling control measures mentioned above are proposed just based on lab-scale or pilot-scale MBRs, and their fouling control efficiency in full-scale MBRs need to be further verified.

Target wastewaters

As demonstrated in the papers distribution (Figure 2), a large number of studies were carried out for the purpose of wastewater treatment and reclamation. The most often applied wastewaters were municipal/domestic wastewater, followed by industrial wastewater and other kinds of water. Besides, the number of papers on industrial wastewater treatment increased annually, indicating that MBR process was increasingly popular in the treatment of industrial wastewater, particularly high strength and refractory wastewater. This was due to its advantages of independent selection of HRT and SRT and the corresponding high sludge concentrations and development of specialised, slow-growing microorganisms. Another application of MBR systems in industry was in the area of landfill leachate treatment. As compared with municipal and industrial wastewater treatment, studies on the application of MBR for surface water treatment in China, were much less. Considering that the surface water pollution in China is very severe, more research efforts are needed to ensure drinking water safety. MBR, as a promising process, is expected to play an increasingly important role in surface water treatment in vast areas of China in the near future.

New progress of MBR processes in China

In recent years, aiming at the disadvantages inherent in integrated or recirculated MBRs, researchers in China made some improvements on MBR configuration. And some new MBR processes were developed, which could attain to better pollutant removal and more stable operation. The aforementioned AEC-MBR and SAMBR were two of them. For example, AEC-MBR had been successfully applied for treatment of toilet wastewater (Xu and Fan. 2003), both reducing cost and optimizing cleaning. The new MBR processes were divided into the following five aspects.

Hybrid MBRs

A hybrid MBR combines the pretreatment processes including adsorption, coagulation and others with membrane bioreactor or adopts the hybrid bio-reactors. Powered adsorbents, such as PAC and zeolite, and coagulants were studied for the pretreatment as suggested by experts from Tsinghua University. While in the hybrid bio-reactors, biofilm or biological contact oxidation were used in acompany with the activated sludge. These hybrid MBRs not only produce treated water with excellent quality but also show much lower membrane fouling than the conventional MBRs.

Anareobic MBRs

Aerobic MBRs were the dominat configuration in the early studies. Recently, anaerobic bioreactors including continuous stirred tank reactor (CSTR) (Wu, et al. 2001), expanded granular sludge bed (EGSB) (Chu, et al. 2005), and upflow anaerobic sludge blanket (UASB) (Wang, et al. 2006) were combined with membrane filtration to produce the anaerobic MBRs. They were primarily employed for the treatment and reclamation of high strength wastewaters, such as food processing wastewater. However, due to the absence of aeration, membranes in anaerobic MBRs are more apt to be fouled. Several anti-fouling methods were thus proposed by several authors including optimization of opearation conditions and suction modes (Wang, et al. 2005a, b), methane circulation (Wang, et al. 2006), and combination of sonication with anaerobic MBRs (Sui, et al. 2006).

Aerobic Granular Sludge MBR

Aerobic granular sludge had recently received growing attention of researchers and technology developers worldwide due to their advantages over activated sludge, such as good sedimentation, high biomass retention, high organic load, and having micro-environments for simultaneous nitrification and denitrification (SND). However, to date, aerobic granular MBRs are still in pilot-scale studies.

Enhanced nutrient removal by MBRs

Nearly all kinds of processes for nutrient removal could be applied in MBR, e.g. sequencing batch reactors (SBR), A^2/O process.

Genetically engineered microorganism (GEM) assisted MBRs

Overview on MBR application in China

MBR technology has great potential applications in wide ranges of waters including municipal and domestic wastewater, industrial wastewater, landfill leachate, groundwater and drinking water, etc. The technical and economical feasibility of this process has been demonstrated through a number of bench and pilot scale research studies. Full scale systems

are also operated in many parts of the world and substantial growth in the number and size of installations is anticipated for the near future. This section provided some case studies of MBR commercial application for wastewater treatment and reclamation in China. Main domestic organizations involved in MBR research and application were also presented at the end of this section considering the close ccorrelation between these organizations and MBR applications.

Case studies

The first MBR project for municipal wastewater treatment and reclamation was installed in Dalian city of East-North China in 1998 by DAIKI Project Environmental Protection (Dalian) Co., Ltd. Following this, a number of MBR systems were constructed in China for municipal and industrial wastewater treatment and reclamation. Up to 2006, the total number for full-scale MBR plants came to 254 (Wang, et al. 2008). They were constructed by both home-grown companies such as Tianjin Motimo Membrane Technology Co., Ltd. and Beijing OriginWater Technology Co., Ltd. and overseas-funded companies like Toray (Japan), Zenon (Canada), Mitsubishi-Rayon (Japan), etc. In East and South China, the constructed MBRs were mostly involved in high strength industrial wastewater treatment, while in North China, MBRs mainly focused on municipal wastewater treatment and reuse. Some case studies for MBR application in China for wastewater treatment and reclamation were listed in Table 2.

Table 2. Some case studies for MBR application in China.

MBR installation	Feed water	MBR configuration	Bioreactor	Capacity (m^3/d)
MiYun WWTP	Municipal	3AMBR, Hollow fiber	3A	45,000
BeiXiaoHe WWTP	Municipal	IMBR, Hollow fiber	Aerobic	60,000
DaYaWan petrochem	Petrochem	IMBR, Hollow fiber		25,000
BaLing petrochem	Petrochem	IMBR, Hollow fiber		7,200
LuoYang petrochem	Petrochem	IMBR, Hollow fiber	Anaerobic+aerobic	5,000
Kingway Brewery	Beer	IMBR, Hollow fiber	UASB	4,000
XuZhou Cigarette	Cigarette	Airlift RMBR, Tublar	Aerobic	2,000
Erdos Cashmere	Organic	IMBR, Hollow fiber		10,000
WenYuHe Purification	River water	3AMBR, Hollow fiber		100,000

Municipal wastewater

1) MiYun wastewater reclamation project (MBR)

MiYun MBR plant, situated in the northeast of Beijing, was co-designed by Tsinghua University and Beijing Guohuan Tsinghua Environmental Engineering Design & Research Institue and constructed by Miyun County Bureau of Water Resources from September 2005 to April 2006. It was one of the largest water reclamation plants aroud the world, adopting the promising MBR technology and the advanced SteraporeSADF^{TM} hollow fiber membrane module supplied by Mitsubishi Rayon, Japan. The design capacity was 45,000 m^3/d. And the reclaimed water was mainly used as landscape water or for toilet washing, car washing, virescence, industries, etc.

2) BeiXiaoHe wastewater treatment plant

BeiXiaoHe Waste Water Treatment Plant, located in the north of Beijing, was one important

water supplier for Beijing 2008 Olympic Games. The plant enlargement project, ended in March 2008, involved the addition of a completely new wastewater line, designed for water reclamation and with capacity of 60,000 m^3/d. This progressive process, using advanced MBR technology with hollow fibre membranes supplied by Memcor Memjet as the membrane module, guaranteed environment-friendly water reuse in the Olympic Village central area, fountains and lakes. After enlargement, BeiXiaoHe became one of the world's largest MBR plants.

Industrial wastewater

1) Food wastewater

Food wastewater was one of the main target wastewaters for MBR application. Operation at HuiLian Food Co. (BeiJing) and ShangHai Asia Pacific Food Co. (Shanghai) demonstrated that this process could be efficiently employed for food wastewater treatment.

2) Petrochemical wastewater

Representative MBR projects for petrochemical wastewater treatment involved thoese located in BaLing Petrochemical Co., LuoYang Petrochemical Co. and DaYaWan Petrochemical Industrial Park. All the above three were installed by NOVO Environmental Technology Inc. Up to present, DaYaWan MBR plant was the largest in China for industrial wastewater treatment, with a densign capacity of 25,000 m^3/d.

3) Cigarette wastewater

The wastewater treatment and reclamation project constructed in XuZhou Cigarette Factory was designed by Tsinghua University and for treatment of mixed domestic and industrial wastewater. The design capacity was 2,000 m^3/d. This project was the first time for application of MBR-RO process in cigarette wastewater treatment in large scale. Advanced airlift MBR was used to cut the energy cost in operation. And the PVDF tublar embrane modules were supplied by Norit X-flow (Netherland) with the pore size of 150,000 Dalton.

Micro-polluted water or drinking water

WenYuHe purification project

WenYuHe purification project was built to improve the water quality of WenYuHe. The influent was river water below □class from WenYuHe. While after MBR purification, the effluent was increased to about level □ and discharged into ChaoBaiHe. The design capacity was 100,000 m^3/d with 0.1 μm hollow fiber as the membrane module. This project was the largest project around the world for purification of micro-polluted river water and inter-basin water transfer.

Main organizations

Main organizations involved in MBR research and application included universities (e.g. Tsinghua University, Tianjin University, Zhejiang University, and Tongji University), research institues (e.g. Research Center of Eco-Environmental Sciences, CAS, Shanghai Institute of Applied Physics, CAS), and companies (e.g. Beijing Origin Water Technology Co., Ltd., Tianjin Motimo Membrane Technology Co., Ltd., Zhejiang University Kaihua Membrane Technology Co., Ltd., Tianjin Tsinghua Daring Co., Ltd.). They contributed a lot to the progress of MBRs in China.

For example, experts from Tsinghua University has made great improvements on MBR configurations and developed several new MBR processes, such as fluidized bed MBR, PAC

or coagulant-MBR process, GEM-MBR process. Besides they did a beneficial contribution to both mechanisms and controls of membrane fouling. And the main MBR projects designed by Tsinghua University included MiYun sewage reclamation project, Airlift MBR in XuZhou Cigarette Factory, Tianjin Kingway Brewery wastewater treatment plant and MBR project at HuiLian Food Co., etc.

Beijing OriginWater Technology Company is a leading company in water resource recycling technologies, especially in the research and fabrication of membrane modules and MBR systems. The main-stream products of this company, including standardized MBRU series of membrane modules, intelligentize integrated MBR system, and compact wastewater treatment (CWT) system, have been successfully applied in many wastewater treatment and reclamation projects. For example, intelligentize integrated MBR system developed by OriginWater had been used in TangHeKou wastewater treatment and reclamation project in HuaiRou, Beijing. Besides, 3AMBR (Anoxic-Anaerobic- Anoxic Membrane Bio-Reactor) process was also developed in this company for nutrients removal. Successful application of 3AMBR in case studies were WenYuHe and MiYun MBR projects.

Tianjin Motimo Membrane Technology Ltd. is the largest manufacturer of hollow fiber membranes in China. It manufactures a comprehensive range of both ultrafiltration (UF) and microfiltration (MF) hollow fiber membrane modules mainly using PVDF material. What's more, Motimo has established dozens of large-scale demonstration projects for membrane applications in municipal, industrial, hospitals, hotels and residential sewage treatment and reuse. Motimo is one of the few companies to have such a range of both membrane materials and application technology to deal with filtration and separation challenges.

Novo Envirotech Co. Ltd (Guangzhou & Tianjin) are wholly-owned subsidiary to United Envirotech company. They have advanced membrane technologies and abundant experiences in wastewater treatment. The UE-MBR technology developed by Novoet has been widely applied for wastewater treatment, such as BaLing, LuoYang and DaYaWan petrochemical wastewater treatment.

Challenges and future vision of MBR

MBR process is an attractive and promising technology for wastewater treatment and reclamation. However, up to date, there are still several challenges for this process. Firstly, characteristics and performance of membrane materials and modules need to be improved, such as the membrane's lifespan, mechanical strength, anti-fouling properties, cost, and flux. And standardizd modules with high treatment capacity and low energy cost should be developed. Secondly, membrane fouling would keep to be the primary challenge for MBR application in the future. The associated fouling mechanisms should be further understood and more effective fouling control methods should be developed. Thirdly, new MBR processes should be developed and operation condtions and parameters still need to be optimized to decrease the energy cost further.

With the progress of MBR process, this technology is anticipated to play a more important role in the wastewater treatment and reclamation in future. It would become more and more attractive for municipal/domestic wastewater treatment with the increasingly stringent discharge standards and the great need of water reclamation and reuse, especially in North or Northwest China due to the shortage of water resources. And the application of MBR process

in industrial wastewater treatment is also expected to gain more popularity in China. It is worth pointing out that studies on the application of MBR technology for surface/drinking water treatment would be boosted profoundly in China in the near future considering that the surface water pollution is very severe and more than half of the domestic watersheds have been contaminated. Besides the extension of the application fields for MBRs, the treatment capacity and plant scale are expected to increase further.

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Use of Appropriate and Affordable Technology for Water Quality Improvement in a Community Managed Water Supply Demonstration Project in Phnom Penh, Cambodia

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Abstract
Water supply is a major problem that local authorities find difficult to handle. Communities in peri-urban areas are often not served by the municipal systems due to limited capacities of local authorities. This paper presents the experience and lessons gained in implementing a community-built and managed water quality improvement demonstration project in Phnom Penh, Cambodia. The project attempted to demonstrate that clean water can be supplied at an affordable price to the urban poor, by adapting appropriate technologies and a participatory development process. The project used simple technology that ordinary people can understand to treat rain water harvested in an earthen pond. Ferro-cement technology was used to construct most components of the treatment system in order to be cost effective. The selection of these two technologies enabled to construct the system within a limited budget. The project also demonstrated that tapping of latent social capital can make community projects of this nature feasible. The output results of the project show that harvested rainwater with high turbidity can be treated to acceptable standards using appropriate technology. The outcome results show that project could significantly reduce physical and financial burden on people. The paper also outlines the measures taken to ensure the sustainability of this demonstration project.

Keywords: Appropriate technology, rainwater harvesting, change agent, community mobilization, social capital

Introduction
Safe and clean water is a basic need for living. However, many local authorities in developing countries are unable to provide safe drinking water for every citizen. Currently more than 1.1 billion people in the world lack access to safe water (World Bank, 2008). While people living in rural areas can rely on natural water sources to meet their fresh water demand, people living in urban areas face serious problems if they cannot afford to buy water from service providers. This problem is even more acute in peri-urban areas where there exist no municipal water distribution systems. People living in such areas have to rely on water transported by vendors or surface water sources such as rivers and canals or ground water. It is very commonly observed that both surface water sources as well as ground water in peri-urban areas are contaminated by agro-chemical residues. This is especially the condition of rainwater that is harvested from fields and stored in open ponds.

In South-East Asian countries rain water harvesting for domestic use is a traditional practice. People have been using large clay jars or earthen ponds to store harvested rainwater. Clay jars have been replaced by cement jars with the developments in Ferro-cement technology. This technology is used not only for making traditional shapes of jars but also for cylindrical jars with bigger volumes for storing and supplying water. However, there is not much attempt to use the Ferro-cement technology[1] for water treatment systems. Instead, the conventional reinforced cement-concrete (RCC) technology is often used even in small scale constructions. RCC constructions are inherently very costly and therefore unaffordable for communities and households who want to improve their water treatment systems. Therefore, community built water treatment systems require less costly yet appropriate construction technologies and treatment systems.

This paper presents the lessons learnt in adapting Ferro-cement technology to construct a community built and managed water supply system in a poor suburban community in Phnom Penh, Cambodia. This initiative was implemented as an alumni demonstration project under the South-East Asia Urban Environmental Management Applications (SEA-UEMA) Project, which is a partnership project between the Canadian International Development Agency (CIDA) and the Asian Institute of Technology (AIT), Bangkok. The demonstration projects component of the SEA-UEMA Project intends to demonstrate three ideas.

1. Involving alumni of AIT as Change Agents for improving urban environmental qualities.
2. Adaptation of appropriate technology and transfer of knowledge for community based environmental management initiatives.
3. Mobilizing communities for finding solutions for their environmental problems through a participatory process.

The demonstration project in Phnom Penh was implemented by Mr. Abdul Rashid Khatri, a graduate of the Human Settlements Development Program of AIT. He is attached to an NGO in Phnom Penh. Ms. Va Dany, an Environmental Engineering graduate of AIT and a faculty member of the Royal University of Phnom Penh, provided technical expertise for designing the water treatment system. Dr. Kyoko Kusakabe, a graduate of the Gender and Development Program of AIT and a faculty member of AIT, served as the gender expert. The author of this paper, who is also a graduate of the Urban Environmental Management Program and a faculty member of AIT, acted as the coordinator of this team of change agents.

The demonstration project was implemented in the Tropeang Chork Community, which is located 24 km from the city center in the Sangkat Prey Veng in Phnom Penh. Although this community is located in the area of jurisdiction of Phnom Penh Municipality, no municipal infrastructure network has reached there yet. Even the access road that passed the community

[1] Ferro-cement is a composite material which consists of cement, sand, and wire mesh as reinforcement. A Ferro-cement structure can be as thin as 2-5 cm, much thinner and lighter than poured concrete structures. Because it has wire reinforcing distributed throughout the structure, Ferro-cement structures have equivalent tensile strength with ordinary concrete but have higher flexibility. It has comparable tensile strength with concrete structures as required for water tanks. For certain types of structures, a cost comparison between Ferro-cement and RCC is about 1:2 . This is a significant cost saving for limited budget projects and other low-cost constructions. Different with conventional concrete structures which require high skilled labor, Ferro-cement structures do not need skillful labor to build. With this advantage, Ferro-cement structures can be constructed in remote areas utilizing available unskilled local labor. However, a skillful technician should oversee the construction process (Nedwell and Swamy, 1994).

was a dirt road at the time of launching the demonstration project. Presently it is macadamized. It will take more time for other basic infrastructure such as water supply to reach the community.

The community used to meet it water needs in different ways. During the rainy people collected water from the roofs and stored in ferro-cement containers (jars or cylinders) for future use. During the dry season some people brought water from a pond that is located about 1.5km away from the community. That water was used for domestic purposes and they bought drinking water from a vending truck which came to the community from time to time. When a road improvement project funded by a local NGO called Urban Resource Center (URC) dug a pit to obtain soil, a pond was automatically created where the community could harvest rain water. However, water in the pond is muddy and full of silt. The above mentioned demonstration project funded by the SEA-UEMA Project was initiated to implement a treatment system that is not only affordable and manageable to the community but also effective in removing silt and other impurities from raw water drawn from the pond. More over, the team of change agents who initiated the project faced the challenge of organizing the community to collectively operate and manage the system on a cost-sharing basis. Cost sharing was essential to deliver clean water to households at a price lower than that of itinerant water vendors. Therefore, as demonstrations project it was a multi-faceted one to showcase; (1) an appropriate water treatment method, (2) an affordable method of construction, (3) a participatory planning and management process and, (4) a cost reduction and cost sharing mechanism. This paper briefly deals with all these demonstrative aspects of the project.

Plate 1 : Sources of Water before Implementing the Project


Harvested Rainwater in Jar


Pond


Water Vendor


Ground Water from a Hand Pump


Brought by Cart from the Pond


Collection from Roof and Vendor

Community Mobilization

Tropeang Chork Community has a total of 106 households and a population of 527. The average monthly income of a household is around 200,000 Riel (≈ 50 USD). People are

engaged in casual work, small businesses, motorcycle taxi operation and rice cultivation. Lack of water supply and sanitation facilities are the most acute problems that the community face. During the rainy season, most people (59%) harvest rainwater from the roofs and some others (24%) utilize pond water for domestic purposes. Others extract ground water using a hand pump installed by a project funded by JICA. During the dry season, 96% of the households depend on water vendors for drinking water. The price of water is about 8,000 Riel (2 USD)/m3 and the source of that water is unknown. The majority of households utilize water brought from a pond for domestic purposes during the dry season. This pond is located about 1.5 km from the community. Carrying water from the pond to households is a burden, especially for men. Water for about 80% of the households is brought by men using push carts or motorcycles. It takes about 1 hour to fetch water from the pond and bring to the community.

Therefore, bringing safer water closer to the community was the major idea of the demonstration project. With this idea, a treatment plant to treat rainwater harvested in the new pond and a distribution system was envisaged. The newly excavated pond is located within the community. Since it is newly excavated, the harvested water in the pond was very muddy. Mr. Khatri, the project implementer, could successfully negotiate with the community and the SEA-UEMA Project for a collaborative intervention to treat and distribute water obtained from this pond. The SEA-UEMA Project agreed to provide financial contribution of 10,450 USD and technical support (through an environmental engineering expert, environmental management expert and a gender expert) and the community agreed to contribute land to install the treatment plant and labor for construction. The community also agreed to install a distribution pipe system from the treated water storage tank to individual households, once the treatment system is completed. The project implementer could also obtain some financial contributions (3,050 USD) from several NGOs, another community development project and a trust fund.

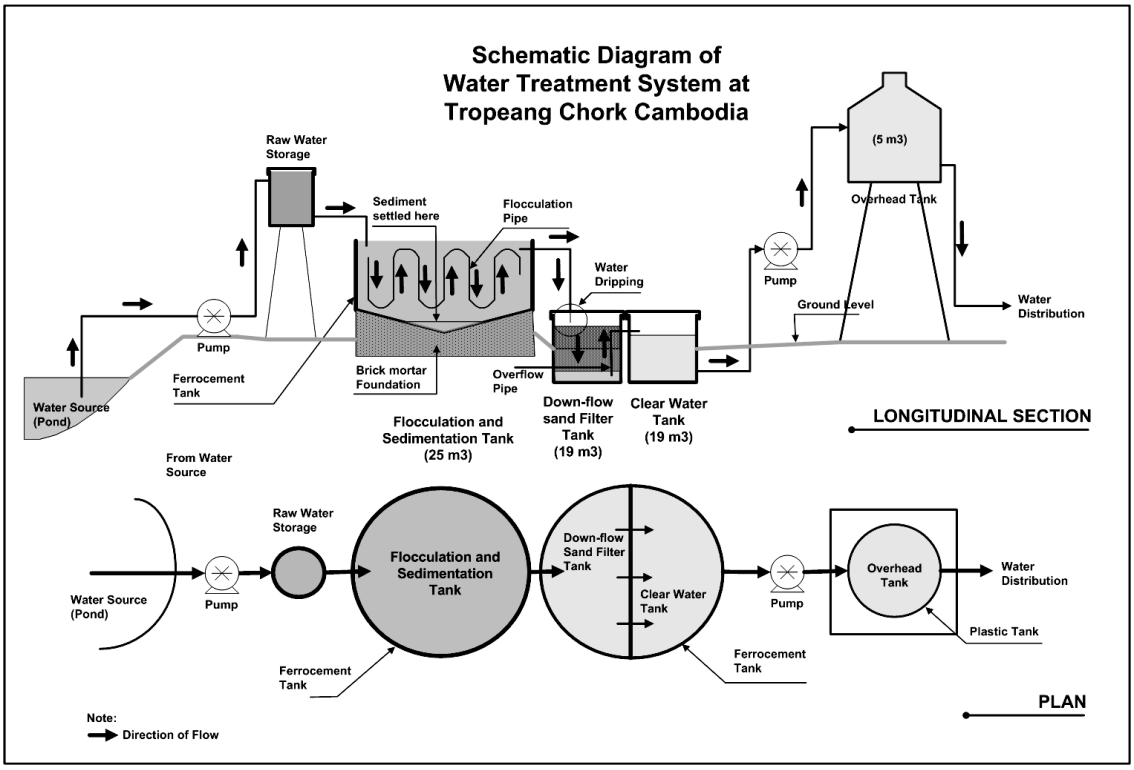
The main activity of the project was designing and construction of the water treatment plant. The team of change agents faced three challenges in designing the system, (1) How to treat harvested rainwater which is contaminated with coli-form and with high turbidity, (2) How to design and construct a treatment system within the available budget, (3) How to design a treatment system which is simple for the community to manage by itself.

The initial design showed that cost of construction using Reinforced Cement Concrete (RCC) will greatly exceed the available budget. Therefore, it was decided to use Ferro-cement technology to reduce the cost of construction. Initial calculations revealed that the cost of construction can be reduced by 50% if ferro-cement is used. Since there was no precedence existed to explain this idea to the community, a scale model of the designed system was built involving some community members. Technical assistance for this was obtained from a local NGO that had some experience in Ferro-cement construction. This was useful for the community members involved in the project to understand how the chambers for coagulation-flocculation-sedimentation and filtration work, and also getting hands-on training on Ferro-cement construction. The model was also useful to build confidence among the community members. There was some pessimism at this stage about the ability of the system to treat the muddy water obtained from the pond into clean water. A workshop was conducted involving both men and women to introduce them how the system works and its potential to reduce their burdens. Since women are the major handlers of water at the households and men are mostly

responsible for fetching water, participation of both genders in the action planning process was very important.

Application of Ferro-Cement Technology for Components of the Water Treatment Plant

The water treatment system consists of the components as shown in the diagram below.



Coagulation, Flocculation and Sedimentation Tank: Raw water with silt is pumped from the pond to this tank through a storage tank. In this tank, water is passed through a coiled perforated pipe that runs vertically up and down along the wall of the tank. A coagulant (alum - Al_2SO_4) is added to raw water in this pipe to enable the flocculation process which works on the principles of 'hydraulic mixing'. Once passed through the pipe, water is retained in this tank for few hours allowing the sediments to settle down at the bottom. The tank was made out of Ferro-cement using a cylindrical shape with the dimensions of 4.0m in diameter, 2.0m in height with 8cm in thickness. This was placed on a 0.7m high base to create a gravitational flow.

Aerator: Air affects water chemically and physically. This fact was explained to the community and used in the project. The water coming from the sedimentation tank was set to pass through a set of perforated pipes and drip into the Filtration tank while aerating water in the process.

Slow Sand Filter and Clear Well: The aerated water passes through a slow sand filter to remove the remaining particles in water. Slow sand filter is a simpler technology that the community can easily manage by replacing upper layer of sand from time to time instead of backwashing sand that is technically more sophisticated. Additionally, the design of the filter has provision to maintain a continuous layer of water on top of the sand layer to prevent any growth of algae on sand. The filtered water is collected in a clear well where Chlorine is

added to destroy any remaining bacteria. The clear well also serves as the ground storage tank before pumping to the over-head tank for distribution. The filter chamber and clear water storage chamber was attached in a single tank to economize on the cost. This was also constructed using Ferro-cement with the dimensions of 5.0m in diameter, 2.0m in height and 8cm thickness.

Overhead Tank: Water from the Clearwater storage tank is pumped to the overhead tank. This tank serves as the hydraulic head provider for water distribution through a gravity system. A RCC structure having 5.0m height was constructed to place a heavy duty PVC storage tank. This is the only major element of the system that did not use Ferro-cement technology. There was no expertise available in Cambodia to construct an overhead tank using Ferro-cement.

Water Meter and Distribution Point: This part is installed at the bottom of the overhead tank to distribute water and measure the quantity of water sold to the consumers.

Plate 2 : Water Treatment System

New Rainwater Harvesting Pond


Water Treatment System

C.F.S. Tank and Slow Sand Filter

Capacity Building

A series of trainings/workshops were conducted involving both men and women of the community, throughout the participatory planning and implementation process. This included;

- Visit to community water supply projects in Kandal Province (20 people - 3 Female)
- Training on Ferro-cement construction (7 people, all male)
- Training for the maintenance team (4 people, all male) on Jar Test, use of alum and Chlorine
- Training on maintaining the sedimentation tank and slow sand filter
- Training on user charge collection and accounting to financial management committee (4 people - 2 Male, 2 Female)

In addition to the above, 10 community meetings were held during the community action planning process with average participation of 44 females and 60 males. These were useful in collective capacity building for shared decision making.

Output Results

The total water demand of the community is 28.6 Cum/day as per the baseline survey. The water treatment plant was designed to produce 30 Cum/day but it yielded only 25 Cum/day at the initial period of operation. This was attributed to the high turbidity level of the input water. Water quality tests on input and output water showed following results.

Table 1. Result of Water Quality Test

Parameters	Unit	Standards		Water Quality	
		WHO	MIME	Raw Water	Treated Water
Iron	mg/liter	0.1 – 0.3	0.3	4.4	0.16
pH	-	6.5 – 8.5	6.5 – 8.5	7.3	7.1
Turbidity	NTU	<5	<5	514	4.2
Total Hardness	mg/liter	<100	<300	54	18
Total Coli form	CFU/100 ml	0	0	12,000	0
E-coli	CFU/100 ml	0	0	5,040	0
Salmonella	CFU/100 ml	0	0	20,000	0

The quality of treated water meets both WHO and MIME (Ministry of Industry, and Mining and Energy, Government of Cambodia) standards, and therefore it is safe for drinking and cooking.

Outcome Results

Following outcome results were revealed at a follow-up community meeting.

Table 2. Indictors of Improvements

Aspect of Improvement	Condition before Project	Condition after Project
Ave. distance travel to fetch water	1.5 km	200m
Average time spend to fetch water	One hour	Twenty minutes
Frequency of fetching water	Once in a day	Two times in three days
Transport mode used	Push-cart/motorcycle	Push-cart/motorcycle/walk
Average price paid for water	USD 2.17 per Cum	USD 0.5 per Cum
Perception on water Quality	Poor, unsafe for drinking	Good, safe for drinking

The follow-up meeting also revealed some other outcome results. The close location of the system to the community lessened the workload of both men and women. Although the share of workload has not changed among men and women after the project since they still have to carry water to homes, their burden has reduced due to the closer location of the new source of water. This will further reduce when the community accumulates enough funds from water vending and savings to install community stand points first, and individual household connections later. The community collectively decided to fix the water tariff at USD 0.5/Cum. This has reduced the financial burden of the households, since they used to pay more than USD 2/Cum for water brought to the community by a vending truck. As a demonstration project the most significant outcome result of the project is the revelation of social capital available in the community to invest in a community enterprise. People's voluntary participation in planning and implementing this community project and their contribution of a piece of community owned land (4,200 sq m.) for the water treatment plant and labor for construction indicated their willingness to invest their social capital. If these contributions are valued in monetary terms, their share is about 80% of the total project cost. However, it was the financial contribution of the SEA-UEMA Project and the interventions by change agents to mobilize the community that trigged the outflow of this social capital.

Sustainability of the System and Challenges

Sustainability is a critical issue in any project intervention. Sustainability concerns already exit in this project after nearly two years of operation. The output level has come down to 15 Cum, that is 50% of the designed capacity. There are two interconnected reasons behind this. Firstly, the high turbidity of input water has clogged both flocculation coil and the slow sand filter. Secondly, the maintenance team has failed to regularly maintain the system due to their livelihood related priorities. Especially during the farming season they have not been able to attend to the maintenance work. Moreover, water is not a scarce resource during the rainy season. People can rely on rainwater harvested from their roofs. This has led to reduced demand during the rainy season, which has disappointed the project management team. People in the community are also loosing the confidence by seeing the gradual reducing of output efficiency of the system. They perceive that the system cannot meet the total water demand of the community. Therefore, they are reluctant to contribute to the community saving fund to install the water distribution system. In order to address these problems, an additional tank for coagulation-flocculation-sedimentation is being constructed using further funding support (USD 11,570) from the SEA-UEMA Project. This tank uses a baffle system for flocculation, instead of the previously used coil system. This decision was taken based on the lessons learnt by monitoring the functioning of the first sedimentation tank. It is also expected to reinstall the slow sand filter using new media to increase its efficiency. Alum is periodically added to the raw water pond to reduce the turbidity of input water. Banks of the pond were consolidated to prevent erosion of the banks and silting water in the pond. Trials are being carried out to identify suitable aquatic plants and ground covers that can reduce the silting of water in the pond. The biggest challenge still remain is the generation of adequate funds to construct the distribution system. Until then, people have to come to the treatment plant to buy water.

Acknowledgements

The author wishes to thank Mr. Ariva Sugandi Permana, a doctoral student at AIT, and Ms. Farhana Lima Khan, a staff of SEA-UEMA Project, for their support in drafting this paper.

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Phytotechnology, a Nature-Based Approach for Sustainable Water Sanitation and Conservation

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Abstract

Developing countries in Asia are threatened by environmental pollution due to the lack of waste treatment facilities. Most wastewater treatment technologies are known as being costly and not affordable by the municipalities and the small scale polluting industries. When land is available, phytotechnology is a promising and cost effective approach for domestic and industrial wastewater treatment. In addition, phytotechnology can be potentially used for rehabilitating degraded environment. This paper briefly discusses about the applications, ideas, and future perspectives of phytotechnology as an appropriate tools in promoting sustainable water sanitation and conservation in Asian countries.

Keywords: phytotechnology, application, advantages

Introduction

The tropical region in Asia is mostly occupied by low to middle income countries, with rapid industrial and urban development. As a consequence, environmental pollution has often occured due to insufficient control technology. For example, Indonesia should face severe environmental pollution, particularly in Java, Sumatera, Kalimantan, Sulawesi, Lombok, and Papua, where urban, industrial and mining wastes are not treated sufficiently. The nation wide Clean River Program (PROKASIH), which was implemented by the Environmental Impact Management Agency (BAPEDAL) during the 1990s (Trihadiningrum, Verheyen and De Pauw, 1997), did not show significant surface water quality improvement.

In addition to the above information, Malaysia has faced rapid urbanization and industrial developments since 1991. The inland water is polluted due to point sources and non-point sources of pollution. Point sources that have been identified include sewage treatment plants, manufacturing and agro-based industries and animal farms. Non-point sources are mainly diffused ones such as agricultural activities and surface runoffs. The storm water was also believed to contribute significant amount of nutrients, heavy metals, oil and grease to the surface water.

Tropical region is characterized by whole year solar energy resource, which can be transformed to biomass through efficient plant metabolism. This condition is beneficial for supporting plant based wastewater treatment technology, which is known as cost effective and publicly accepted. In the US such a technology is widely applied as an acceptable clean-up technology for polluted sites.

The term phytotechnology describes the application of science and engineering to examine environmental problems and provide solutions involving plants. This term promotes a broader understanding of the importance of plants and their beneficial role within both societal and natural systems. A central component of phytotechnological concept is the use of plants as *living technology* that provides services in solving environmental problems. The term phytoremediation is used to describe the plants processes in absorption, extraction, conversion and releasing for contaminants from one medium to another (Mangkoedihardjo, 2007).

Phytotechnology has been introduced and developed for the treatment of urban runoff, domestic and industrial wastewater, and remediation of polluted soil since the last three decades. Constructed wetlands and phytoremediation are examples of the most commonly applied technologies for removal of pollutants in water and soil. Phytotechnology is not only known as cost effective means for water quality improvement and stormwater control, but also provides aesthetics and wild life habitat (USEPA, 1993).

This paper briefly discusses about the applications, research experience in persistent pollutant removal, ideas, and future perspectives of phytotechnology as appropriate natural tools in promoting sustainable water sanitation and conservation.

Mechanisms, advantages and disadvantages of phytotechnology

In phytotechnology, the plants act as solar-powered pump-and treat systems as they take up water soluble contaminants through their roots, and transport them through various plant tissues, where they can be metabolized or volatilized (Doty *et al.*, 2007). Former researchers have identified various tolerant plants which are able to significantly reduce organic and inorganic pollutants in the waste water and in the polluted soils and surface waters. According to Kramer (2005) and Doty *et al. (*2007), there are several mechanisms of water and soil environment improvement using phytotechnology:

- Phytostabilization: a mechanism which is used more to providing a vegetation cover for heavily contaminated soils, thus preventing wind and water erosion. Plants suitable for phytostabilization develop an extensive root system, provide soil cover, possess tolerance to contaminants, and ideally immobillize the contaminants in the root system
- Phytoextraction: a mechanism, where pollutant tolerant plants concentrate and accumulate soil or water contaminants in their tissues. At the end of the growth period, the contaminant enriched plants are generally harvested and dumped; or dried and incinerated. Heat from the incineration is used for energy generation
- Phytovolatilisation: a mechanisms, where plants transport soluble pollutants to the above ground tissues and volatilize it to the atmosphere.
- Phytodegradation: a mechanism where plants, associated with aquatic or soil microorganisms, biodegrade organic pollutants

Phytotechnology is an accepted method for it's advantages as a cost effective technology, publicly accepted, and does not altered soil matrix. However, there are several limitations of this technology, such as:

- site specific properties for optimum plant growth (soil texture, pH, salinity, type of pollutants)
- limited uptake capability of the plants
- time consuming

Applications of phytotechnology

Phytotechnology has been applied for stormwater remediation in Putrajaya, Malaysia's new Federal Government Administrative Centre. Central to this city is the 400 hectare man-made lake created by damming of Chua and Bisa rivers. The Putrajaya Wetland was constructed in 1997-1998. Construction and operation of the wetland is aimed to create a self-sustaining and balanced lake ecosystem and to ensure the lake's water quality complies with standard set by Putrajaya Authority and suitable for body contact recreational activities. The wetlands are strategically located to act as buffer to the Putrajaya Lake which drains a catchment area of 50.9 km^2. Involving an area of 197 hectares and 12.3 million wetland plants, this wetland is one of the largest fully constructed freshwater wetlands in the tropics (Huat, 2002).

When land is available, application of phytotechnology is also considered to be appropriate for treating small scale pollutant sources.| For example, domestic wastewater, where sewage treatment facility does not exist, can be treated using phytotechnology. This technology is also appropriate for treating industrial wastewater, which contains biodegradable organics, such as slaughter house, seafood, and tofu and sugar manufacturing industries (*e.g.* Sohsalam and Sirianuntapiboon, 2008; Sari, 1999).

The tropical Asian countries are famous for their traditional *batik* and waven cloth. Unfortunately, these products, in Indonesia in particular, are mostly manufactured in home scale industries, where wastewater treatment facility is not provided. As a consequence, coloured waste water with high COD and suspended solids levels is discharged directly into the environment with very limited treatment. The following discussion is focused on a successful wetland technology application for domestic wastewater treatment in Indonesia, and present research work on the use of plants for the treatment of waste water from a small scale yarn dyeing industry.

Wetland technology for domestic wastewater treatment

Domestic waste water from a community in Tlogo Mas Village, which is located in Malang town, East Java Province, Indonesia, was successfully treated using vertical flow subsurface system (SSF) constructed wetland, which was designed by Mr. Agus Gunarto. One hundred and ten houses have been connected to this wetland facility since 1990. The wetland facility consists of 3 primary reactors (or floating tanks) using water hyacinths (*Eicchornia crassipes*), and 3 secondary reactors (or subsurface tanks) using cattails (*Typha latifolia*) (Figure 1). The wetland facility has a depth of 1,5 m. Daily wastewater intake is 50 m^3, and detention time in each tank is 12 hours. Peak time occurs at 06.00 to 08.00 am, and at 04.00 to 07.00 pm.

This SSF wetland worked with a maximum BOD loading rate of 70 kg/ha.day. A successful vertical flow SSF wetland can remove organic matter, total N, and total P of >96%, 36%, and 63% respectively (Fitriarini, 2002). With an average medium level of Indonesian domestic wastewater characteristic of BOD of 220 mg/L, total N of 40 mg/L, and total P of 8 mg/L (Djajadiningrat, 1992), this wetland system could produce good quality of effluent. The area of the old wetland was planned to be extended to 24 m x 30 m, with the addition of floating and subsurface tanks.

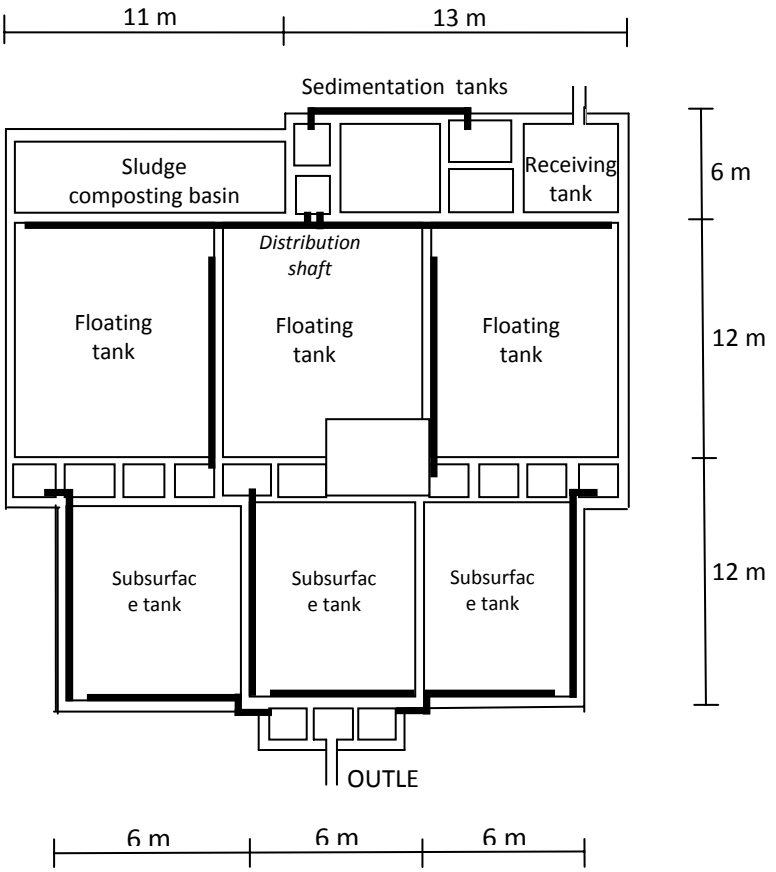

Figure 1. Lay out of wetland SSF system for treating domestic water in Malang City, Indonesia. (After Gunarto, 1999; in Fitriani, 2002)

Study on wetland technology for treating waste water from yarn dyeing industry

Batch bioreactors were prepared in a green house for testing the potential of water lettuce, water hyacinth and *Canna sp* in removing persistent pollutants of the yarn dyeing wastewater, collected from Sidoarjo town, East Java Province, Indonesia. The wastewater had black colour and high pH, COD, and total suspended solid (TSS) values (Table 2), which exceed the quality standards. This waste water is usually discharged to the surface water without any treatment. The Range Finding Tests for determining the plant tolerance to the wastewater, resulted in much low levels of COD, BOD, and TSS levels, in which the plants could grow satisfactorily (Table 1).

Table 1. Yarn dyeing wastewater charateristics and the tolerable pollutant levels for water lettuce, water hyacinth and *Canna sp*

No.	Characteristics	Waste water	Wastewater characteristic which is suitable for the plant growth
1.	Colour	Black	Black
2.	pH	11,58	9,5
3.	COD (mg/L)	26.800	400
4.	BOD (mg/L)	10.720	160
5.	TSS (mg/L)	24.216	464

Application of the three plant species in the batch reactors within 30 day detention time showed significant removal efficiencies of organic matter and TSS, with the highest values in *Canna* reactor (Table 2). Yet the effluents did not meet the waste water quality standards. Moreover, none of these plants showed tolerance in the original waste water. Therefore, phytotreatment technology can only be applied in the final or tertiary treatment stage in such a kind of waste water, which contains recalcitrants. Due to the high COD levels, a combined four compartment anaerobic baffled reactor (ABR) and wetland system are thought to be appropriate for treating the waste water, before it enters the plant reactor or wetland (Figure 2). Selection of the ABR system is based on the cost effective and easy operation and maintenance considerations (Bell and Buckley, 2003). This system can be applied as a communal wastewater treatment facility from similar industries.

Table 2. Influent and effluent characteristics and the removal efficiencies of COD, BOD, and TSS in water lettuce, water hyacinth and *Canna* reactors.

No.	Parameter	Influent	Pollutant levels in effluent and removal efficiency			Wastewater quality standards
			Water lettuce	Water hyacinth	*Canna sp*	
1.	Colour	Black	Clear	Clear	Clear	-
2.	pH	9,5	7,2	7,4	7,2	6-9
4.	COD [(mg/L, (%)]	400	200 (50)	216 (46)	120 (70)	100
5.	BOD [(mg/L, (%)]	160	64 (60)	77 (52)	33 (79)	50
6.	TSS [(mg/L, (%)]	464	139 (70)	154 (67)	107 (77)	50

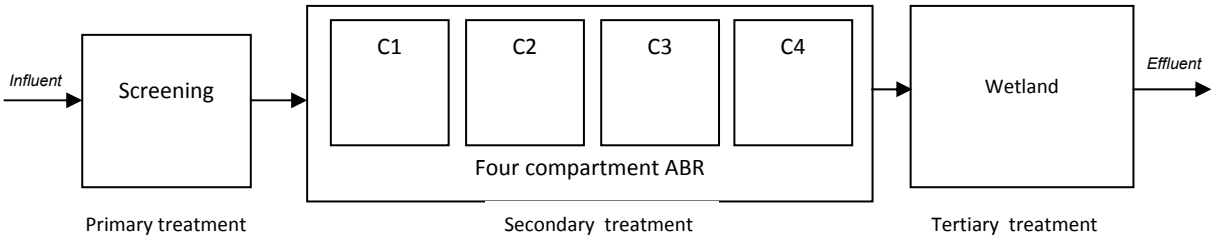

Figure 2. Scheme of ABR and wetland system for treating small scale yarn dyeing waste water.

Former studies showed that the ABR system could remove 70-90% COD, BOD and TSS, and colour removal of 86% (Bell and Buckley, 2003, and Haris, 2007). Using assumed removal efficiencies in the ABR reactors of 70-80%, the combined ABR and wetland system can be expected to produce effluent, which meets the quality standards (Table 3).

Tabel 3. Estimated combined ABR and wetland performance for communal treatment of textile dyeing industries

Parameter	Influent	Estimated effluent quality in each treatment unit									
		ABR Compartment I		ABR Compartment II		ABR Compartment III		ABR Compartment IV		Wetland	
		Efficiency (%)	Effluent (mg/L)	Efficiency (%)	Effluent (mg/L)	Efficiency (%)	Effluent (mg/L)	Efficiency (%)	Effluent (mg/L)	Efficiency (%)	Effluent (mg/L)
COD	26.800	80	5.360	70	1.608	70	482,40	70	144,72	50	72,36
BOD	10.720	80	2.144	70	643	70	192,96	70	57,89	61	22,61
TSS	24.216	72	6.780	72	1.898	72	531,59	72	148,85	70	44,43

Discussion

The above mentioned case studies show that phytotechnology can be applied for communal treatment of domestic and small scale industrial waste water. However, this technology may be suitable for supporting a secondary treatment facility in the domestic waste water treatment, but is more suitable to be applied as a tertiary treatment facility in the industrial waste water treatment plant. Table 4 summarizes the comparison of the application of phytotechnology in domestic and small scale industrial waste water treatment.

Table 4. Comparison of domestic and small scale industrial wastewater treatment and the possibilities of the application of phytotechnology.

Item	Domestic wastewater treatment	Industrial waste water treatment
Primary treatment	Screening for solid particles/grit removal	
Secondary treatment	Phytotechnology using highly tolerant plants or biological waste water treatment technology	Chemical or anaerobic waste water treatment
Tertiary treatment	Phytotechnology using less tolerant plants	Phytotechnology using highly tolerant plants
Plant tolerance	Considerably high. Low tolerance may appear in concentrated waste water	Generally low, particularly in waste water which contains recalcitrants.
Pollutants which are removed	Organic matter, macro- and micro-nutrients, TSS	Organic matter, heavy metals, TSS, colour.
Harvested biomass	Can be used as raw material for energy and compost production using biological treatment	Energy and compost production using biological treatment requires determination of recalcitrant contents in the biomass

Future perspectives of phytotechnology

As plants have been used as natural cover blanket of the earth, its application is not limited only for remediating polluted water and soils, but also for stabilizing eroded slopes. Studies on the remediation of degraded water, soil, and land using plants (lately known as *bioengineering*) have been extensively implemented and applied. Vetiver grass (*Vetiveria zizanioides,* or *Chrysopogon zizainoides*), a *super-absorbent* and deep rooted perennial grass, could be used for landfill rehabilitation, erosion and leachate control in particular (Truong and Stone 1996). Because of the high tolerance of this grass species to high acidity, alkalinity, heavy metal levels, this grass species is also recommended for the rehabilitation of mining areas (Truong, 1999; Grimshaw). Therefore, phytotechnology is not merely applicable for water sanitation, but can also be also involved more to water conservation.

The harvested plants from the application of phytotechnology, however, needs additional measure in a completed treatment cycle. Particular cultivation treatment, such as cutting and harvesting of the plants are needed for maintaining the pollutant removal efficiency. The plants from nutrient, greywater and blackwater treatment facilities may not pose a problem for disposal. These nutrient accumulating plants may be used for composting and for energy production. In many cases, the harvested plants are dried and incinerated. The heat released

from the incineration is used for energy generation. However, plants from remediated sites, which are polluted by hazardous waste, are generally suspected to contain significant amount of hazardous pollutants and need careful disposal measures (Kramer, 2005). Incineration of the plants may be costly, and is believed to become hazardous gas and ash emmission sources. Fermentation technology for biogas production is one of the solutions of these problems. In addition to this bioenergy production alternative, biodiesel can be produced from rich oil seed producing plants (e.g. sunflower and *Jatropha curcas*), when they are used for environmental remediation. A conceptual scheme of energy transformation and phytotechnology is shown in Figure 3.

Future R&D activities in phytoremediation are multidisciplinary, and may involve various expertises, such as environmental engineering, hydrology, environmental chemistry, plant ecology and physiology, microbiology, and molecular biology. Current research activities in western countries are focused on genetically modifed organisms (GMO) for inventing tolerant plant species to particular environmental pollutants with high removal efficiencies. A number of research works are done today to seek bioenergy production feasibilities from the harvested plants.

To end, phytotechnology is a promising, cost effective and environmentally sound technology for water sanitation and conservation. The remarkable capabilities of the plants in water pollutant removal and rehabilitation of degraded environment, together with the biomass and energy recovery potentials, provide a nature-based technology which supports sustainable development program in our countries.

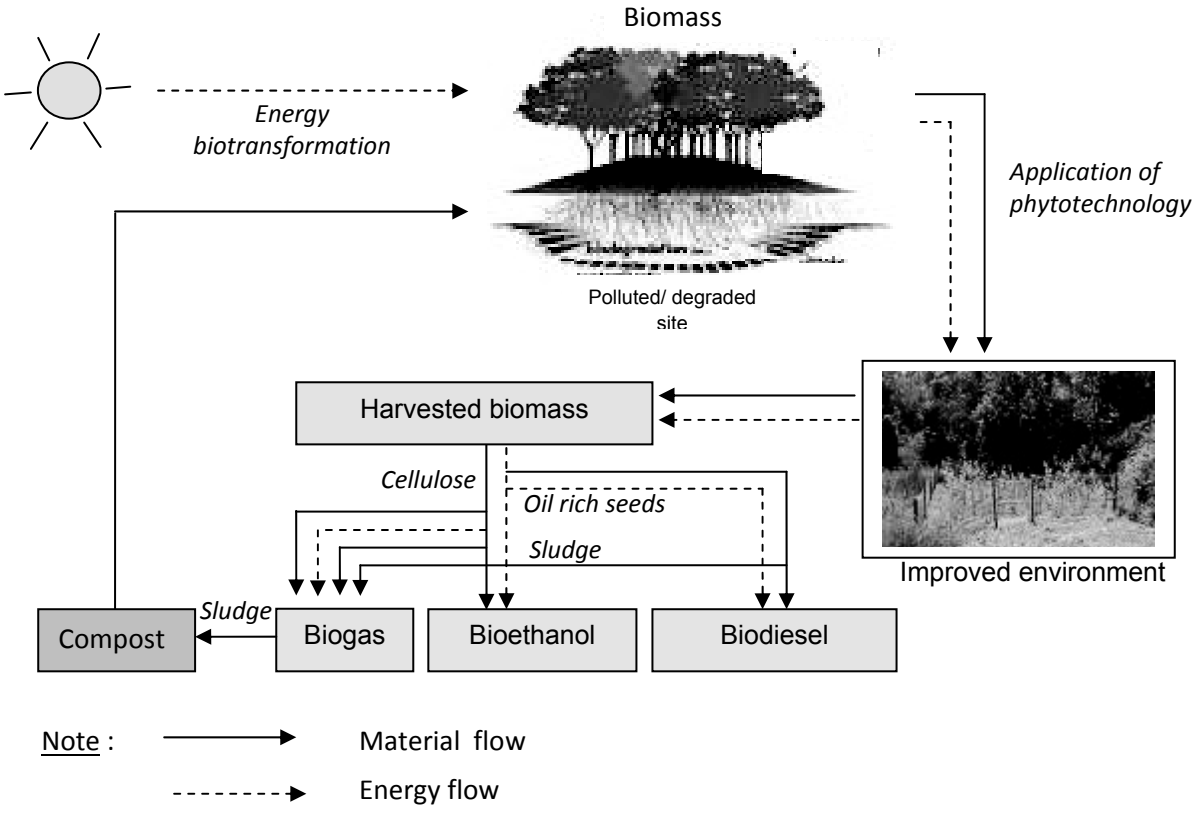

Figure 3. Conceptual scheme of phytotechnology application and energy biotransformation

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Decentralized Domestic Wastewater Treatment in Rural Areas in China—Efforts of the Japan-China Water Environment Partnership Project

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Abstract

As part of the Japan-China water environment partnership project agreed on between the leaders of the both countries, the Japanese Ministry of the Environment started a four-year rural area decentralized wastewater treatment model project in 2008. This project is intended to install model treatment facilities in some regions with typical requirements or conditions based on the experience of the both countries, and to work on the penetration of these systems in the future. In 2008, treatment systems were installed in Taizhou, Jiangsu and in mountain areas of Chongqing, in light of the conditions of these areas. A gravel contact aeration system and an constructed wetland system were selected for Taizhou and Chongqing, respectively. A gravel contact aeration system based on Japanese technologies and a constructed wetland system based on Chinese technologies were used. Both countries will further study the operation of these treatment systems to promote their penetration in the future.

Keywords: Domestic wastewater, Rural area, Decentralised system, Japan-China water environment partnership, Adaptability evaluation

Introduction

In China, the amount of domestic wastewater has accounted for a larger percentage of the total amount of wastewater than that of industrial wastewater since 1999, and the gap has been widening year by year. Therefore, promoting domestic wastewater measures has been a major issue. To cope with this situation, heavy investments have been made in the development of sewage systems in urban areas, where 1,178 sewage treatment plants have been built and operated across the country by the end of 2007. This pushed up the sewage treatment rate to 60 percent. A total of 472 out of the 1,178 sewage treatment plants were built between 2006 and 2007, and it is believed that the development of sewage systems in urban areas will further pick up speed in the future. Thus, domestic wastewater measures in urban areas have almost been put into place, but rural areas, with a larger population than urban areas, are far behind urban areas in these measures.

Rural areas, which are less densely populated than urban areas, require a decentralized sewage treatment system to cover a relatively highly populated area rather than a large-scale centralized sewage treatment system as seen in urban areas. In view of the economic situation of rural areas, systems that have low construction, maintenance, and operation costs are required.

In Japan, the sewage treatment rates in Tokyo, Osaka, and other urban areas with a population of over one million have reached almost 100 percent, but those in local city areas with a

population of less than 50,000 still remain around 65 percent. In these local city areas, decentralized treatment systems that have low construction, maintenance, and operation costs have been introduced on a trial basis. Under these circumstances, those involved in the Japan-China water environment partnership project started to work to build decentralized domestic wastewater treatment systems in rural areas in China based on their respective experience, as part of the project.

Necessity of Domestic Wastewater Treatment in Rural Areas in China

There is less information available on domestic wastewater discharge conditions in rural areas than on those in urban areas, and there are many unknowns. Liu, et al. estimated the nitrogen flow in rural areas by supplementing the existing statistical data with field work surveys, and studied the effects of human life on the flow[1)]. They estimated the nitrogen flow in Taoyuan, Hunan and Taihe, Jiangxi located in the middle to lower reach of the Chang Jiang River. Both districts are rice-producing rural areas, but Taoyuan has introduced more machinery into its agriculture. In rural areas in China, raw sewage has been recycled as fertilizer over a long time[2)]. The recycle rates of raw sewage in terms of nitrogen in Taoyuan and Taihe were 27 percent and 67 percent, respectively. In Taoyuan, about 70 percent of lavatories have been converted into flush toilets and this shows the gradual development of sewage systems, but sewage treatment has lagged behind the development of sewage systems. In Taihe, on the other hand, the recycle rate of raw sewage is high, and flush toilets account for only about 30 percent of all lavatories because vault toilets are widely used, and people there are less satisfied with their toilet conditions than those in Taoyuan. In Taoyuan, chemical fertilizers account for 70 percent of nitrogen put on agricultural land, which reflects the advanced mechanization of agriculture. These study results suggest that the recycle rates of raw sewage in rural areas will be lowered following the increasing mechanization of agriculture and improvement in people's living standards, and the necessity of domestic wastewater treatment will be increased. The necessity of domestic wastewater treatment will be further increased at an accelerated speed by new agricultural village construction projects and other urbanization policies. Thus, construction of domestic wastewater treatment systems in rural areas is an urgent issue to be addressed for the improvement of hygienic conditions in rural areas and the reduction of effects on watersheds.

Rural Area Decentralized Wastewater Treatment Model Project

Under these circumstances in rural areas, the Japanese and Chinese ministers of the environment signed the "Memorandum on a Joint Rural Area Decentralized Wastewater Treatment Model Project" on May 8, 2008. Following the conclusion of this memorandum, the Japanese Ministry of Environment started the project by working on the installation of model decentralized wastewater treatment facilities in China and the following items:

(1) Study the reduction of water pollutants and what water environment management should be

i) Analyze the current situation and issues of the model project areas

ii) Collect and analyze basic information necessary to introduce decentralized domestic wastewater treatment technologies

iii) Work on the formulation of policies or laws and regulations on decentralized domestic wastewater treatment

(2) Introduce decentralized domestic wastewater treatment technologies
i) Introduce decentralized wastewater treatment technologies
ii) Determine the effects of decentralized wastewater treatment technologies

(3) Help those involved in the Chinese government with capacity building and enhance policy dialogue

(4) International seminar on theory and practice on total pollutant amount control in Japan and China

Based on the installation of model decentralized wastewater treatment facilities in China, this project will promote the penetration of these facilities in China from 2008 to 2011.

Installation of Model Decentralized Wastewater Treatment Facilities

Overview of Model Installation Areas

In 2008, model facilities were installed in the Chang Jiang River basin, or in Taizhou, Jiangsu, which has attracted many industrial complexes and been urbanized because of the resultant economic growth, and in Zhong and Wanzhou, Chongqing, located in the upper reach of the Three Gorges Dam. In Taizhou, new agricultural village construction has promoted the readjustment of land for industrial use, agricultural land, and residential land, and residences, which had been scattered over agricultural land before, have now formed villages of hundred to several hundred families. Thus, wastewater treatment must be provided for each of these villages. These villages basically use flush toilets, but conventional treatment facilities, which were based on septic tanks installed in individual households, do not provide satisfactory treatment of wastewater. In this area, creeks run around the villages like the mesh of a net, and wastewater from the villages is discharged into the creeks. Thus, insufficient treatment of wastewater may affect the surrounding water environment. In addition, economic growth has increased the convenience of the land to make it difficult to acquire a large land lot for a wastewater treatment plant, which makes it inevitable that wastewater plants will be installed near residences.

On the other hand, Zhong and Wanzhou of Chongqing are comprised of purely agricultural, mountain villages with large, terraced paddy fields. In these mountain areas located in the upper reach of the Three Gorges Dam, villages of several thousand people are scattered, and wastewater treatment must be provided for each of these villages. Since the incomes of those in the purely agricultural villages are not so high, construction, maintenance, and operation cost requirements for wastewater treatment plants in these areas are severe. However, a relatively large land lot can be secured for a wastewater treatment plant, though it is difficult to secure a flat land lot in the hilly areas.

Selection of Treatment Systems

In Taizhou, compact and high-level treatment technologies should be used because of the difficulty of acquiring large land lots, and the proximity of treatment plants to residences requires measures against odor to be taken. Considering the future spread of these treatment plants, construction, maintenance, and operation costs as well as the production of sludge, the major problem in operating treatment plants, must be kept low. In view of these requirements, a gravel contact aeration system, which has been increasingly used as a decentralized

treatment facility in Japan, was introduced in Taizhou. A treatment facility of this system is topped with soil to produce fewer odors. Based on a biofilm process, this system produces less sludge than an activated sludge process. The target quality of treated water is a CODcr of 60 mg/L or lower, a BOD_5 of 20 mg/L or lower, an SS level of 20 mg/l or lower, ammonia nitrogen of 15 mg/L or lower, and a coli form bacteria count of 10^4 MPN/L or lower. This quality of water complies with Class 1-B of the discharge standard of pollutants for municipal wastewater treatment plant in China. The target maintenance and operation cost was set at 0.09 US$ per m^3 of sewage.

In Chongqing, to keep treatment plant construction, maintenance, and operation costs low, a treatment system based on a constructed wetland was applied. To secure stable operation of a constructed wetland over a long time, a preliminary aeration process was combined. A general contact aeration system was adopted for preliminary aeration to reduce the production of sludge, and a plastic filter medium commercially available in China was selected as a contact medium. The target quality of treated water is a CODcr of 100 mg/L or lower, a BOD_5 of 30 mg/L or lower, an SS level of 30 mg/l or lower, and ammonia nitrogen of 25 mg/L or lower. This quality of water complies with Class 2 of the discharge standard of pollutants for municipal wastewater treatment plant in China. Considering the economic conditions in the region, the target maintenance and operation cost was set at 0.05 US$ per m^3 of sewage. Because Japan has no experience in domestic wastewater treatment using a constructed wetland, a constructed wetland designed by China with a good track record was combined with this wetland.

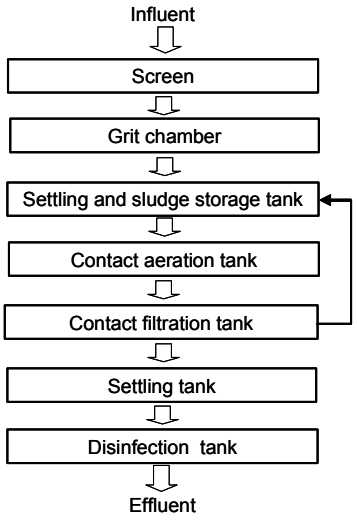

Figure 1. The treatment flow of gravel contact aeration system.

Overview and Features of Treatment Systems

Gravel Contact Aeration System

This system consists mainly of a settling and sludge storage tank, a contact aeration tank, and a settling tank, and uses gravel as a contact medium. Figure 1 shows the treatment flow. Sludge produced by treatment is stored in the settling and sludge storage tank, and must be removed once or twice a year. The removed sludge is recycled as a liquid fertilizer. The sludge production is about 15 to 25 percent of that for a commonly used standard activated

sludge process or oxidation ditch process. Because the treatment facility is topped with soil, a treatment plant may be installed in a corner of a residential area in Japan, and so not so much consideration needs to be given to measures against odor. In Taizhou, a facility with a treatment capacity of 150 m^3/day and another facility with a treatment capacity of 40 m^3/day were installed. While the facility with a capacity of 150 m^3/day is of reinforced concrete, the facility with a capacity of 40 m^3/day uses a liner sheet, concrete blocks, and other building materials rather than concrete building frames to keep the construction cost low. This construction method cannot be used for a large facility, but can keep the construction cost low for an ultrasmall facility. Figure 2 shows the construction status in Japan.

Figure 2. The construction status of the low cost facility.

Preliminary Contact Aeration—Constructed Wetland System

As shown in Figure 2, depicting the treatment flow, this system consists mainly of a settling and sludge storage tank, a preliminary contact aeration tank, a sedimentation tank, and an constructed wetland. According to the guidelines in China, wastewater put to a constructed wetland must not contain a CODcr of greater than 200 mg/L, a BOD_5 of greater than 70 mg/L, an SS level of greater than 40 mg/l, and ammonia nitrogen of greater than 30 mg/L. Since this quality level cannot be achieved by settling separation alone, a preliminary aeration process must be combined. The aeration time was set at four hours, but it must be optimized through actual operations because the length of the aeration time greatly influences the maintenance and operation cost. Produced sludge can be stored in the sedimentation separation tank for up to about one year.

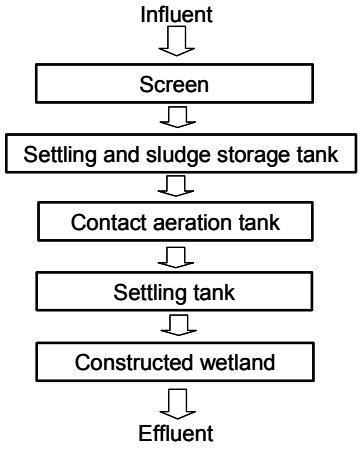

Figure 3. The treatment flow Preliminary Contact Aeration-Constructed Wetland System.

Future Prospects and Issues

Model treatment technologies were selected and installed in Taizhou and Chongqing in light of the situations of these regions. In Taizhou, where the readjustment of residential land has been promoted by new agricultural village construction, a compact, simple treatment flow system was selected. Not a pre-fabricated treatment system popular in Japan but a system that can be constructed in China was used. In Chongqing, a constructed wetland system was selected in light of the economic conditions of the rural areas and the relatively warm, humid climate. However, to allow stable operation of a constructed wetland over a long time, preliminary biological treatment was combined. In the future, Japan and China will jointly study the operation of the model treatment systems to develop them into more advanced, versatile systems.

This time, the reduction of sludge production was a criterion for selecting these treatment systems. However, because the production of sludge cannot be avoided, treatment or disposal of sludge must be further studied with an eye toward the future. Basically, produced sludge should be recycled as fertilizer for use in these rural areas, and how it should be recycled must be studied also from the perspective of farmers. Especially, whether to recycle sludge as liquid fertilizer or dry fertilizer, which decides whether to add a sludge drying process or influences the design of a treatment system in other ways, must be clarified in view of the form of agriculture in that region.

This model project has been promoted based on adequate discussions between the Japanese and Chinese governments and engineers. Therefore, adaptable cooperation of China can be expected, and the project will be further promoted with the experience of the both countries. Since these decentralized domestic wastewater treatment systems are also important in other countries, improvements both in tangible and intangible aspects for the development of adaptable systems must be sought, and further efforts must be made to develop the Japan-China water environment partnership project into foreign aid based on cooperation between the both countries.

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People's Participation in Rural Water Supply and Sanitation Project: A case study in Jorong Kampung Baru, Solok, West Sumatra, Indonesia

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Abstract

This study analyzed Rural Water Supply and Sanitation (RWSS) quality improvement under Water and Sanitation for Low Income Communities (WSLIC II) project in Jorong Kampung Baru, Solok district, West Sumatra. The paper explores people participation in the project with emphasized on equal participation between men and women in decision-making process, implementation, operation and maintenance, monitoring and evaluation. In decision-making process, men more actively participate and they attended the meeting more frequently than women. Women also participate in the project construction as well as men as unpaid labors. However, women did not get any knowledge about the schemes during the project construction or trainings. Women use the facilities more often than men but lack of general knowledge on the schemes make the women unable to do maintenance tasks. Men and women participation in monitoring and evaluation was very low because most of them were not involved in evaluation activities, besides they did not have initiative to report and discuss the solutions concerning damage or destruction of facilities. The sustainability of the project in the next five or ten years is threatened because women were not effectively involved in the project. Therefore, involving both men and women effectively in the project phases need to be emphasized and implemented in the achievement of project sustainability.

Keywords: people's participation, WSLIC II, rural water supply project.

Introduction

Access of rural communities to sanitation in Indonesia is reported 52%, however the real number might be lower since the data do not specify whether the existing sanitation facilities meet the minimum standard for sanitation, whether the facilities in good condition and being used by the communities or not (Robinson, A., 2005). Many efforts related to provision of clean drinking water and sanitation has been implemented by the Indonesian government which is supported by national and international agencies, NGOs and other institutions.

However, the performance of water supply and sanitation sector in Indonesia is lower compared to other countries in South East Asia (WHO – UNICEF, 2004 cited in proposal of National Program for Community Water Supply and Sanitation Services). A study by Sara and Katz (1997) on rural water supply sustainability in relation to project rules in some projects in some countries, reported that Indonesia has the lowest score in physical condition, operation and maintenance, consumer satisfaction, financial management and willingness to sustain the system. Some of the problems are low quality of construction that cause the decrease on water flow and lack of people knowledge to cope with destruction. Women as the

main beneficiaries prefer to use old water sources because they are not satisfy with the new water facilities. As the consequence, community particularly women do not have sense of ownership to the system which cause unwillingness to sustain the system.
The objective of this paper is to explore people's participation in rural water supply project by analyzing both men and women participation as the main water users. In this context, people participation means that involving women as well as men This paper would address the question, whether women are involved as well as men, if yes whether women exclusion or inclusion influence the sustainability of the project. This study employs five techniques in data collection namely participant observation, in depth interview, focus group discussion, recording of oral history, survey and review of secondary data.

Water and Sanitation for Low Income Communities (WSLIC) project in Jorong Kampung Baru, Nagari Gantung Ciri

WSLIC Project

WSLIC is a single sector water and sanitation project. The project is funded by World Bank and AusAid. The funds are channeled through four lines agencies. WSLIC is a government project where the Ministry of Health is primarily responsible for the project. WSLIC project is mainly concerned to the low-income communities in the rural area through community empowerment approach in decision-making process, implementation, operation and maintenance and for its sustainability.

Study Area

Jorong Kampung Baru is located in Solok District, West Sumatra. Based on the secondary data collected in 2002, there are 185 households living in this area. Educational background of the people is very poor; most of them are graduated from elementary school (84%). The majority of the people are farmers. More than half of the community (52%) is categorized as poor based on welfare classification conducted by Village Implementation Team of the project in 2002. Jorong Kampung Baru was chosen based on the proposals to the WSLIC II committee in 2002. The consideration is related to the diarrhea disease, social and economic condition of the community. In fact, water sources are available, but it is difficult to access and there was not any effort to improve water accessibility.

Water and sanitation in Jorong Kampung Baru

Water sources in Jorong Kampung Baru are available in a great amount. The water sources are spring, river, stream, unprotected well. However, the location of springs is quiet far from the settlements. They are about 2 km from the settlement. People have to walk through rocky path for collecting water. Nevertheless, the water depends on the season. The quality of water during dry season is better than in rainy season. However, the amount of water during dry season is not enough to fulfill the needs, water shortage mostly happened during this period. Moreover, most of people do not have well in their house because it is hard to find water sources although they have already dug the well. People usually fetch water from the house that has well for about 500 m to 1 km from their house. They use the water only for drinking. Other household needs such as for bathing, washing the dishes and washing clothes are done on streams that flow near their houses.

Most of the people in *Jorong* Kampung Baru do not have appropriate sanitation in their house. They usually defecate in stream or pond near their house and also from the dry agricultural lands (ladang). People are not used to defecate by using latrine. They think that it is dirty and it is not proper. The general condition of sanitation in Kampung Baru described as follows (Table 1).

Table 1. The condition of sanitation in Jorong Kampung Baru.

Sanitation Facilities	Number (household)
House holds/private	
Sewage system	0
Sanitary latrine	0
Unsanitary latrine	2
Without any facilities	159
Having trash can facilities	0
Institution	
School latrine	0
Medical centre latrine	

Source: Village Implementation Team of Jorong Kampung Baru, 2002.

Both, bad latrine and lack of clean water supply in this area has caused diseases such as diarrhea and skin disease especially during dry season. Due to lack of facilities, most of the people have experience this bad and unhealthy habits for many years.

Referring to the MPA-PHAST (2002) conducted by the Community Facilitator Team (CFT), there were two options for water source used in this project namely river and spring. Spring is chosen as the source of water considering some factors such as physical water quality, source of contaminant, capacity of water, distance from settlement, flowing system. Physical water quality is based on four indicators: smell, taste, turbidity and color. Debit of the spring is 2 lit/sec during dry season. The seasonal fluctuation is relatively constant in dry season and tends to increase in rainy season. Technical options of the project are completed with water catchments, reservoir and pressure releasing chamber.

People participation in rural water supply and sanitation project

Community participation is one of the important factors in the achievement of goals of any development activities. People participation is known as the most effective way in promoting and achieving sustainability of rural development projects, particularly in developing countries (Livingstone and McPherson, 1993).

People participation in project initiation and decision making process

WSLIC II is a development project, which applies participatory approach. All phases of the project are intended to encourage community participation. One of the facts showing the involvement of people in the project is the process of proposal formulation. Each *Jorong* was excited in preparing the proposal for the WSLIC project.

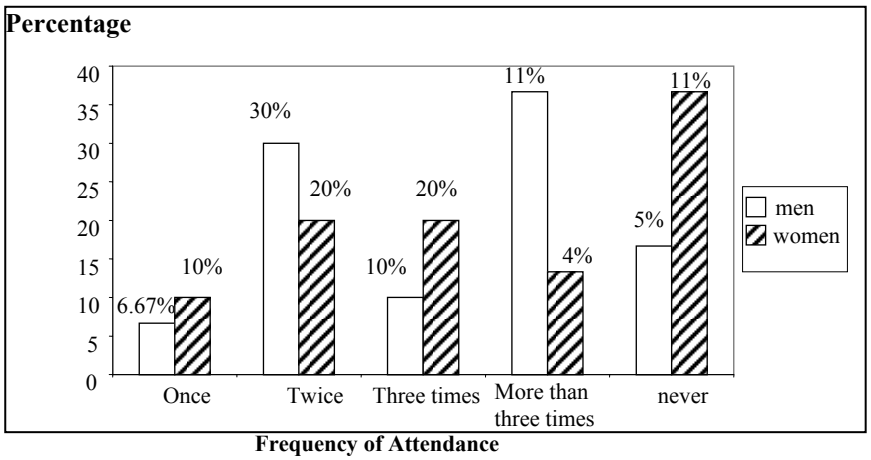

Figure 1. Frequency of People Attendance in Meeting

Socio cultural plays important roles in decision-making process. Related to its socio cultural system, the people in Kampung Baru usually discuss any problems for the improvement of their *kampung*. This activity is known as *musyawarah*. However, it is usually done by men. Women are rarely take part in *musyawarah* because the people think that women responsible only to take care children and household's activities, such as cooking, washing, cleaning the house and sometimes help their husband in *ladang* (Figure 1). The absence of women in a meeting is not merely caused by the objection of men to their involvement or hesitation and fear (Prokopy, L.S 2004). In this study, women mainly claimed that their absence from the meeting is due to their roles as wife and mother**.** Moreover, the meeting is usually held in the evening that makes women reluctant to attend the meeting.

People participation in project construction

In areas with a different gender culture, men do the works such as digging while women and children do transporting, catering or organizing other support activities (Abeywardena, 1977; Jaeger and Mattson, 1989; Mc eachem et al., 1983; NCU, 1991., cited in Wijk, 1998). A different situation is found in Kampung Baru, whose people are all Minangese. The women were not only transporting materials or other supporting activities but also digging, lifting the pipe and other jobs usually done by men (Figure 2). This is caused by *Minang's* culture where the people used to work together, known as *Gotong royong*. Moreover, women are used to do agricultural works, which help them much easier to do physical works during project construction. The flexibility of women social mobility in the context of culture have reduced, which create opportunity and chance for poor women to work out side their home to support family life. The same situation is also found by Joshi, D and B. Fawcett (2001) in donor funded and managed urban slum projects.

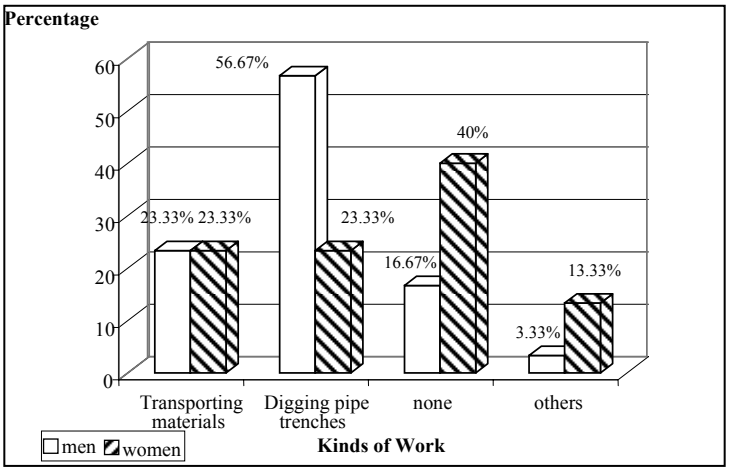

Figure 2. Project Construction Works

In the study area, men and women do not paid for their unskilled-labor, except for skilled labor that usually only one or two people from the village. During the construction works, women are used to do the unskilled works, such as lifting or transporting materials. Women do not get any new skills or knowledge related to technical aspect. If the problems occur after the project completion, the only thing women can do is asking men's help or waiting for the Village Water Committee (VWC) to fix the problem. Women should be involved in the training on technical aspects, so that they can get new skills and able to solve technical problems.

People participation in operation and maintenance

Based on the WSLIC II approach, people were fully involved in the operation and maintenance of the facilities. When the construction is completed, the operation and maintenance of the facilities were delegated to the community. For this purpose, water committee was formed at the village level. In Kampung Baru, almost all of the people including men, women and children use RWSS facilities. However, the frequency in using water facilities is quiet different; men usually use the facilities for drinking but rarely use the facilities for washing their agricultural products.

Table 2. People Involvement in the Operation and Maintenance

Responses	Men (N=30)		Women (N=30)	
	f	%	f	%
a. always	4	13.33	12	40
b. often	3	10	9	30
c. sometimes	14	46.67	4	13.33
d. rarely	9	30	5	16.67

N= Number of respondents, f = frequency

Table 2 shows the frequency of people involvement in the operation and maintenance of facilities. Women use the facilities more often than men do. The reason why people rarely use water facilities is because they have water source near their house. They feel more comfortable to use water from river than other water sources. Water facilities are only used as drinking water. The frequency in using water facilities influences the task of maintenance.

Women have more chance to do maintenance task, which is mainly to keep the area around the tap clean. The maintenance task particularly related to the damage of facilities considered as the responsibility of VWC. People report any damage or destruction to the VWC (Table 3).

Table 3. People Reaction on the Damage of Water Facilities

Responses	Men (N=30)		Women (N=30)	
	f	%	f	%
a. Try to fix it	1	3.33	0	0
b. Report to VWC	25	83.33	27	90
c. Let it and wait for the VWC	2	6.67	2	6.67
d. nothing	2	6.67	1	3.33

N= Number of respondents, f = frequency

Observing women activity in fetching water, it was found that they spend more time to fetch water because they cannot bath in the taps. Some of them are reluctant to wash their clothes at the tap stands because the location of tap stands along the roadside. Consequently, they have to collect more water to their home. People collect water from springs or well two or three times a day before water facilities were built. When the facilities have been built, the water needs increased, but the frequency of fetching water is not significantly different from before. This is because children can bath and collect water for their own needs.

People participation in monitoring and evaluation

Monitoring and evaluation activities are done to assess the functionality and sustainability of the scheme. However, community participation in the evaluation and monitoring phase is still low. This might be caused by low level of community educational background and lack of knowledge on water scheme, especially on technical aspect. The people are not able to detect facilities destruction. They cannot give any suggestion for a better condition of the RWSS facilities. Monitoring and evaluation conducted by donors are focused on the community satisfaction on water supply and sanitation facilities. However, the results show that most of the people never asked about any problems during the operation of water facilities (Table 4).

Table 4. Involvement in Monitoring and Evaluation Activities

Problem	Responses	Men (N=30)		Women (N=30)	
		f	%	f	%
Have you ever been asked by the VWC or project team concerning the constraints or problem in the operation of RWS facilities	a. yes	5	16.67	9	30
	b. no	18	60	14	46.67
	c. don't know	7	23.33	7	23.33

N= Number of respondents, f = frequency

People participation in monitoring and evaluation is influenced by the participation in three previous project's cycles: initiation and decision-making, implementation, operation and maintenance phases. The knowledge about the system can be derived from their participation in previous phases. The people will be benefited by the system and will feel that the system belongs to them if they were involved in every project phase.

People participation and project sustainability

Monitoring and evaluation of the project was held by the independent agency two years after the project accomplished. Although it is not a proper way to represent the sustainability of the project, which collected the information only at single point in time, at least it can describe the condition of water supply and sanitation facilities in the study area. Focus group discussion was applied during the monitoring process. Field visit to villager houses was also conducted to get the information related to consumer satisfaction on the scheme.

The physical condition assessment in terms of materials used during the construction shows that the facilities construction such as water catchments is in good condition. It is also protected hence water contamination can be avoided. On the other hand, the tap facilities are often damage or broken. People were not aware to repair the broken tap. The leakage of the pipe and joint seems to be a problem that should be considered although it is not yet influence the quantity of water supply to the taps.

The sustainability of water supply and sanitation project in the study area is threatened by the lack of people's awareness and general knowledge on the schemes. This is due to community participation in project phases; women were not effectively involved as well as men. Lack of ownership and responsibility on the facilities lead to the damage of the facilities. Some of the taps are no longer used by the community because they are located near the houses that have access to water source. Women have to fetch water not only for drinking but also for bathing. Women cannot bath freely in the taps because the taps are located along the roadside. Most of the people do not use public latrine facilities anymore. They feel more comfortable to defecate in the streams or in the river. It is estimated that 3% of the poor, 14% of the middle and 9% of the rich family who has built sanitation facilities.

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From the Ground Up: The Water, Agroforestry, Nutrition and Development (WAND) Approach to Water Quality Conservation in Mindanao, the Philippines

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Abstract
The paper presents an approach called WAND or water, agroforestry, nutrition and development which provides a multi-pronged approach towards water quality conservation and poverty alleviation in Mindanao. Our contention is that water quality conservation is directly linked with poverty alleviation. From an initial area of 2 barrios in 2003 the initiative has grown to cover 26 barrios in 3 provinces. The latest inclusion is ecological sanitation that closes the loop between agricultural production and food consumption, prevent contamination of water sources and prevent the spread of diseases. The wand approach is effective and replicable in most rural areas in the Philippines because a) it provides a menu of solutions to various farmers' felt needs and problems rather than proposing single solutions, stakeholder mobilization and linkages is strong and we collaborate and cooperate rather than trying to work alone; b) self-propelling local organizations are established to sustain the process. These grassroots organizations are federated in order to provide a single platform for policy and advocacy works; c) agro-reforestation is advanced as a viable way to improve water sources at the same time providing precious food, fodder, incomes and various resources to farmers. This is deemed important in view of the burgeoning population and lack of land resources.

Keywords: ecological sanitation, sustainable farming, multi-pronged approach

Introduction
The WAND Foundation (formerly LEF, Inc) started as a localized initiative implemented in 2003 in 2 barrios in Mindanao aptly enough with water, agroforestry, nutrition and development (wand) components. In 2004 we won in the World Bank-initiated Philippine Development Marketplace competition and since then, several donors have funded its expansion to cover 26 barrios in 3 provinces in Mindanao in about 4 years time. One inclusion in 2007 is the integration of human excreta management by implementing ecosan and using human waste as fertilizer thereby closing the loop between food production and consumption and lessening disease incidence and groundwater contamination. This won us another award in the recent Philippine Development Marketplace sponsored by the World Bank in April 2008.

The context of our effort is Mindanao, in southern Philippines which is a region suffering from poor infrastructure, high poverty incidence, and violence that have claimed the lives of more than 120,000 in the last three decades. The violence and rebellion are derived from unfulfilled hopes of peace and economic prosperity after the 1986 restoration of democracy. In the project areas before the project started socio-economic exclusion and poverty is prevalent, availability of potable water difficult, most of watershed areas remain denuded, ill-health and general malice characterizes the population. The government is unable to deliver

the much needed services especially in the agricultural sector where it is most needed because of the gargantuan budget deficit, insurmountable foreign debt servicing, corruption and overburdened bureaucracy. The rural areas remain stagnant with very few viable enterprises operating and farmers producing primary crops being subjected to pricing dictated by middlemen. This project is slowly reversing the difficult scenario by the implementation of potable water system, developing sustainable small farms by integrating vegetable gardening, small and large animals and planting fruit and timber trees, forming functional rural associations and improving the position of women in the community. Our overall objective is, "to uplift the socioeconomic situation of resource poor marginal farming families so that they will be able to live more humane and dignified lives and fully participate in the life of the community".

Discussion of project components and methodologies

The project is implementing a multi-pronged approach consisting of the following:

a. Installation of community-managed gravity-fed water system. The water system is series of catchments emanating from the source and connected to the population center by sanitary polyethylene pipes. The water systems are managed by the barrio association.

b. Community education through barefoot extension agents. The agents are trained volunteers from among the members of the community and act as resource person in their community.

c. Community-based nursery and communal tree planting of watersheds and eroded hillsides. The local associations are mobilized to plant and care for their planted area. Most important ASEAN fruit and tree species are raised and planted to enrich and maintain local biodiversity.

d. Promotion of vegetable gardening to combat malnutrition and improve incomes.

e. Large and small animals are released to farmers to improve their farming system and lessen the burden in the field. The small animal is also a ready source of protein and income.

f. Organizing associations to sustain and manage the initiative. Organizing local associations follow a 3-stage iterative process of formation, strengthening and organizational consolidation.

g. Incorporating gender and development in the whole process and nurturing women leaders.

Our outputs so far include the following:

1. Installation of 5 gravity-fed potable water systems in 5 barrios in Misamis Oriental.

2. Establishment of 39 unit ecological sanitation toilets to control contamination of groundwater and waterways and using the processed human excreta as fertilizer for the seedling nurseries.

3. Establishment of 3 central nurseries to produce high-quality seedlings and planting materials. The nurseries are able to produce an average of 20,000 seedlings per year and the planting of 75,000 fruit and timber trees in 200 hectares watershed areas using ASEAN's most important species (Durio zibethenus, Mangifera indica, Lansium domesticum, etc).

5. Promoting agro-reforestation and vegetable gardening among a total of 2,500 beneficiaries. The agro-reforestation integrates cash crops, trees and farm animals in a given area of land.

6. Training and deployment of 175 progressive local farmers as barefoot technicians and extension agents able to train other farmers and share on the material inputs.

7. Organizing and strengthening of 23 local associations and neighborhood groupings able to manage their own activities and sustain the process through participatory planning and implementation and organizing and building the capacity of a farmers' federation.

The success factors of the project include the following:

1. Rather than providing ready made solutions to peoples' felt-needs, the project provided a menu of inputs involving water, farming development, nutrition and health for them to select depending on their needs, capabilities, personal choice, budget and the condition of their farms. I posit that efforts at water quality conservation will not be successful if the approach is singular and not integrated and divorced from the needs of local, resource-poor farmers. One example of this is the massive drive of a government agency for people to plant trees in the watershed areas to help ensure that water sources is protected. The problem is that people do not participate because their need is more on food and cash crop and they do not see any value to planting timber trees such as Gmelina arborea.

2. The participation and collaboration of stakeholders involving local governments, line agencies, business, youth and religious ensure that support is generated at various levels. Our experience shows that there is a need for each of the stakeholder to know fully well their roles and responsibilities before they will participate fully.

3. Eco-sanitation provides ready and cheap fertilizer for farmers at the same time containing the spread of diseases carried by wayward excreta. It also weaned farmers from the dependence on chemical fertilizer and generates much needed savings. However one problem that we are encountering in the promotion of eco-sanitation is local people's natural abhorrence to human excreta.

4. The promotion of ASEAN's most important species such as durian, lanzones and rambutan help ensure that this specie will not be lost forever and instead will help improve biodiversity as well as improve incomes of farmers. In our experience in the field, we found out that they plant trees only if they find that this will provide them with clear source of income in the future.

5. The creation of community farmers' groupings and a federation help ensure localization and sustainability of the practices and integrate it into the cultural fabric of the community. The current practice by local extension agents is to train individual farmers (early adopters) hoping for a multiplier effect. In the case of our project, we focus more on building the capacity of local groups and start intervention from these groups then expand to nearby villages as the groups become more able to manage their own affairs.

Cross-cutting Themes

a. Gender and Social Inclusion
The subject and object of the project are the near-landless and small farmers in the area. The theme is 'development with equity.' The rule of thumb in community organizing is that at least 50% of the leaders in the barrio associations are women.

b. Leadership and Community Empowerment
In 2007 we started in-depth organizational development activities and consolidation of the local associations organized in the area. Toward this end, some of the farmer-leaders felt that it is high time to create an umbrella federation that will govern all the rest of the clusters/association created for ease in communication and management. Thus for this year the "Nakasama Na" or Nagkahiusang Kapunongan sa mga Mag-uuma nga Nagtikad sa West Misamis Oriental (Federation of Small Farmer Tillers in West Misamis Oriental)was born. The federation is composed of 23 clusters/neighborhood associations.

c. Promotion of biodiversity and watershed amelioration to improve the integrity of water sources
Our agroforestry focus is in promoting ASEAN's most important trees such as rambutan (Nephelium lappaceum), mangosteen (Garcinia mangostana), lanzones (Lansium domesticum), santol (Sandoricum koetjape), tamarind (Tamarindus indica), mango (Mangifera indica) and noni (Morinda citrifolia) for their high valued food and medicinal source. Promotion involve production and dissemination of a popular community-based nursery and tree planting manual, tree planting and small-scale wood processing to generate economic value and market out of planted fast-growing trees. The problem we try to solve is in the fact that seedlings are not readily available and farmers have to source seedlings from far places and not so well known quality and origin. Also seed collection for seedling production does not discriminate what type of trees to use and therefore quality suffers much.

The practices that we promote include; a) use of high-quality seeds and planting materials in tree planting resulting to high quality and production of trees with good genetic quality, b) improvement of knowledge in the control of pest and diseases in the nursery resulting to good quality seedlings, c) proper management of the nurseries (regulated lighting, supply of water, etc)., d) proper field planting techniques (spacing, holing, fertilizing, pest and disease control, etc), e) improved knowledge in wood processing resulting to low wastage and high economic value of processed wood, f) increased appreciation of the economics of tree planting and the management of fruit and timber. The following topical areas were covered in the education activities; assisted natural regeneration; timber stand improvement, small-scale plantation management, sloping land techniques, biodiversity management. Small scale wood processing is covered because there is a dearth in knowledge on the proper use of wood especially coming from small-scale plantation resulting to economic losses and wastage of scarce resource.

Currently we are establishing a "living museum" wherein forest and upland resource of mostly Higaonon and Subanen Indigenous People will serve as the main resource and indexing, propagating and marketing seedlings of ASEAN's most important trees in Mindanao. The concept of the living museum is different from the traditional herbarium, enclosed type but will feature not only the forest resource but also their living culture and way of life. A 6-hectare land area is being used for this initiative. We are starting to look at how

we are able to produce and market products from plants for the local market and later on to seek commercial partners from outside. For example banaba (Lagerstroemia speciosa) grows wild in the area and is said to be high in corosolic acid which is a natural plant insulin and useful in lowering blood sugar. Cough remedies coming from plants are already marketed locally with some success. Treatment of intestinal parasites of farm animals using leaves of local plants are also being done.

Project Results

Table 1. Ecological Sanitation and using processed 'ecosan products' as fertilizer.

Province	Ecosan unit implemented per province	No. of people served	Crops grown and fertilized with ecosan products	Estimated average income increase per year per farmer	Estimated savings in liters water per year compared to 'flush-type' toilet (ave. 6 liters/flush x 1 visit/day)
Misamis Oriental	19	1,260	Vegetables, bananas, seedlings, tree farms, corn	34,000 pesos	2,795,400
Lanao del Norte	4	400	Vegetables, tree parks	Un-computed; newly implemented	876,000
Zamboanga del Norte	16	1,700	Vegetables, banana, fruit and timber seedlings, tree farms	22,000 pesos	3,723,000
Total	39	3,360			7,304,400

Note: Our total investment to date for ecosan toilet establishment is Pesos 1,750,000, one ecosan double vault toilet costing around Pesos 35,000.
Additional benefits in promoting ecological sanitation include;

a. Less pollution of groundwater and waterways as a result of no longer flushing human excreta down to septic tanks.
b. Production of compost/organic matter annually estimated at 35 kilograms per ecosan user x 3,360 users = 117,600 kilograms. This compost when used to plants will increase the plants tolerance to water stress and is essential for nutrient utilization.
c. Less spread of diseases as a result of open defecation.

I don't have empirical data yet for letters a and b and this will be subject to further research.

Small water system establishment
The water system in Barrio Gimaylan is impounded using deep well pump and it is operational already since 2006. The system is being managed by a water committee with LEF as the advisor. During this period, the water system broke down 2 times but was immediately repaired and running again with the repairs shouldered out of the monthly user fees collected.

The system is indeed a big boost to the 120 inhabitants in the area who are dependent upon the Gimaylan Creek for their water needs. With the water system, incidence of diarrhea especially among children was drastically reduced because using the water in the Gimaylan creek is shared with the many animals, people and waste upstream. People also do not need any longer to negotiate steep slopes in order to get water from the creek and carry it upwards to their houses.

Three other water systems were established in 2007, one in Dipolog City and another in barrio Pagawan, municipality of Manticao, Misamis Oriental and in Balintad, Manticao, Misamis Oriental. The water system in Dipolog consists of a concrete catch basin and a deep well. Water is impounded using a portable pump. The water system serves 15 families in the area as well as it is the main source of water for the seedling nursery. The water system in Pagawan is gravity-type with water drawn from a natural aquifer. The main source is connected by polyethylene piping and it is serving a total of 200 families. Incidence of diarrhea has been drastically reduced because the local inhabitants no longer get water from rain pools and mud holes. The water system in Balintad is also gravity-type and serves 75 households. A spring source is where the water is taken and stored in a reservoir.

Draft Animal Loan

The draft animal continues to provide the centerpiece asset that the farmer can have. Our draft animal dispersal system tried and tested for over 4 years now from animal procurement, release, care and management and repayment collection/passing-on is one of the most successful program in the country today with most draft animal dispersal program especially that of the government ending-up as failures, with the ingredient of community organizing and empowerment lacking in substance. Aside from the organized communities we continue to provide technical assistance to ensure that the animals are well taken-care of and that pass-on is ensured.

A total of 202 draft animals have been released to 200 beneficiaries adding to the 44 released in 2006-2007 with a total 246 animals in all. Fifteen offspring has been realized already but there were 3 mortalities recorded

Table 2. Result of the draft animal loan component

Aspect	Result	Peso value
No. of animals released	246 large animals released to 244 small farming families	3,567,000
Average income in being able to farm on time and to improve overall farming efficiency	244 farmers x ave. of 12,000 pesos increase per year	2,928,000
Increase in income as a result of being hired in other farms, average of 40 man-animals days per farmer for the entire	Pesos 150 per day x 244 farmers x ave. 15 days per year	549,000
Total economic value		7,044,000

Note: Our investment to date in this component is Pesos 4,500,000

Other un-computed incomes by farmers will include, income realized from offspring, increase in animal marketability as a result of increase in weight and income in farming efficiency as the farmer now is able to cultivate his farm on time and in an efficient manner (compared to when he has no draft animal).

Challenges of the Project

The challenges of the project include the following;

a. Lack of government support and weak barrio government units. Municipal and barangay governments have very little resources to support development interventions in the rural areas. Added to this is the problem with weak planning and corruption.
b. Peace and order problem especially in the interior areas and massive evacuation results to loss of lives and livelihood.
c. People's slow acceptance of human excreta as organic fertilizer especially for home gardens.
d. Very poor soil condition takes so long to nurse back meanwhile people have to use it to grow food. This problem is coupled with the burgeoning population, loss of biodiversity and soil erosion.

Conclusion

Our approach towards water quality conservation, i.e. watershed rehabilitation, protection of upland water sources and ecological sanitation to prevent groundwater contamination maybe different from other approaches and thus highly successful in the sense that;

a) We do not provide single solutions rather we provide a menu within the ambit of water, agro-reforestation (crop-tree-animal integration), nutrition and building self-propelling organizations of which local farmers can chose from. This is far more superior with the realization that felt needs of farmers are varied and that they participate only when they felt that there is something in it for them.

b) We promote ASEAN's most important trees in the protection of the watersheds and water sources and this approach creates a lot of interest among local and international supporters as these trees are neglected but have the potential to improve incomes at the same time improving our watersheds.

c) We work closely with a multitude of stakeholders and not limit only to a few. We realize that more hands and heads are indeed better. Importantly, we work in close coordination with local government units in the areas fully realizing that they have much to share in terms of policy and technical support. Other players in the NGO community sometimes bypass LGU collaboration in order to remain "pure."

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The Most Polluted River in Japan: Ayasegawa River
~Campaign Breaking the Worst One~

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Abstract
Ayasegawa River was the most polluted river in Japan. Fig.1 shows "the ranking of the polluted river in Japan" which is disclosed by Japan Government every year. It shows that Ayasegawa River records 19 times continuously, total 25 times the worst from 1972. How ashamed result is it! Government and the local gave up the improvement, and they recognized the status. But we realized that they did the best for the improvement of the river very hard when we started the research in our campaign. For example, government and prefecture have planed distribution plans 10 years ago and have constructed the direct purification plant. NPOs have also done the grassroots actions individually to change the river to a clean and clear one. We, Water forum which connects Tokyo Bay to Arakawa, Tonegawa and Tamagawa River, had no information about Ayasegawa River at that time. We knew the river recorded the worst polluted river in Japan, but we believed the responsibility in the government and the local. Saitama prefecture raised the big campaign, "Breaking the most polluted river in Japan: Ayasegawa River" in 2005. Our NPO also agreed to the campaign. We campaigned with the basin NPO together widely. This report is the review of the big campaign.

Keywords: the largest improvement river in Japan

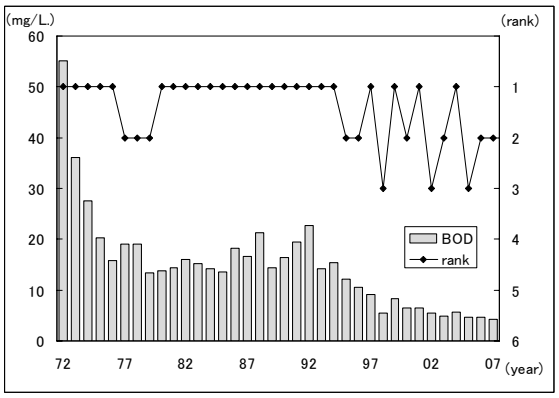

Figure 1. The ranking of the polluted river in Japan.

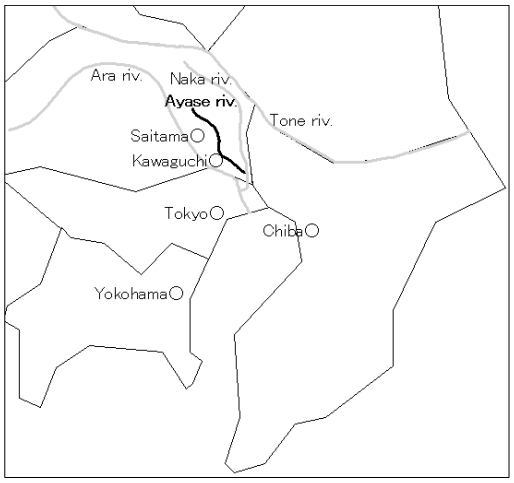

Figure 2. The map of the Tokyo metropolitan area in Japan.

Overview of Ayasegawa River

Location
Fig.2 shows the Tokyo metropolitan area in Japan. Tokyo Bay is located on the south, and Tonegawa River and Arakawa River are located on the east, on the west, respectively. Ayasegawa River is located in the middle. The river originates independently. The upper side of the river is used as agricultural irrigation canal. The middle and downstream are used as agricultural and storm drainage systems. The river is main role to accept the domestic

wastewater in the resent years. It accepts the domestic wastewater and drainage, and reaches the Tokyo bay through Arakawa River. The area of the river basin is 178 km2, the population of the basin is 1.25 million, and the length is about 47 km.

Features

The flood control project of rivers began 400 years ago in modern Japan. Ayasegawa River had abundant water supply, and was the booming shipping and fishing industries before because it connected Tonegawa and Arakawa rivers. Rice farming was the most important in the modern Japan's agriculture, so people ensured that water was the highest priority. Ayasegawa River was used for the agricultural irrigation and drainage systems. The river was loved and developed by basin. However, with an increase in the population of capital Tokyo, has also increased the population around Ayasegawa River. Fig.3 shows the change of the population. The rapid increase in population has changed the condition of Ayasegawa River. Naturally, the river has received wastewater from houses and factories. The receipt of the wastewater has brought the river to the most polluted river.

Cause of the most polluted river in Japan

Whenever people live, people must be the release of wastewater from houses and factories. River pollution is inevitable. In the case of Ayasegawa River, is it the same reason? As described in Fig.4, the wastewater from houses, from industries, and agricultures are almost 73%, 18%, and 5%, respectively. About three quarters of wastewater come from houses. Classified the wastewater from houses in detail, we can find that it consists 40% from kitchens, 30% of toilets, 20% from bathrooms, and 10% from close washers.

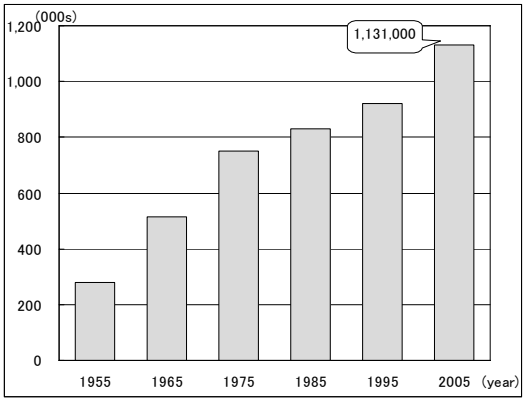

Figure 3. Population growth around the basin for 50 years.

Activities required

We recognized that the biggest factor of the river pollution came from the wastewater from houses through our research. We are convinced that the around Ayasegawa River had to realize the fact, recognize their own responsibility, and take measures.

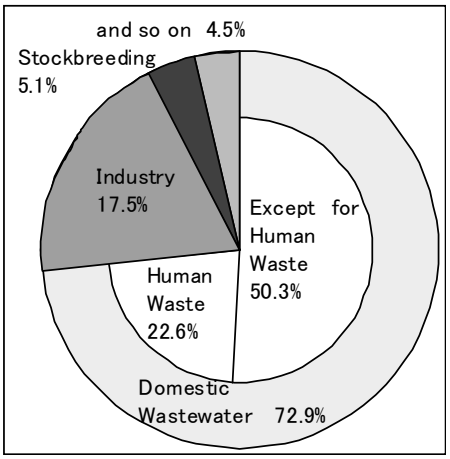

Figure 4. Factors of BOD in Ayasegawa

Objective of our campaign

Our campaign is very simple. It is an activity of the domestic wastewater by residents. Improvement of manner for draining the domestic wastewater is expected obviously. People must drain the wastewater when they live. The worst thing is to drain the wastewater without treatment. We call it, "Tarenagashi" in Japanese. How is your family? Can you permit that the polluted water is drained without any treatment? No one can clean up. As you recognize, you have to use the water after some treatment. Water is circulating around the world, and into the space. Our campaign, "Campaign breaking the most polluted river in Japan", means a domestic wastewater measures and improvement of manner for draining the domestic wastewater. In other word, it is consciousness by the residents. This is our mission and duty.

Activities of our campaign
The following is our various activities breaking the most polluted river in Japan.

Activities by government and prefecture
1) Removal of the polluted sediments
Large amount of polluted sediments deposits in river. The rivers which have ability of self control system, for example, with large amount of Dissolved Oxygen (DO) can decompose the sediments, but in the rivers in urban areas the sediments deposit. The deposited sediments must be removed by a mechanical way like mobile cranes.

2) Purification plant
Water from the river is sent to the plant directly, and returned after purification. 2 plants by the Government and 8 plants by the prefecture exist through the Ayasegawa River.

3) Securing water
Main industry in this area is farming, so the required water volume of the river theoretically reduces to 0 in winter. To compensate it, some amount of water is supplied. Now the government decides 1.8m3/s of water supply to Ayasegawa River. The prefecture decides 0.5m3/s of water supply. In the near future, the amount will be increased.

Drainage measures and treatment of effluents
Drainage measures in Japan are introduced here. As I mentioned before, 73% of the reason was the domestic wastewater. The following is the drainage measures in Japan. It consists of 75% of public swage treatment, 10% of *Johkaso* treatment which is on site treatment, and 15% of non-treatment. According to the government instruction, the public swage treatment is done by the prefectures. Large scale of treatment plants is constructed in urban areas, the drainage pipes are connected with the public pipes, and the wastewater is collected. Most treatment plants are adopted activated sludge process. *Johkaso* treatment is mainly used in the suburbs, and every house has a small plants. Ability of treatment is improved to 6~10 mg/L of BOD. Additional and advanced investment for the treatment causes the availability of use for factory and farming.

Activities of NPO
Basic part of the campaign was done by NPO. And main purpose was improvement of manner for draining the domestic wastewater and of consciousness by the residents. The following is some examples of our activities.

1) Clean up campaign
We call it "Gomihiroi" in Japanese. It is held all over Japan. Some groups are doing their action every day, every week, every month and once a year. Wastes must be divided into 4 types in Japan. The waste is divided by the type to be re-used and recycled. The divided wastes which the NPO gathered are packed and sent each other by the government. Children can attend this campaign with observation of nature. They can observe changes of the plants and the bird watching. They also can analyze the quality of water through the campaign. We sometimes prepare a short game in it.

2) Research of water quality in the river
It is very important to analyze the water quality of the river and assess the environment. Scientific data is acceptable for any people. It is also important to compare with the past such as 1 year, 5 years and 10 years ago. Each NPO can adopt the research methods and items like COD, NH4, PO4, NO2 and NO3. But it is difficult to analyze BOD, so we ask for analyzing it to the professional organization if necessary. We also can analyze transparency, flow rate of the stream, temperature, smell and color of the water. Our analysis technique is not so specialized, but it is

very meaningful to measure as a perspective of the residents frequently. Finally we discuss the measures with the government together using the collected data.

3) Education about the environment
The education system is studied in primary schools and junior high schools. Japanese schools have some curriculum of social issues, and students of each grade study various levels of the social issues. NPO can support the lessons regarding the environment, river and water. The students can study by the documents and pictures of our activities in their classroom. They sometimes can experience analysis of water quality. They discuss the reason for pollution of the river each other and the better way to recover the river.

They sometimes have open-air lessons. The lessons take more 2 hours. We take the students to the river, and they smell, observe the color of water, clean around the river and watch many plants, fish and birds. They realize the dirty and polluted river by themselves.

The students usually talk to their family at home about the lessons they learned. Their family talks to their neighbors and friends. The information is spread automatically. We are looking forward to seeing the reports or essays written by the students.

Activity using check sheet
We also start an action using a check sheet not to pollute the river. The residents check their lifestyles by 10 items. The items are the following.

1. Use any filters at the drainage area of kitchens and baths.
2. Not to cook the excess amount of meals, and not to throw leftovers into the drain of kitchen.
3. Manage to consume all the vegetable oil for fryer, and adsorb on the papers or waste cloths.
4. Wash the dishes with oily food using acrylic wash sponge.
5. Use the washing water of rice to feed for plants and the others.
6. Wash cloths as much as you can, and use adequate amount of detergents.
7. Use the soap which is good for the environment in laundry, car wash and so on.
8. Drain to the public treatment system, or maintain and clean up the *Johkaso* regularly.
9. Clean up the river and drain paths and attend the clean up campaign voluntary.
10. Attend the seminars regarding any environment issues.

It may be difficult to agree with some items for people outside Japan. But these are very useful items and familiar in Japan. Few people can do the right actions against all items from the beginning, but it is a useful action to realize by them. This action has not been done by only NPO. Cooperation with city administration is necessary. The action needs huge effort because we ask for any assistance of many city organizations. Action once is not effective very well, so it should be repeated 3 times and 5 times. People experienced the check sheet 3 times can success more than 80 %. Therefore continuous action is the most important.

Nonuse of detergent
An Acryl wash sponge is enough to wash dishes without detergent. We distributed the wash sponges to the basin residents. It is a handmaid sponge by NPO members. The detergent is one of the main reasons for deterioration of water quality. Do not use it as possible. Use of the acryl wash sponge is effective.

Recommendation of tidy (garbage in the kitchen sink)
It is important not to throw out the solid waste from kitchen as possible. We also distributed a tidy. The solid waste can be removed from the domestic wastewater by the tidy. These continuous and steady actions were base of our campaign.

Collaboration with the government
NPO's actions are only inside the community even if we do the best. On the other hand, the government's action also has various limitations. The most important thing is that NPO and the government realize by themselves what we can do or not, and collaborate together. The residents trust and cooperate with the collaboration after ripening relations. But it is difficult to have a good relation from the beginning. This is the result of continuous efforts.

Effect of our campaign

Collaboration among NPOs, the government and the private companies
Each NPO has been campaigned separately for a long time. They had a limitation of their action area and action issues. We also have known that Ayasegawa River was the most polluted river in Japan, but NPOs did not any collaboration and cooperation. Saitama prefecture asked for the policy of the campaign to NPOs in 2006. Only 5 NPOs attend the campaign at first. After that each NPO cooperated together, asked for other NPOs to join. Now more than 40 parties attend. Clean up campaign is sometimes done by one NPO, and sometimes by many NPOs. Non NGO members such as the government and residents become to attend frequently. This change means the progress of our campaign. Our NPO is also encouraged.

The system of governmental administration is not so simple. Ayasegawa River is not so long river (64 km), and the downstream 10 km is administrated by capital Tokyo, the upstream 40 km is administrated by Saitama Prefecture, and the middle 15 km is administrated by the national government. It has 60 branch rivers. Each river is administrated by 13 cities. No controlled systems between these organizations existed, so the actions are decided individually, and the government noticed that this situation was worse, but less effort for improvement was tried. Recently the improvement among the governments is progressing, and collaboration with the residents is also tried.

Collaboration with the private companies is also progressing. They release large amount of effluent and some chemical compounds. In 2007, 40 companies support economically. The basin companies also hope to have a good relationship with the basin residents, and to make the river clean. They cooperate with NPOs and educate in their office. We, NPO, visit the companies, tell them to thank and report our campaign. This causes a good relation and collaboration.

Clean up campaign is one of the most familiar activities for the NPO. The action is introduced above. This action did not go well without collaboration with the government and NPO, but most case goes well. The volume of the waste is gradually decreasing. The people who throw away the waste is decreasing, because the active NPO becomes to increase. Clean up campaign is quite simple. Clean up campaign means that picking up the waste thrown by others, so people feel bad. But the mind of picking up the waste, not throwing away the waste and willing to clear a river is the same as the mind of loving the water. And this is the origin of heartwarming communication.

Campaign of cooperation with school becomes more active. The campaign is held from 50 to 100 times a year around Ayasegawa River. Many NPOs support each other depending on the issues and themes.

Collaboration among NPO, the government and the private companies is really progressing. The residents do not believe and cooperate without the collaboration. We convinced that the campaign becomes powerful, and becomes to have fruitful results, because the collaboration is going well, and the residents believe and feel how the collaboration runs.

Media becomes to cooperate. Sometimes a newspaper reports our activity. NHK (National broadcast) often broadcasts from last year. The media which broadcasts by many images is very effective. The program titled as, "Ayasegawa River; the most improved quality of water in Japan", broadcast through the country on 18th July 2008.

Fig.5 shows the comparison of water quality between the past 20 years and 2007 fiscal year.

Promotion of many challenges by the governmental organization and continuous, daily campaigns by NPOs are leading to the successful results.

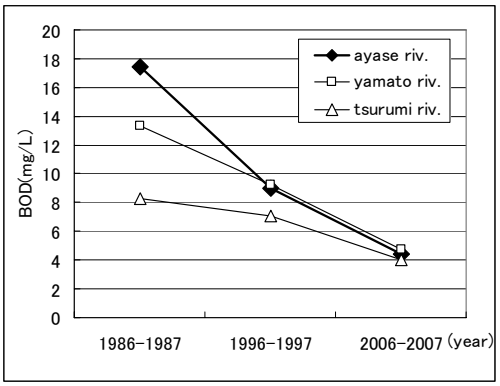

Figure 5. Improvement of BOD among worst 3 rivers in Japan.

Conclusion

We were surprised that Ayasegawa River got status of the most polluted river in Japan. It lasted for 15 years and 19 times. We appreciate and thank that the government made a decision of starting "Campaign breaking the most polluted river in Japan". The greatest finding in the campaign is that the drainage treatment of domestic wastewater occupied 79 % in the wastewater would be the most effective. Besides, we decided that main activity in the campaign should be an improvement for manner of domestic wastewater. We convinced that the decision is right.

The residents attending the campaign really recognized useful. As a result, Ayasegawa River jumped up from the worst position and got an honor of the largest improvement river in Japan (against 10 years ago, 20 years ago).

Progress in collaboration among the government, the prefecture, cities and NPOs will be a great driving force around the issue.

Saitama prefecture decides that they really try to improve a maintenance level of Johkaso. It is a wonderful decision. The decision leads the residents to cooperate.

We had a confidence our activity because our responsible campaign gave a great result. Finally, tightening network of the residents and formation of the manner are also another effect.

What we have been pursuing for 15 years is that Ayasegawa River becomes the cleanest and clearest river in Japan. The aim has been fulfilling as expected.

Acknowledgment

The authors acknowledge Ministry of Land, Infrastructure, Transport and Tourism, Kanto Regional Development Bureau, and Water Environment Division, Department of Environment, Saitama Prefecture for providing the data in the paper.

Local Initiatives in Water Quality Management Programs in the Philippines: Policy Issues and Challenges

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Abstract
The future quality of water is one of the most pressing environmental problems in most Asian developing countries, like Philippines. With urbanization, water governance has to cope with increasing demands for steady supply and access to potable water, both for the immediate and long term. National institutions usually manage water supply/quality and sanitation. However, local governments still lack the ability to ensure efficient and sustained delivery of basic water services. Thus, some institutional development interventions among local governments were initiated to monitor, improve and sustain water quality and conservation for domestic, industrial, agricultural and other uses. Strengthening the local government's mechanism is important for integrating efforts, coordinating and managing integrated water resources and related water operations in the area and driving the different sectors involved to treat water resource in an integrated manner. Such initiatives hopes to shift from fragmented to integrated local water agenda and action, to be catalyzed by an integrated management scheme at the local government level. Specific targets for capacity-building are the strategic planning and development of the local government and the public utilities sector that manages the water treatment facility. This paper presents case studies on water quality management programs and intervention reforms for sustainability.

Keywords: index of drinking water adequacy, local initiatives, water environment, water quality management programs

Introduction
In response to the growing problem in water quality, the Philippine government enacted the Clean Water Act (CWA) in 2004 and its Implementing Rules and Regulations (IRR) the year after. Praised for its innovations in water quality management, the Act and its IRR require integrated approach, stronger collaboration among stakeholders, and promotion of co-ownership of the water bodies. From 2001 to present, the Department of Environment and Natural Resources-Environmental Management Bureau (DENR-EMB) through its regional offices have monitored 238 water bodies either for classification or for regular water quality monitoring. Depending on the regions' resources, monitoring for these water bodies is done monthly or quarterly. In ADB's publication "Asian Water Development Outlook 2007" or AWDO 2007, the ADB warned that water availability in the Philippines could be "unsatisfactory" in eight of its 19 major river basins and in most major cities before 2025 (ADB, 2007). The ability of groundwater to meet future water demand has been projected to be limited, amounting to only 20 percent of the total water requirement in the country's nine main urban centers by 2025. This development review study is focused on qualitative data, through interviews and observations, and quantitative data, where cause and effect is sought

to produce generalizations on policy issues and challenges. Some case studies on local governance initiatives on water quality management program (WQMP) and intervention reforms, as well as best practices and lessons learned on WQMP are presented and discussed in the succeeding sections.

Water Quality Management Programs (WQMP)

Philippine water quality is assessed based on the set beneficial use as defined in the DENR Administrative Order (DAO) 34, Series of 1990. Under this DAO, there are 33 parameters that define the desired water quality per water body classification. Accordingly, a water body must meet all the criteria of each applicable parameter 100 percent of the time to maintain its designated classification. In the absence of a water quality index, an interim methodology based on compliance to DAO 90-34 water quality criteria is used for all surface waters. Parameters monitored include: (a) dissolved oxygen (DO), biochemical oxygen demand (BOD), total suspended solids (TSS), total dissolved solids (TDS), and heavy metals for inland surface waters; (b) fecal coliform, nitrates, and salinity (chloride content) for groundwater as defined in the Philippine National Standards for Drinking Water; (c) DO, coliform, and heavy metals for coastal and marine waters; and (d) biological parameters such as phytoplankton, zooplankton, and benthos were monitored in selected water bodies. On legal and policy aspects on water quality management, the Philippines has an extensive water and water-related legislation and regulations that provide the legal bases for programs on water quality management. From 2001 to 2005, one major legislation on water quality management was passed. This was RA 9275, otherwise known as the Philippine Clean Water Act (CWA) and signed into law on March 22, 2004. Water quality management in the Philippines is spearheaded by the EMB of DENR. In support to the DENR's mandate, other government agencies, financing institutions, and donor agencies have also implemented programs and activities on water quality management. The Philippines is a recipient of official development assistance for water quality management. Its main donors are: the government of Japan through the JICA and JBIC, ADB, USAID, United Nations system, and the WB. Grants have been provided by bilateral agencies as environmental assistance, while loans to finance investments in environment projects have been provided by ADB, JBIC, and WB.

Best Practices and Lessons Learned in WQMP

This section presents best practices and lessons learned in water quality management, including waste minimization efforts that could be adopted by others. This process will not only give credit to those "good performers", but will also allow others to duplicate the documented "best practice in water quality management." In addition, this section showcases efforts of government agencies, private sectors, business or industry associations, LGUs, civil society, communities, academes and others (Fruh,2003).

River Water Quality Management - Initiated as part of the USAID project on Sustainable Agriculture and Natural Resources Management, the Philippine Water Watch (PWW) capacitated local farmers in understanding and performing water quality monitoring that was focused on drinking water quality and its impact to public health (World Bank, 2003). Moreover, local farmers developed the capacity to address problems on bacterial contamination, soil erosion, and sedimentation. A successful technology transfer was demonstrated through exchanges in technology adoption. For instance, after the PWW volunteers used the *Easygel* rapid method for *E. coli* testing, it was adopted by the AWW. In

the same manner, methods for TSS and stream discharge sampling that were initially used in the Philippines. The PWW program resulted to the formation of three active groups in Mindanao and Bohol. Together, they have collected thousands of stream water samples. This multi-year information documents a clear gradient of declining water quality across four sub-watersheds of the *Manupali* River, which is related to human population, deforestation, and agricultural development. Drinking water supplies have been identified as contaminated, and public health risks have been minimized through remediation. PWW volunteers have been active in educating their neighbors in water issues by giving presentations at village meetings and in schools. The pioneering effort of the PWW has attracted local and national attention, with great potential to impact water policy. The data and the process of community-based water quality monitoring have been incorporated into the Natural Resource Management Plan of the Municipality of Lantapan, Bukidnon. The local government of the Province of Sarangani initiated a similar water quality monitoring program in their region. Moreover, the PWW data were used by the Philippine Institute for Development Studies to advise Congress on the value of community-based water monitoring during the formulation of the CWA.

Lake Water Quality Management - Laguna Lake is one of Southeast Asia's largest inland water bodies. Since its establishment in 1966 through RA 4850, the LLDA has been protecting and preserving the quality of the Lake as well as the 21 river systems that flow into it. The holistic and integrated approach that LLDA is implementing not only reduces pollution draining into the lake and improves lake water quality but also becomes the benchmark in water quality management. Some of the best practices that LLDA carries out include: (a) *Controlling point source of pollution through the EUFS* – A market-based instrument that encourages companies to invest in and operate pollution prevention/abatement systems within their establishment. Applying the "Polluter Pay Principle", the system provides direct accountability for damage inflicted to the Lake. Since the implementation of EUFS in 1997, the LLDA observed decreasing annual BOD loadings from 5,402 MT in 1997 to 193 MT in 2004 (Figure 21) generated by 222 firms; (b) *Cleaning up river system by creating additional livelihood* – Tagged as 'Environmental Army", this group convenes monthly to haul out wastes from various rivers in the Lake's basin. Once biodegradable river wastes are collected, these are fed into drum kilns, until they are carbonized and later pulverized. The carbon particles are then mixed with a binder and pressed into their final shape and form. After which, these are dried, packed, and sold for PhP15/pack of 25 pieces. The briquette-shaped charcoal is more solid and slower to burn than the flake-shaped charcoal being sold commercially. It provides livelihood to poor fisherfolk and creates opportunities for small business enterprises around the Laguna Lake Region, in the provinces of Rizal and Laguna, and in Metro Manila. Though the project offers a host of environmental benefits and provides livelihood opportunities for the marginalized sectors, marketability of the briquettes has become a stumbling block for the project's sustainability. Local acceptability and finding potential investors are some of the issues that have to be solved. However, despite the set-back in the marketability of the converted wastes, the environmental army initiative on river clean-up has created an advocacy among the communities to take active roles in river/lake rehabilitation.

Public-Private Sectors' Collaboration to Promote CP – Promotion and adoption of CP is one key strategy that is strengthened under the CWA to prevent point sources of pollution. Inter-agency collaboration has demonstrated success in transforming the paradigm of industries to focus on an integrated, preventive environmental strategy to processes, products, and services to increase efficiency and reduce risks to humans and the environment. A successful collaboration was illustrated by the Metro Cebu Environmental Initiatives Council (MCEIC)

and its partner agencies and industries in Region 7. To give due recognition, a MOA was signed in April 2004 by the MCEIC, Pollution Control Association of the Philippine, Inc. Region 7, Cebu Chamber of Commerce and Industry, Inc., and the DENR-Region 7. Signatories of the MOA agreed that companies that document and submit their CP practices be given due recognition. A total of 21 firms submitted their CP program documentation and were then reduced to 10, following this set of criteria: (a) Innovativeness of CP Technique Used; (b) Pollution/Waste Reduction Attained; (c) Cost Savings Result; (d) Increase in Production Efficiency; (e) Proper Resource Use/Management. These firms were given "Award for Outstanding Cleaner Production Practices" in June 2005. As an added incentive, Region 7 granted the awardees environmental permits with five-year continuous validity.

Pilot and Demonstration of Water Actions (PDA) - This PDA strengthened the Baguio City government's mechanisms for coordinating and managing water resources. Baguio City in Northern Luzon, located 1500 meters above sea level, is home to 250,000 people (ADB, 2007). Tourists by the thousands drive to this mountain resort every year, adding to the city's problem of short freshwater supply. This proposed PDA will focus its institutional development interventions in Baguio City, Philippines. The city faces problems with unaccounted for water aggravated by the growth of small-scale water suppliers and settlements along watershed areas and presence of minerals that affect water quality. Attempts at charting directions and investments to efficiently manage the water resources in Baguio City have been initiated. In the regional and provincial plan documents, the role of Baguio City is to protect and preserve watersheds within its territorial jurisdiction. In a separate report containing the urban plan for Baguio, water issues were sketched under the infrastructure component that tackled water supply, surface water sewerage, sanitation and sewage disposal. This PDA hopes to enable Baguio city to shift from fragmented to integrated local water agenda and action, to be catalyzed by an integrated management scheme at the local government level. Specific targets for capacity-building are the city planning and development office as a coordinating and management office of the city government, and the public utilities sector office that manages the water treatment facility. The expected results of this PDA are as follows:

(a) an Integrated Medium-Term Local Water Operational Plan and Investment Priorities of Baguio City; (b) a Cost-Recovery/Sustainability Plan for the City's Water Treatment Facility; (c) information and Communication Materials that Capture the Lessons Learned from the Project. This PDA assisted in the formation and design of a multi-sectoral, multi-functional, and multi-lateral City Water Governance Committee (CWGC) for better and sustainable water governance in Baguio City; and encouraged the participation of local governments and national agencies in a seminar to disseminate lessons learned from Baguio City's experience.
One of the main purposes of the *AWDO 2007* is to focus the attention of national leaders and key decision makers on the need to increase investments in the water sector if the MDG targets are to be achieved by 2015. Although some countries have made good progress, others need to make dramatic improvements as can be seen from Table 1. Nearly half of the targets for 11 of the countries in the table will not be met by 2015. Simply providing access does not necessarily mean all problems are solved and all benefits are received. For example, an improved water supply must also provide good quality water delivered at the tap, and improved sanitation must include effective waste disposal and wastewater treatment (ADB, 2007).

Table 1. Progress in Achieving MDG Targets, and IDWA values.

Country	Urban water (%)	Rural water (%)	Urban sanitation (%)	Rural sanitation (%)	IDWA value
Bangladesh	82	72	51	35	37
Cambodia	64	35	53	8	19
PRC	93	67	69	28	61
Fiji	43	51	87	55	n/a
India	95	83	59	22	60
Indonesia	87	69	73	40	59
Kazakhstan	97	73	87	52	74
Pakistan	96	89	92	41	39
Philippines	87	82	80	59	80
Samoa	90	87	100	100	n/a
Sri Lanka	98	74	98	89	51
Viet Nam	99	80	92	50	76

Key	Target already met	On track for 2015	Off-track — expected to hit target after 2015	Off-track and regressing

IDWA = index of drinking water adequacy; MDG = Millennium Development Goal
Coverage figures from published WHO/UNICEF data for 2004. Although not the latest data available from individual countries, which may use different definitions and are likely to be overoptimistic in their assessments, they provide consistency in performance comparisons. For Cambodia, definitions of improved facilities and urban/rural areas were changed after 1990, so MDG target progress from 1990 to 2004 is not directly comparable.

(*Source: ADB, 2007; Annex 1)*

Food and Water Quality Management Programs at MMSU

Various academic institutions are actively pursuing studies on water quality management. Their activities range from regular water quality monitoring to special studies on analytical method formulation and/or validation and testing of substances to assess impacts on water pollution and food product development to help local entrepreneurs. A GPS-guided survey for about 250 food processors in Ilocos Norte were conducted by MMSU researchers to assess their food processing and explore to improve their food products packaging and development for food safety, use of clean water and enhanced their income (MMSU, 2007). At MMSU, initiative is being done to conduct current good manufacturing practices (cGMP) on food and water resources for crop production, dormitories, faculty houses and water refilling projects for MMSU and for food processors of vinegar/wine, local sausage and other local food products in the community. Moreover, WQMP is also being instituted in the university to provide clean water for the community and for food processing. A water refilling station is now being established as well as a mobile food and water packaging toll facility to help small entrepreneurs in the rural areas to process their food products with clean water for food product development and drinking water, for cGMP. As a continuing effort of the university, a team is assigned to monitor the water and food quality in the community, as well as promoting water conservation techniques such as rainwater harvesting, growing drought resistant crops and soil and water conservation measures.

The implementation of the Philippine Clean Water Act of 2004 by the DENR, other national government agencies, LGUs, private sector, civil society, and other concerned entities require appropriate planning processes, regulations, capital investments, and resources. It is evident that more actions and resources are needed to build on existing water quality management

programs. Due recognition should be made on the interrelationships and collaboration among agencies and stakeholders responsible in addressing water quality problems. The framework should pave the foundation for a cohesive direction, involving stakeholder participation towards the implementation of various water quality management strategies. The active involvement and participation of stakeholders should be enhanced in implementing water quality management programs. It should promote a sustainable proactive approach to managing water quality particularly at the local level. Successful water quality management requires a strong community-based effort with diverse stakeholder involvement, good partnership building with consensus, and effective and collaborative decision making on best management practices. The challenge is to internalize the message that water is an important resource and that everyone has to play a role in the conservation and management of our water resources.

Conclusion

Major water quality challenges that the country needed to improve the quality of its surface, ground, and coastal waters. The government should pursue aggressive strategic plans to address the seemingly decreasing trend of the quality of our water bodies. This implies safe drinking and bathing waters and water bodies that foster production of our aquatic resources. The active involvement and participation of stakeholders should be enhanced in implementing water quality management programs. It should promote a sustainable proactive approach to managing water quality particularly at the local level. Successful water quality management requires a strong community-based effort with diverse stakeholder involvement, good partnership building with consensus, and effective and collaborative decision making on best management practices. The challenge is to internalize the message that water is an important resource and that everyone has to play a role in the conservation and management of our water resources.

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Livelihood Challenges of the Communities in Catchments Area of and along the Hong Kae Semi-artificial Drainage Channel in Vientiane Capital, Lao PDR

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Abstract

Livelihood challenges of the communities in catchments area of and along the Hong Kae semi-artificial drainage channel in Vientiane Capital, Lao PDR.

Wastewater in Vientiane Capital has drained to Nong Chanh Marsh. There are two main semi-artificial channels, Hong Kae and Hong Xeng, functioned as gravitational drainage channels connected between wastewater storage of Nong Chanh Marsh and the ecological wastewater treatment system of That Louang Marsh, about over three Km length, before draining into Mekong River at the South of Vientiane Capital at Houy Mak Hio River Mouth. The study area is based water quality monitoring in the particular Hong Kae Channel, which is one of the large channels in Vientiane that stores wastewater from the communities in the urban area. There fore the objectives of the study are to: Monitor dynamic changes of water quality and their distinctions in different seasonal periods in one of the main drainage channels in Vientiane Capital, Hong Kae; and Assess major economic and social impacts to some communities residing around Hong Kae channel. Methodology of the study is part of the program on water quality monitoring and social economic impacts, for particular water quality monitoring and impact analysis on Hong Kae Channel, the study team, Field survey was conducted by preparing questionnaires and interviewing of representatives of 32 households, residing around Hong Kae area in 3 villages of Xaysetha District.

Based on household interview, 59.4% of interviewees used water from Hongkea for their agricultural and fishery activities, while 40.6 % was never. From all of these interviewees, 87.5% of them claimed that wastewater created physically and mentally disturbance for their daily lives. Within these, 93.8% claimed of bad odor, 56.3% of too much garbage, and 21.9% of less water. Most of interviewees reported that the serious wastewater disturbances started from 2000.

According to the study in three periods as a model, it was analyzed that water quality status in the Hong Kae Channel was terribly deteriorated, especially since 2002. This drove a number of possible impacts to the communities as well as living things and ecosystem in the catchment of and along the Hong Kae Channel. It is, therefore, recommended that relevant organizations should pay their stronger attention for wastewater management in the Hong Kae, as well as other channels in the Vientiane. These may include effective planning of wastewater and solid waste management; intensive water quality monitoring and information sharing; awareness campaigning on conservation of water resources, ecosystem and environment, basic hygiene and health care, and regular channel clean-up.

Keywords: Hongkea, Wastewater, Water quality, Monitor dynamic changes, Chemical and Physical Analysis, Social and Economic Impact Analysis

Introduction

Vientiane is the Capital City of the Lao PDR at where about over 6 hundred thousand inhabitants resided in its urban area. Wastewater in Vientiane Capital has drained to Nong Chanh Marsh. There are two main semi-artificial channels, Hong Kae and Hong Xeng, functioned as gravitational drainage channels connected between wastewater storage of Nong Chanh Marsh and the ecological wastewater treatment system of That Louang Marsh, about over three Km length, before draining into Mekong River at the South of Vientiane Capital at Houy Mak Hio River Mouth.

The study area is based water quality monitoring in the particular Hong Kae Channel, which is one of the large channels in Vientiane that stores wastewater from the communities, restaurants, markets, factories, hospitals in the urban area of Vientiane capital. The length of Hong Kae Channel form Nong Chanh to That Louang Marsh takes about 3,400 m. Before 2000, Hong Kae used to be irrigation channel supplied water from Mekong and Vientiane flood water to the Northeast part of Vientiane, where the agricultural areas existed. These agricultural areas have been narrowed due to the urbanization of Vientiane Capital. The system was modified as domestic wastewater and Vientiane flood water transport and treatment facilities. There fore the objectives of the study are to:

- Monitor dynamic changes of water quality and their distinctions in different seasonal periods in one of the main drainage channels in Vientiane Capital, Hong Kae; and
- Assess major economic and social impacts to some communities residing around Hong Kae channel.

Methodology

- The study is part of the program on water quality monitoring and social-economic impacts, conducted by the Faculty of Environmental Science and Development, National University of Lao PDR, which had been taken place in that Louang Marsh and its draining channels during 2002 – 2008.
- For particular water quality monitoring and impact analysis on Hong Kae Channel, the study team, included my self Oulavanh Sinsamphanh and Ms. Souksamone Latsachanh, Bachelor Students of the Faculty of Environmental Science and Development, National University of Lao PDR, was formed, for this particular purpose.
- The study had been advised by Dr. Bounthan Bounvilay, Vice Director of Faculty of Environmental Science and Development, University of Lao PDR, and Mr. Panya Simounkhoun, Lecturer of the mentioned Faculty.
- Field survey was conducted by preparing questionnaires and interviewing of representatives of 32 housholds, in which 65.6% was female and 34.4% was male, residing around Hong Kae area in 3 villages: Sysangvone, Hong Kae and Phonthan of Xaysetha District.
- Secondary data were also collected from reviewing the Water Quality Monitoring Report in 2002 – 2003 of the Faculty of Science, Department of Chemistry, the National University of Laos and the Study Water Quality of That Louang Swamp Wetland by Integrated Physical-Chemical and Biological Factors, May 2004. Accordingly, the data was analyzed comparing the values of some key water quality indicators resulted in September and December 2002, and May 2003.
- Based on the results, conclusions and recommendation were conceptually prepared.

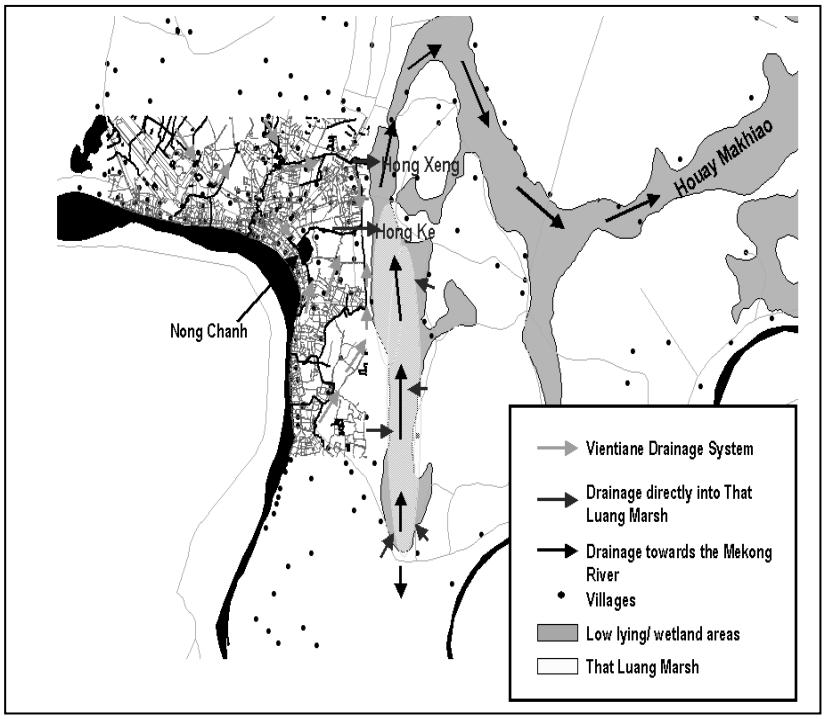

Figure 1. Map of Central Vientiane and That Louang Swamp and semi-artificial channels

Results and Discussion

Chemical and Physical Analysis

In 2000, the Science Technology and Environment Agency issued a Decision on Wastewater Management and Monitoring. The Decision set the classification of domestic effluent water quality standards and Ambient Water Quality Standard. The aim of the decision is to set the foundation for managing and monitoring of domestic wastewater and agricultural discharge water quality. Numbers of applied parameters and their set standards are shown in Table 1.

Table 1. Determination of standard for waste water treatment from public areas to the environment

No	Unit (mg/l)	Standard
1	pH-value	6 – 9.5
2	BOD: the amount of oxygen required by polluted water to clean up by means of bacteria flora by using oxygen dissolved in the water.	No more than 30
3	Suspended solids	No more than 30
4	Settleable solids	0.5
5	Total dissolved solids	1,500
6	Chemical oxygen demand (COD): the amount of oxygen required by polluted water to clean up by means of chemical reactions	No more than 120
7	Sulfide	1
8	Total Kjedahl Nitrogen (TKN)	No more than 100
9	Fat oil and grease	No more than 5
10	Temperature [°C]	No more than 40

Due to the study was to integrate physical-chemical and biological Factors for the more comprehensive results as it would suitably be used for reflecting impacts from water quality to the surrounding community. Therefore, some of the parameters applied for the study are not included in the issued standard, eg. EC, DO, nutrients values of NH_3-N, NO_3-N, NO_2-N, PO_4-P, Total-N, and Total-P. On the other hand, some parameters applied in the standards are not part of

study parameters, eg Suspended Solids, Total Dissolved Solids, COD, Sulfide, TKN, and Fat oil and grease.

There were 11 chemical and physical water quality parameters applied for the analysis, while some of them were not set in the Ambient Water Quality Standard, issued by the Science Technology and Environment Agency in 2000 (Table 2). However, these can sufficiently be matched to the social and economic analysis.

Table 2. Values of water quality monitoring at Hong Kae during September and December 2002, and May 2003, comparing to ambiant water quality standard.

Parameters	Unit	September 2002	December 2002	May 2003	Standard (STEA, 2000)
pH	(mg/l)	7.8	7.9	8.8	6 – 9.5
Temperature	^{o}C	28	24.1	32.6	*
Electrical Conductivity (EC)	(micro/cm)	266	279	438	*
Dissolve Oxygen (DO)	mg/l	2.8	1.4	1.1	>2
Biological Oxygen Demand (BOD)	mg/l	39	64.6	78.3	4
Ammonia nitrogen (NH3-N)	mg/l	0.294	0.461	0.389	0.2
Nitrate-Nitrogen (NO_3-N)	mg/l	3.064	2.824	3.991	0.8
Nitrite-Nitrogen(NO_2-N)	(mg/l)	0.605	0.455	0.831	5
PO_4-P	(mg/l)	5.4	5.95	6.45	30
Total-N	(mg/l)	5.6	*	3.19	*
Total-P	(mg/l)	*	*	5.951	*

Source: Study water quality of Thatloaung Swamp wetland by integrated physical-chemical and biological factors, by faculty of science.

Based on seasonally periodical monitoring and analysis found that:

- Rages of temperature were between 24.1°C and 32.6°C, in which the minimum temperature was in December and the maximum is in May of the study periods. Trends of water temperatures in the Hong Kae Channel were consistent to the seasonal air temperatures, which was observably considered as normal condition;
- pH values were ranged between 7.73 and 8.75, which were considered as minor changes and still within the limitation ranges of issued standard;
- Electrical Conductivity was ranged between 266 and 438 micro/cm. It was analyzed that within the physical factors, distinctions of EC values were caused by the increasing of dissolved solid ion in the channel wastewater in each season. This reflected the increasing pollution in the channel and diluted by flow volume in different seasons.
- Dissolved Oxygen in September 2002 (Rainy Season) had the highest value of 2.8 mg/L and dropped to the lowest in May 2003 of 1.1 mg/L. It was observed that in general the average DO value in the three observed periods was lower than the standard ranges (>2 mg/L). This was caused by high concentration of pollutant during the low flow and high temperature period, which was consistent to the Oxygen demand by bacteria for solving the increasing organic matters in the opposite direction of DO;
- Bio Oxygen Demand values were changed based on seasonal measures. The BOD value was at minimum level of 39 mg/L in September 2002 and maximum level of 78.3 mg/L in May 2003;

- According to the analysis of DO and BOD values, which were considered as important factors for water quality monitoring in theological context, we can observe that trends of these two parameters will change in opposite direction. In each measure, BOD was increased while DO was decreased. It was found that BOD values extracted from each monitoring period were over the domestic wastewater discharge standard, issued by STEA in 2000 (4 mg/L).

- The results of monitoring of Ammonia Nitrogen in the three study periods had shown that: in September 2002, the Ammonia Nitrogen values in September and December 2002 and May 2003 were 0.249 mg/L, 0.461 mg/L and 0.389 mg/L, respectively. In comparing the three values, it was analyzed that the Ammonia substance caused a considerable impact to aquatic ecosystem during and at the end of rainy season, while high pH value in dry season caused relatively high Ammonia value and exceeded the standard (Std = 0.4; pH > 7.5), which drove dangerous to aquatic reproduction process in the Hong Kae Channel.
- The results of monitoring of Nitrate Nitrogen in the three study periods had shown that: the concentration of Nitrate in rainy season reached the highest value of 0.831 mg/L and lowest value in dry season of 0.455 mg/L.
- The results of monitoring of Phosphate concentration in the three study period had shown that: Phosphate values during rainy and the end of rainy seasons of 2002 and dry season of 2003 were 5.4 mg/L, 5.9 mg/L and 6.4 mg/L, respectively.

Generally, it was observed that trends of water quality in the Hong Kae Channel from previous up to date has been gradually deteriorated and drove more seriously impact to inner and surrounding environments, especially in the dry seasons when low flow and high pollutant concentration were occurred. It was analyzed that major influences to the water quality in the Hong Kae Channel were the causes of

- The increasing number of population in nearby and within catchment area of the channel as of urbanization and immigration. The building structures and domestic sanitary and drainage systems in Vientiane including the study area were already poor coupling with low environmental awareness of dense residential dwellers and newly household community-scale businesses and industrial processing activities created in the area who directly and indirectly disposed and discharged to the channel system;
- More intensive agriculture practices in outer skirt of the urban area of Vientiane center. Even though the agriculture land had gradually diverted to urbanity, however agriculture waste was still one of the major sources of pollution in the whole drainage system, including Hong Kae Channel. In order to improve the productivity, more intensive agriculture was practiced which consumed more fertilizers and pesticides were applied which drove more concentration of chemicals and fertilities in the drainage system; and
- The channel improvement project conducted by the Vientiane Urban Development and Administration Authority. The project consolidated the channel from earth to concrete structure which considerably reduced bioactivities and natural treatment in the channel;

Social and Economic Impact Analysis

Based on household interview, 59.4% of interviewees used water from Hongkea for their agricultural and fishery activities, while 40.6 % was never. From all of these interviewees,

87.5% of them claimed that wastewater created physically and mentally disturbance for their daily lives. Within these, 93.8% claimed of bad odor, 56.3% of too much garbage, and 21.9% of less water. Most of interviewees reported that the serious wastewater disturbances started from 2000.

Interviewee's opinions regarding existing wastewater that 65.6% claimed relevant organizations ignored sufficient wastewater management, 12.5% claimed industrial factories discharged their used water without prior sufficient treatment, 65.6% claimed the wastewater source from domestic discharges, 68.8% claimed the lack of environmental awareness village communities due to the lack of awareness program at village and community levels, 12.5% claimed some villagers / farmers applied chemicals for their agricultural practices, and 9.4% claimed the use of pesticides.

Regarding time dimension of wastewater evolution based on the interviewee individual observation, 78.1% reported water in Hong Kae Channel was in fresh condition before 2002 and only 9.4% reported water in the channel was remain fresh after 2002. Before 2002, only 34.4% reported their observation of dense domestic solid wastes in the channel, which increased to 81.2% after 2002.

Another observation was that water weeds were rapidly spread throughout the channel, while aquatic lives, e.g: natural fish, were reduced. Further more, there were common responses on the impacts that some water-borne diseases occasionally spread in the communities, such as diarrhea and cholera etc. 68.8% of interviewees believed that pollution in channel water impacted their health through consuming vegetables from their gardens where they used channel water for irrigation, however actual residues has not been detected; 56.3% observed that soil fertility was degraded; and 40.4% reported their gardening products were increased, while 31.1% reportedly reduced.

Conclusion and recommendations

According to the study in three periods as a model, it was analyzed that water quality status in the Hong Kae Channel was terribly deteriorated, especially since 2002. This drove a number of possible impacts to the communities as well as living things and ecosystem in the catchment of and along the Hong Kae Channel. It is, therefore, recommended that relevant organizations should pay their stronger attention for wastewater management in the Hong Kae, as well as other channels in the Vientiane. These may include effective planning of wastewater and solid waste management; intensive water quality monitoring and information sharing; awareness campaigning on conservation of water resources, ecosystem and environment, basic hygiene and health care, and regular channel clean-up.

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Current State of Water in Myanmar

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Abstract
A potential of water resources in Myanmar is abundant for demand of agriculture production and other sectors. Agriculture is a major economy of country so as to enhance irrigation system for promotion of agricultural production especially for rice based system development. After the construction of irrigation system, crop production can be promoted any time with an availability of stored water in the reservoir in irrigation system. It is also urgently necessary to adopt more appropriate ways for generating the complex water resources project in Myanmar to meet requirement of all sectors. At the same time, water conservation with appropriate management and planning practices are also required in view of the rapid socio- economic development of the country as well as for protection against water related environmental degradation. The paper discusses the water potential in Myanmar, water resources utilization and challenges, opportunities and threads in water resources development scheme, water quality protection and its standard and government actions for pollution control, water sector profile and international cooperation. In connection with technical and institutional bodies of water resources utilization should be adjusted to support for solving economic, social and environmental issues through successful implementation of IWRM.

Keywords: Water resources utilization, opportunity and threats**,** Legal and institutional frame works, water quality protection.

Introduction
Myanmar is rich in water resources. The total utilization of the nation's water resources is only about 5 percent or 45 million acre- feet (56 km^3). It is clear that the physical potential for further development of water resources in Myanmar is substantial. Among them, the freshwater resources are mainly used by the agriculture sector with small quantities being used for domestic, industrial and other purpose. Due to the importance of the agricultural sector, the Government has accorded high priority to its development, and numerous irrigation facilities have been implemental since last two decades for irrigation and water supply to monsoon and summer paddy crops. Apart from the agricultural sector, the hydropower sub-sector is also the most important in terms of economic development and investment. Moreover, dry-season irrigation, especially by use of river pumping project, has been successfully increased as a result of power demand is also increasing annually. In fact that, renewable hydropower generation is very important to contribute considerably to socio-economic growth in country. Therefore, electric power generation projects are being implemented wherever possible in order to meet the demand for electricity supplies.

At the same time, the Government is implementing plans for water conservation with appropriate management and planning practices so as to support for the rapid socio- economic development of the country as well as for protection against water- related environmental degradation.

Water Potential in Myanmar

Myanmar is geographically located between 9˚ 32' and 28˚ 31' North Latitude and 92˚ 10' and 101˚ 10' East Longitude. It is characterized by mountain ranges in the north, east and west and a long coastal strip in the south and west. Lengthwise, it stretches about 1280 miles (2060 km) north to south and approximates 587 miles (945 km) east to west thus leading to the area coverage of 67.65 million hectares (676553 sq km) for the whole country. It has common international borders with China in the north, Thailand and Laos PDR in the east, India and Bangladesh in the west and again with Thailand in the south.

The water basin characteristics in Myanmar are quite variable due to the differences in physiographic features. The principal water courses flowing separately in Myanmar comprise four major rivers, the Ayeyarwady, Sittaung, Thanlwin., Bago and their major tributaries. All rivers with the exception of the Thanlwin within Myanmar territory and can be considered nationally own water assets. Their drainage area is spread widely over the country, amounting some 876.73 million acre/ft (1,082 km^3) of water volume per annum from a drainage area of about 284,800 sq-miles (738,230 km^2).

The monthly distribution of river flow vary according to the pattern of rainfall, ie. about 80 percent during the rainy season (May- October) and 20 percent in the dry season (November- April). The estimated groundwater potential in Myanmar is about 495 km^3 in eight principal river basins in Myanmar.

On the basis of stratigraphy, there are eleven different types of aquifers in Myanmar. Depending on their lithology and depositional environments, ground water from those aquifers has disparities in quality and quantity. Out of these, ground water from Alluvial and Irrawaddian aquifers are more portable for both irrigation and domestic water use. However on the water scared regions, ground water from Peguan, Eocene, and Plateau Limestone aquifers are extracted for domestic use.

Water Resources Utilization and Challenges

Myanmar is an agricultural country with an abundance of water resources. The agricultural sector is the most basic economic of the state as well as the main source of livelihood in rural areas, since the rural population represents some 70percent of the nation's population. At present, the state has been systematically disseminating advanced techniques and support for the development of the nation's economy. Dams are now irrigating more than, 1.7 million ha of farmland. In addition to the dams, river water pumping stations, underground water tapping stations and small dams have been built throughout the nation.

A total of 305 river pumping projects are irrigating about 188,000 ha of cultivated land. In addition, 8136 numbers of tube wells have been provided to irrigate 48,000 ha of farmland. Total irrigated area is increased up to 18% of the sown area in 2006-2007.

Tributaries originating in the western hill region and southern part of the country constitute some 10 percent of the catchment areas and surface runoff. The hydropower potential of these tributaries is considerable. According to studies by the United Nations and other sources, the hydropower potential of Myanmar is estimated to be as much as 41,000 MW. By 2008, 35 hydropower stations (including 15 medium scale projects had been completed with a total

estimated generated power of 390 MW, which as almost 1 percent of potential generated hydropower in Myanmar.

Moreover, the Development Affairs Committee under the supervision of the Department of Development Affairs (DDA) has implemented projects for sinking 15,715 no of tube wells to supply drinking water for about 10,602 villages by using funds from the Government, the DDA and donors from inland and abroad. The projects have been implemented with participation by international and non- governmental organizations.

The water sector faces some challenges including unusual and uneven rainfall patterns in some years, flooding and drought in some of the main agricultural areas of the country due to climate change,, and also negative basically by the impacts of shifting and slash and burn, cultivation, illegal logging in watershed areas as well as management conflicts of interest and lack of coordination and cooperation within agencies. The most important challenges includes,

(a) to strengthen the legal framework for ensuring the effective and harmonious integration of water resources management, development and protection activities into the socio- economic development process of the country.
(b) to enhance and consolidate of the existing systems
(c) the operation, maintenance and rehabilitation of facilities safely, reliably and efficiently
(d) to enhance organizational capacity and effectiveness of the water resources coordination system.

Mission and Vision Statements

The mission statement for the water sector is to establish a beneficial framework and effective mechanism for managing, developing and protecting water and related resources in an environmental and economically sound manner in order to meet the needs of the people of Myanmar. "This statement is adopted by the Government and will provide a guiding light towards establishing national strategies for both short and long term efforts by all agencies, people and stakeholders towards the common goals of national socio- economic development and environmental conservation.

The vision statement of Myanmar is : Sustainability of water resources to ensure sufficient water quantity of acceptable quality to meet the needs of the population in terms of heath, food security, economy and environment' and which clearly mentioned/ identified in Myanmar Agenda 21 for more efficient freshwater resources management.

Opportunities and threats in water resources

A different kind of Water Resources Projects has been constructed throughout the country. It consists of isolated and multiple- reservoir systems, ground water and river pumping projects, diversion head- works and sluice gates for flood protection and saline water intrusion. According to the country's agriculture base economic development policy, those infrastructures were implemented especially for irrigation in conjunction with hydropower generating for industrial and domestic water supply, and environmental sustainability. Although Myanmar has abundant water resources and no scarcity of water at present, proper management and a strong policy on sustainable and continuous development of the economy and the conservation of the environment are required for the security of future generation.

And also to provide innovative and integrated solutions for sustainable management of water resource to meet national developments.

Sedimentation is one of the major adverse effects of storage dams and in the lower courses of rivers. Mining and deforestation along the upper reaches of river basins cause serious watershed erosion problems, Transported sediment is reducing the storages capacity of reservoirs and the bed level in the lower reaches of river is rising.

Flooding in the downstream of river and navigation faces serious problems. Although some nutrients and some sediment are needed to support the aquatic environment, the Government is emphasizing the implementation of the terrace farming system to reduce shifting cultivation.

The development of industry and increasing population density will cause increasing demand and also increasing river pollution and health risk for people living close to the rivers. Careful management of groundwater extraction is also required in order to avoid contamination of arsenic.

Moreover, current legal and institutional frameworks also threaten to the water resources development in Myanmar. Present organizational arrangements at the national and provincial levels generally support the achievement of national policies, but the current institutional problems in the water sector are mainly related to (a) weak of coordination and collaboration between agencies within the sector and with those of other sectors and (b) inadequate communication and coordination between the national agencies and authorities.

Despite the many Acts, Laws and regulations related to the water sector, should be amended and reviewed with a view to enacting a unified water resources law in order to promote a more effective legal framework for coordination and management of water resources.

Other weaknesses in the water sector are limited manpower, scare financial resources, and a lack of appropriate monitoring facilities, proper and systematic record keeping and regular monitoring and surveillance of water quality. As for water quality control, basic standards of quality for drinking water were recommended in 1990, but have not yet been approved. Anyway, joint efforts of the Government, local communities and NGOs, will be the key to the success of water resources management programmes. Moreover, institutional strengthening, capacity building and public awareness are essential elements of development work.

Water Quality Protection and Standards

The main courses of deteriorating water quality are sewage, solid waste industrial waste and agrochemical waste. For water conservation through water quality protection is undertaken by concerned local City Development Committee. Actually, the control of wastewater is both a municipal and industrial problem. In cities that are undergoing rapid industrialization , the municipal treatment issue is complicated by the addition of untreated or semi treated industrial discharges into the municipal sewage system, thus stricter law to control the water quality should be imposed. Mover over, there is still facing the problems of direct discharging waste water from factories into the river or stream. Recently, NCEA (National Commission for Environmental Affairs) and NGOs propose effluent standard for proper disposal of waste water from factions. By the way, it is seen that to disseminate the knowledge about the proper

disposal of waste water and public cooperation are essential to conserve the quality of natural resources.

In agriculture sector, the government and ministry concerned has banned impact of some toxic pesticides and encouraged utilization of conventional bio- fertilizer as a substitute for chemical fertilizer to mitigate the water quality deterioration. At present controlling of water quality for various purposes are based on the WHO standard. Deforestation in the catchments area and environ of water sources caused a serious problem of degradation water quality and quantity. It physically generates topsoil loss and land degradation by gully and sheet erosion leading to excessive level of turbidity in receiving water and off- site ecological and physical impact from deposition in river and lakebed. And chemically, the silt and clay fractions, the carrier of absorbed chemical, are transported by the sediments in to the aquatic system.

In order to control the quality of water resources, effluent quality standard of domestic water and industrial waste water which are discharged on the land mass or discharged into water body should be established.

In the current situation, concerned ministries and departments have organized a forum of expert on Water Quality issues. WHO proposed standard was adopted as a reference. Water quality control measures were being taken as case- wise, especially for bottle drinking water production. Arsenic and other parameters have been tested in collaboration with Water Resources Utilization Department (WRUD), Department of Development AFFAIRS (DDA) and United Nation International Children Emergency Fund (UNICEF).

Laws regulation and legislation and legal support

Since the early 1900s, there have been established in laws, regulation, legislation and legal support for water resources development, management and utilization in the water sector. However, there is still needs that to be reviewed, improved and amended in line with IWRM improvement for the sectors. The existing laws and legislations in the water sector and water related sectors should be reviewed and, if necessary, new ones in line with national and international laws for IWRM should be added in the sectors.

Laws of Govern Pollution

In relation to pollution, Myanmar has no specific laws to govern water pollution. There is a general provision in section 9 of the Public Health Law of 1972 which empowers the Ministry of Health to carry out measures relating to environmental health, such as garbage disposal, use of water for drinking and other purposes, radioactivity, protection of air from pollution and food and drug safety. However, detailed provisions do not exist to ensure more effective and comprehensive regulation of these matters. In the regulation for hotels and tourism, there are no provisions whatever for pollution control. Although the" Burma Ports Act of 1908" contains a paragraph about harbor pollution, this merely focuses on the detriment to navigation. The only control of water pollution in the country is through guidelines issued in June 1994 by the Myanmar Investment Commission. These guidelines require that new investment projects have waste water treatment systems. River and Lake pollution from sewage, industrial waste and solid waste disposal are serious problems in Myanmar, but are not regulated explicitly by any laws, so new laws relating to pollution should be enacted.

Water sector profile in Myanmar

At present, Myanmar can be identified as low stress country concerning with water use. However, Myanmar has now reached a major turning point in the use of water resources for all-round development of the country. Several government agencies and departments under different ministries are operating their own programs independently without proper coordination with the principal executing agency.

In fact that, from fragmented sectors water resources management to a holistic integrated management, Myanmar has to strengthen the capacity to undertake IWRM exercises, developing projects in water supply, irrigation and hydropower without regard to the intersectional effects. Provision of the agricultural water is the first priority in water resources management for the country at present and in the future as well. It was found out that about (91) percent of the water use was for agriculture, about (8) percent was for domestic consumption and (1) percent was for industrial purpose.

International Cooperation

Myanmar becomes a permanent member of International Committee on Irrigation and Drainage (ICID) since 1982. MCID was established in 2001 and had formulated its constitution in 2003 and actively associated with irrigation and drainage activities in the region as well as international level. In 2003, Irrigation Department as a focal point agency of Myanmar, cooperating with FAO and UNESCAP, had launched program to develop "Myanmar Water Vision" with a view to implement and realize the World Water Council's Water Vision. Moreover, this "Myanmar Water Vision" can become a basic guidelines and framework for the preparing of IWRM which is formulated by the year 2006 in Myanmar. After that UNESCAP discussed with Irrigation Department (ID) to carry out Strategic Planning Management (SPM) as the follow up activity.

Myanmar, former SEATAC member is actively participate in GWP-SEA activities and attended series of meeting and training program for upgrading awareness. Moreover, Irrigation Department as a focal point agency of Myanmar has close cooperation with other organizations such as WEPA, AQUGARINE, PWA, and INWRAF and so on.

Institutional bodies for water resources utilization

Several government agencies and departments under different ministries are engaged independently both in surface and ground water use but the extent and type of water use are different from one another.

Agriculture is the main sector of the utilization of water in Myanmar as water is very important for cultivation of crops. The Irrigation Department is harnessing such resources, not only concentrates in providing efficient increase irrigation for the development of the agriculture sector, but also embraces objectives pertaining to adequacy of drinking water, protection of environment and generating of hydro-electricity.

Water Resources Utilization Department also takes parts on developing water resources, both surface and groundwater, for socio-economic development through provision of irrigation water and drinking water.

Department of Hydroelectric Power Implementation is being the primary user of water for power production. Public works, the Department of Development Affairs, City Development Committees, and the Department of Human Settlement & Housing Development are responsible for domestic water supply and sanitation works in urban areas and underground water controlling works in Yangon City, while Department of Health taken care for the water pollution and water borne diseases.

Department of Meteorology and Hydrology is responsible for measurement of discharges of major rivers yearly to compute Runoff data for each stations and monitoring water quality at some places.

Fisheries Department involve in water sector is to enhance food security conjunction with sustainability of mangrove ecosystem and conserving natural resources. Forest Department also take responsible for the conservation and management of watersheds.

Watershed Protection

With the aim of ensuring sustainability of water resources of country, forests of Myanmar are well conserved and safe guarded covering 50% of the nation will contribute to fulfill the human needs. Shifting cultivation and slash and burn practices provide significant contribution to forest loss and at the same time, it can adversely affect the environment in a number of ways such as soil erosion and degradation, deforestation, rapid silting of reservoirs , rising of river bed, causing flood at the downstream and navigation problem, etc. Therefore the government is making arrangement to reclaim the highlands and major watershed areas to substitute terrace farming for shifted cultivation.

In recent years a special programme has been launched by Forest Department for greening of 13 districts in central dry zone which is the most critical region in terms of degradation of land conservation of forest and establishment of forest plantation as follows:

(a) Plantation of fast growing multipurpose tree species at the rim and its periphery of the basin boundary such as 50,000 trees for high dams, 40,000 for medium dams and 20,000 trees for low dams to prevent watershed degradation as well as to restore ecological balance.

(b) Land rehabilitation and soil conservation activities in the most critical watersheds of upper Myanmar.

Concluding Remarks

Myanmar being an agro- based country; development of the agriculture sector is one of the key factors that can spell the enhancement of people's economic life, living standard and food security. As water is the most fundamental requirement for agriculture, steps are being taken to ensure that there is sufficient water for the cultivation of crops at the required time. The construction of irrigation facilities meant not only for the agriculture purpose but also for greening the environment, for supplying drinking water to local people and for generating electricity wherever possible. In this case proper water resources management is important to ensure the long term benefit and improved socio- economic life for farmers, the majority of the population.

It is also important to emphasize and disseminate new practices and farmers participation on-farm level for effective use of irrigation water. In Myanmar, several agencies are engaged with supply and management of water. Lack of cooperation and coordination among water related agencies is main issues for the proper management of water resources.

It is important for the enhancement of public awareness and public participation for successful implementation of IWRM in the country. We would like to call on the stakeholders, national entrepreneurs, and international organization to make concrete efforts to participate for the development of agriculture, livestock, and power and forestry sector in Myanmar.

Role of MSMA in Promoting Sustainable Urban Drainage Systems in Malaysia

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Abstract
The Urban Stormwater Management Manual for Malaysia (MSMA) is a guideline published by the Department of Irrigation and Drainage Malaysia (DID) in 2000 to indulge the long term nationwide directions and needs in ensuring sustainable urban drainage systems are fully utilized. Concurrently, the Cabinet gave full approval and directive for this manual to be referred and followed by every development project starting from 1st January, 2001. The manual enables overarching issues like flash flood, excessive sediment outflow and water quality deterioration generated by any land opening activities are controlled within its own project boundaries.

The emphasis on the control at source techniques proposed by MSMA could be divided into three main items, which includes water quantity control, erosion and sediment control, and water quality control. Water quantity control is measures to curb post construction flash flood problems while erosion and sediment control is measures to minimize erosion and sedimentation problems during construction stage. The final item, which is the water quality control; measures intended to reduce post construction non-point source pollution problems.

This paper intends to scrutinize the evolution of MSMA as a focal urban stormwater management guideline in Malaysia and share the milestones faced in promoting and implementing it. The paper also elaborates some of the success stories achieved since the last 8 years of implementation while outlines some of the strategic directions and action plans required to cushion any unprecedented debacles through practical and sound engineering practices so that MSMA will hold itself as a prime reference in Malaysia for all stakeholders i.e. the public and private sectors.

Keywords: Control at source, water quantity control, erosion and sediment control, water quality control, enforcement activities and strategic directions

Introduction
Since 20 to 30 years ago Malaysia's pace of development is unimaginable. Towering structures, airports, highways and railways, massive industrial and housing estates are just some parts of on going natural landscape alteration processes. With yearly precipitation between 2000~3000mm, the degree of excess runoff generated from these areas is tremendous. Flash flood, scenes of garbage flowing into rivers and silts generated from on going and abandoned construction areas are some common views causing severe damages to natural river system and its habitat.

To tackle these problems, the Government embarks programs like Clean Our River Campaign since 1993 to discourage people from throwing rubbish in rivers, streams and drains; followed by the establishment and utilization of MSMA in Malaysia in 2001. In a matter of few years, eco- friendly stormwater management facilities as proposed by MSMA become compulsory

yet popular among the public especially potential buyers. Value added infrastructures that support the livelihood of urban community become future development trend. This induces stormwater management facilities to be compulsory structures; proudly visualized among various urban infrastructures.

Background

MSMA has been introduced as a replacement of the previous Urban Drainage Design Standards and Procedures for Peninsular Malaysia, published in 1975. The manual emphasizes on control at source strategy with in depth explanation on water quantity control and water quality control through best management practices (BMPs). Besides enabling all new development areas to practice sound erosion and sediment control techniques through the implementation of Erosion and Sediment Control Plan (ESCP), MSMA is also meant to ensure peak discharge generated by extra runoff should align according to the downstream river capacity. In this respect, the extra discharge to be released by any developed area should be contained within that compound itself especially during peak flow. Once the flood recedes the extra volume accumulated could be released towards the downstream section without affecting the livelihood of the downstream community.

Immediately after launching, the 1st phase of MSMA focuses on the water quantity control agenda where requirements are instilled within all Drainage Layout Plans submitted by developers. Two (2) years later in 2003, the 2nd phase of MSMA was initiated where DID started to promote the Erosion and Sediment Control Plan (ESCP) as part of Earthwork Plan. In this respect, all development projects have to submit ESCP to ensure earthwork does not pose unnecessary threat to receiving water bodies. This is followed by the 3rd phase of MSMA where post construction water quality control measures were emphasized utilizing treatment control facilities like gross pollutant traps (GPTs), constructed wetlands, engineered waterways, fat oil and grease traps (FOGs), infiltration facilities, bio-retention facilities, sediment forebays, swales and etc.

Furthermore, DID as the focal department promoting MSMA initiates extra role through retrofitting exercises to ensure rapid disposal facilities are converted to eco-friendly stormwater facilities. This exercise involves heavy financial needs and investment; hoping by 2020 this program shall visualize its own and unique success stories. In terms of training and awareness, more than 10,000 stakeholders have attended conferences, seminars, workshops and courses that are related to MSMA consists of professional like engineers, planners and architects from Government Agencies as well as consultants, developers and contractors.

Until today, DID still faces obstacles in promoting MSMA especially in terms of maintenance of completed stormwater facilities. With more than 2000 detention ponds already constructed by developers, the amount of funds required for maintenance program is tremendous. To avoid any negative perceptions, DID embarks special exercises where detailed cost benefit analysis was conducted. Consequently, the economic analysis shows that these detention ponds are saving billions of tax payer's money due to the fact that without these stormwater facilities, the public will have to finance more towards unnecessary flood mitigation works. On the yearly basis, the ratio of saving is four to one (4:1).

Water quantity control

Stormwater management in Malaysia has traditionally focused primarily on managing the impacts of flooding by adopting *conveyance-oriented approach*. Stormwater systems designed in accordance with this approach provide for the collection of runoff, followed by the immediate and rapid conveyance of the stormwater from the collection area to the point of discharge in order to minimise damage and disruption within the collection area. Stormwater runoff is viewed as a nuisance to be disposed of as quickly and efficiently as possible.

Until recently, stormwater management has developed to the point where there are now two fundamentally different approaches to control the quantity, and to some extent, the quality of stormwater runoff. In addition to the traditional *conveyance-oriented approach*, a potentially effective and preferable approach to stormwater management is the *storage-oriented approach*. The function of this approach is to provide for the temporary storage of stormwater runoff at or near its point of origin with subsequent slow release to the downstream stormwater system or receiving water (detention), or infiltration into the surrounding soil (retention). This approach can minimise flood damage and disruption both within and downstream of the collection area. Runoff may also be stored for re-use as a second class water supply for irrigation and domestic purposes. The principal elements and techniques used in a *storage-oriented* system are stormwater detention facilities and retention facilities like *on-site storage, community storage* and *regional storage*.

Retention facilities are also utilised and designed to reduce the volume of stormwater runoff from small frequent storm events by storing collected runoff and allowing it to infiltrate into the surrounding soil. Retention is a suitable technique for infiltrating pre-treated runoff into areas with relatively high permeability soils. Pre-treatment by filtering to remove coarse sediment and debris is necessary to minimise blockage of the infiltration media. Regular maintenance is also essential for their effective operation.

Water quality control

The primary objective of stormwater quality control is to achieve good water quality standards released from completed development project. The activities outline in this program is based on three types of best management practices (BMPs).

Housekeeping BMPs: Housekeeping BMPs are techniques that aim to change human behaviour to reduce the amount of pollutants that enter stormwater systems by targeting the control and/or prevention of pollution at its source. These techniques are:

- community education and participation activities;
- management activities, such as landuse planning and development control;
- operations and maintenance activities, such as garbage collection and street sweeping, and
- improved site planning and management.

Source Controls BMPs: Source controls BMPs are those practices that tend to keep both runoff and pollutants contained at their source. These include pervious areas and buffer strips towards which runoff is directed, infiltration controls, porous pavement, erosion and sediment control plan (ESCP), which include the submission and compliance to the approved plans and etc.

Treatment Controls BMPs: To protect the quality of local streams, lakes, and river systems, a number of treatment controls BMPs may be adopted as follows:

- the establishment of lakes, primarily as biological treatment systems;
- the utilisation of water quality control ponds and wetlands, as physical and biological treatment systems, upstream of lakes;
- the incorporation of gross pollutant traps on inlets of lakes and water quality control ponds and wetlands to intercept trash and debris and the coarser fractions of sediment, and
- the incorporation of 'off-stream' sediment basins into land development to intercept (and chemically treat if necessary) runoff prior to its discharge to stormwater systems.

Erosion and sediment control

Erosion and sediment control (ESC) activities during construction works is based on the preparation of Erosion and Sediment Control Plan (ESCP). Accordingly, six principles of ESC are governed, which include 1) Planning Considerations, 2) Vegetative Stabilization, 3) Physical Stabilization, 4) Diversion of Runoff, 5) Flow Velocity Reduction, and 6) Sediment Trapping/Filtering. Some of the ESC measures outline in the ESCP are topsoil stockpile, preserve vegetations, seeding and planting of vegetations, mulching, stabilization, earth bank, diversion channel, slope drain, outlet and inlet protection, check dam, sediment fence, sand bank barrier, brush or rock filter, sediment trap and basin.

The utilization of ESCP for developed areas becomes compulsory since October 2005 after being endorsement by the National Council for Local Government. In short, every development project that is more than 1 hectare has to submit ESCP and Earthwork Plan together to DID to be reviewed and endorsed before approval is given by Local Authority. For area that is less than 1 ha, ESC measures shall be put straight away inside the Earthwork Plan allowing small scale development to skip full ESCP submission.

Enforcement activities

Model study conducted in the State of Selangor since 2005 shows that enforcement activities need to be addressed collectively by various Agencies steered by strong political commitment. Current legislation like Street, Drainage and Building Act (SDBA) has been used in Selangor emphasizing on polluters pay policy. Until the middle of 2008 more than RM15 million compounds have been collected by Local Authorities from developers that failed to comply ESCP requirements e.g. poor earthwork controls. Since the success of the program in securing clean runoff water, the Federal Government has approved its utilization for the entire nation in August 2008 through the endorsement obtained from the National Water Resources Council. Future success of this program is vital to ensure developers, contractors and consultants are aligned with national strategic stormwater programs.

Strategic directions

Under the Vision 2020, Malaysia is targeted to be a developed nation. The current manual paves the way for a nation to achieve its vision through a sustainable fashion. To ensure achievable goals, the strategic direction was set especially to examine existing problems arise among stakeholders and streamline specific actions that should be taken by decision makers. The National Stormwater Management (SWM) Goal – “Stormwater shall be managed so that it contributes towards sustainable development of the country”. The strategic direction is

divided into three areas 1) SWM infrastructure asset, 2) Stormwater and related eco-system as a resource, and 3) Stakeholders and users of the resource and the SWM infra asset.

SWM Infrastructure Asset

To develop a world-class SWM infrastructure accompanied with an equally world-class O&M to achieve an efficient, safe and eco-friendly SW management system. World-class infrastructure shall embody the contemporary best practices and technologies benchmarked against those found in developed countries. Strategies related to this program are i) upgrade existing infrastructure, ii) improve operation and maintenance, iii) improve development planning and control, iv) address point source pollution, v) tighten regulatory and enforcement, vi) knowledge and development and vii) training and education.

Stormwater and Related Eco-System as a Resource

To have an equitable, beneficial and sustainable utilization of the resources. The resources may be utilized as alternative source for non-potable use in urban areas, allow recreation, conducive to tourism and as a source for water supply and for the eco-system. This program elaborates on i) establish policy on stormwater utilization, ii) promote stormwater through education with strong provision on resource control, and iii) strengthen legal aspects.

Stakeholders and Users of the Resource and the SWM Infra Asset

To promote effective stakeholder participation towards the development of stormwater facilities and environment while at the same time benefiting from their proper use. This program emphasizes on i) education, ii) improve framework for public participation, and iii) improve regulatory and enforcement.

Way forward

Stormwater management is a continuous process involving various stakeholders. Future activities that up hold the strategic directions need to be addressed tactfully to ensure MSMA continuously indulges Malaysia in becoming a developed nation by 2020. Among important future activities are establishing the Total Maximum Daily Loads (TMDL) in various catchments, tax incentives initiatives for developers and investors that fully complied MSMA requirements and revision of the existing manual and guidelines to include additional needs like climate change.

In terms of providing adequate experts to fulfill the knowledge gaps, capacity building programs embarks by DID shall focus on training and accreditation exercises. Consultants, contractors and site supervisors shall be required to attend and pass certain minimum standards before being allowed to submit drainage and ESC plans. The program also ensures competent consultants responsible for the design while competent site supervisors handle site supervision works. Most of the training courses conducted by DID nowadays focus on hands on programs so that the level of knowledge increases according to the current and future needs.

Conclusions

Stormwater Management Program especially in urban areas is vital for a developing nation. Spearheading by “VISION 2020”, stormwater program in Malaysia is moving forward towards streamlining the strategic direction into strategic action plans. Most of developed nations have developed their own National Stormwater Management Framework complete

with their vision, mission, objectives, targets and strategies. Some countries have succeeded their short, medium and long term programs to the extent of full scale strategic action plans implementations.

In its 8th year of implementation, MSMA has evolved into a main stream guideline to ensure nation building programs fulfill sustainable development agenda as required by various international standards and signatory bodies. Malaysia is committed in promoting sustainable development and it is obvious that MSMA achievements set clear directions; thus, filling the gaps created by our ancestors while provides hopes for our children to inherit.

Malaysia still has a long way to go in getting full success in this program. The basic foundation for eco-friendly urban stormwater management program has been launched more than 5 years ago. With more than 12 years to go before reaching the year 2020, it is indispensable to strengthen this effort by exercising coordinated and integrated management approaches among relevant Agencies to ensure all requirements are fulfilled at the stage of pre-construction, during construction and post construction. Consequently, the targets for higher quality of life through sustainable development could also be achieved concurrently without compromising the environmental needs.

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The Current State of River Basins in Vietnam-Pollution and Solution

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Abstract
About 2 decades after "Renovation", Vietnam economy is developing remarkably; beside fast economic growth, it is the fact that all river basins in Vietnam are now facing pollution problems. Among many river basins in Vietnam, Cau, Nhue-Day and Dong Nai basins belong to the most polluted group. The river water is polluted with organic compounds, oil, suspended solids, etc, since untreated wastewater is often discharged freely into the rivers from cities, towns, industrial zones and craft villages. The pollution is threatening health of the basins' residents. Some efforts of Vietnam on improving river basins' environment management were presented.

Keywords: River basin, Cau, Nhue-Day, Dong Nai, water quality, pollution

River basins in Vietnam: An overview
With 13 large river systems, which cover 10,000 km2 in total, Vietnam is considered to have a complex and dense river network with most of the large river systems linked. Amongst those 13 main river systems, 9 have basins which contribute to 90% of total river basin area in the whole country. The 9 main river basins are those of Red, Thai Binh, Bang Giang-Ky Cung, Ma, Ca La, Thu Bon, Ba, Dong Nai, and Cuu Long river. The Red river and the Mekong river systems have the largest basin areas (155,000 and 795,000 km2 respectively) as well as the highest total volume of water flow. Other than that, each river system has its own distinctive characteristics, thus environmental management approaches may vary greatly from one river basin to another, depending on socio-economic conditions, land use, environmental factors, and their economical and ecological values, .etc.

In this short review, 3 river basins chosen to focus on are of the Cau, Nhue-Day and Dong Nai river. The Cau river, a large river of the Thai Binh river system, is 288 km long and passes through Bac Kan, Thai Nguyen, Vinh Phuc, Bac Giang, Bac Ninh, Hai Duong provinces and Hanoi before it merges with Thai Binh river. The whole river basin area of Cau river and its branches is originally rich in natural resources such as forests, minerals, etc. However, those natural resources have rapidly depleted together with the economic growth of the provinces along the river. Many human activities such as mining, agriculture, establishment of craft villages, ...continue to add more pressure on the natural resources. Moreover, the population density of the Cau river basin is twice as high as the average population of Vietnam (427 per km2) and is unevenly distributed between the rural and the urban areas. Although the GDP of the provinces along Cau river has recently rise up, there is a reduction in environment condition here.

Nhue-Day river system includes Day river, which is linked with the Red river but has its own basin with tributary rivers such as Nhue, Tich, Thanh Ha, etc. The Nhue-Day river basin

(7,665 km2) stretches from the mountainous Ha Tay, Hoa Binh provinces to Ha Nam, and finally to the coast Ninh Binh, Nam Dinh provinces. After dam construction and reform, the Day river (237 km) is now a draining river and serves to diverge floods in the rainy season. The Nhue-Day river basin, which mainly is plain, creates many advantages for building and economic development. In addition, many branches (Tich, Thanh Ha, Hoang Long river) flow through towns, cities and industrial zones and provide important water sources for agriculture and industrial production. Again, the population density of the basin is about 3.5 times higher than the national average, with most of the population concentrates in Hanoi, Ha Tay and Nam Dinh. In recent years, the expansions of big cities like Hanoi and Ha Tay, together with the spreading of residential areas, industrial zones, and craft villages have brought up the GDP of provinces along the Nhue-Day river system. At the same time this economic development has put the river environment in great danger.

Different from the 2 river systems described previously, Dong Nai river system flows in the south Vietnam and passes through 11 provinces and cities in total. That includes HCM city, Lam Dong, Binh Phuoc, Binh Duong, Tay Ninh, Dong Nai, Dak Nong, Long An, Ba Ria-Vung Tau, Binh Thuan and Ninh Thuan provinces. The river basin covers an area of 14,800 km2 and has 266 rivers and streams of over 10km each. The Dong Nai basin system is reach with minerals resources such as gold, iron, tin, zinc, etc. which are being exploited rapidly. Besides mineral resources, this basin system is also covered by tropical forests with a great biodiversity of tropical ecosystems. These forests also protect the area from flash-flood in the rainy season and maintain water lever for Dong Nai river in the dry season. However, fast urbanization in the basin and the high growth rate of the population have contributed to gradual deforestation. Although the basin has a rapid economic development and urbanization, the environment is concerned and protected to an extent. As a result, this is considered one of the economic development regions which have achieved fast and sustainable economic growth.

The current state of Vietnam river basins pollution

After the Renovation, Vietnam has been developing nonstop in economy. However, this economic development is faster than the establishment of the infrastructures. As a result, growth puts increasing pressure on the environment in general. The river systems' environment also shares the same fate; many reports have described the dramatic decrease of river water quality and the high concentration of various toxins in the water. The level of pollution varies among different river systems and also among different parts of one system. In this part, the particular situations of the 3 concerned river basin systems are described separately.

In general, the surface water of Cau river is locally polluted by organic pollutants, suspended solids and oil waste. In the section passing through Bac Kan province, the river is polluted heavily with BOD5 and suspended solids. The part flowing through Thai Nguyen city is probably polluted the most, due to the untreated waste water released by heavy industrial factories, paper mill, mining (gold and coal mining) and agriculture activities along the river. Pollutants in this part of Cau river are mainly organic compounds (eg. Nitrogenous compounds) and oil compounds which give the river a distinct oily smell. The river section from Vat bridge to Pha Lai has been severely polluted with organic substances and the level of pollution becomes far higher than the permitted standard. This organic pollution was caused by waster water from domestic, urban and tourism activities as well as oil pollutants

from industrial waste. Moreover, this part of the river system has many craft villages established along the bank. These villages mainly focus on food processing, animal husbandry, paper recycling, scrap recycling, metallurgy, etc. and waste water is often discharged directly in to the river.

In comparison to the Cau river, the Nhue-Day river basin is facing an alarming level of pollution caused by the release of waste water from domestic, industrial, agricultural and aquaculture activities. In the case of the Nhue river, since the To Lich river heavily polluted water mixes with the Nhue river, the section flowing through Ha Dong of Nhue is tainted with COD and BOD5 at a level 4 times higher than the standard. The Nhue river after the confluence point with To Lich has water darken with scum, sludge and has a fishy smell. This condition only worsen in the dry season as the pollutants are less diluted. Moreover, the pollution of the Nhue river causes a chain reaction which leads to pollution of the Day river, since the 2 rivers are linked. The section of Day river from Ha Dong to Phu Ly town is mainly polluted with organic substances; however, the flowing section to Hoang Long suffers from both Nhue river's pollutants and waste water discharged from Phu Ly town. To sum up, the Nhue-Day river basin is one of the most polluted basin systems in Vietnam with domestic waste water contributing 56% of the river total volume.

Similarly to the 2 described river basins, the Dong Nai river basin is also severely affected by pollutants resulted from fast economic growth with little regard to environmental issue. Especially, the downstream section of Dong Nai is heavily polluted with organic, suspended solid substances and has lead concentration few times higher than the permitted limits. The water downstream is also seriously salinized to the point that can not be used for domestic and agricultural purposes. In the part of Sai Gon river system, rivers are severely polluted with organic pollutants (eg. N-NH4+ level is about 30 times higher than VN standard), coliforms (3-168 times higher than permitted limit) and heavy metals (eg. Fe content in Be river: 10-12 times higher than VN standard). The most critical case is Thi Vai river, which is highly contaminated with mercury, zinc, organic compounds, etc. With this severe pollution, almost all species are unable to survive and the river is now a dead river.

Water quality management

As described in the previous parts, many of the river basins in Vietnam are now suffering from heavy pollution level. Therefore, protecting the river basins' environment is a crucial part in water resource management. However, water quality management in river basins meets many difficulties. They include the unclear definition of responsibilities and competences among ministries and sectors; the lack of mechanism to acquire resources from private, non-governmental, international organizations and communities in water resource protection, etc. Recently, environmental legislation has been adapted by the Vietnamese government to support the water source protection. Some of the most important laws are the Law on Environmental protection (2005), the Water resource law (1998), the Land law (2003) and Systems of Vietnamese Standards – river/lake water quality standards. Although, the environmental legislation has provided the activities of water resource protection a legal ground, the application and implementation of those laws are still limited and inadequate.

Water quality management of the river basins is separated to 2 levels. In the national level, the Ministry of Natural Resources and Environment (MONRE) was established in 2002 with the main task of preparing master planning on water resource protection, management and use in

the principle river basins. With this task, the MONRE has promoted institutional preparation for effective water management and submitted to the Government for issue. In addition, MONRE has also contributed many guidelines for environmental legislation improvement. At the regional level, the provincial Departments of Natural Resources and Environment (DONREs) have been established. Therefore, the water quality management started with focusing at the localities. However, these local organizations have no common voice, unity or close cooperation in water resource management, thus their activities still have little effect on improving the river basin environment. Some of them even have the wrong concepts of environmental protection purposes for the river basins and their responsibilities in organizing environmental protection in the local river basin.

Another important step in water quality management is examination and inspection. This is an important action to ensure that the environmental laws are being obeyed and protect the river basins of the illegal waste water discharge from industrial zones, craft villages and domestic uses. The importance of this step has been emphasized by the incidence of Thi Vai river, where Vedan company had illegally released untreated waste water for 14 years before being exposed earlier this year. Even though this release of waste water has been stopped but Thi Vai river has turned to a "dead" river which will take billions to restore its water quality. These billions would not be wasted if only the illegal activities were discovered earlier. The inspection can be periodic or spontaneous; also there are insitu inspection in which the industrial zones and establishments analyse their own environmental conditions and exsitu inspection carried out by MONRE and/or DONREs. The inspection activity also helps identifying the economical activities which release the most contamination into the river basins, as well as companies causing serious pollution and ones having environmental friendly practices. From the result of inspection and examination, legal activities can be applied to establishments which purposely breach environmental laws and adjustment would be considered to ensure a sustainable economic development in Vietnam river basins. However, in fact both water quality management planning and inspection activities are limited since the environmental protection organizations' lack of man power and financial resources. Moreover, the environmental legislation is still developing, and needs years of experiment and correction to tightly regulate the activities of water resource management.

Some priority solutions to protect the water environment of river basins in Vietnam

As mentioned in the previous parts of the report, the level of pollution in river basins is increasing rapidly together with the fast growth rate of the economy. In this situation, preventing increased pollution and restore the polluted rivers to their previous condition are urgent tasks. The common solutions for these tasks are improving legal regulations, management and inspection activities, cleaning technologies and public awareness. Firstly, the law on water resources are needed to be revised to give clearer definition of responsibilities and coordination mechanisms between central and local authorities, among ministries and among local governments of provinces in one river basin. Moreover, an environment protection mechanism for one particular river basin with clear indication of environmental problems and provision of codes of conduct for relevant parties should be stated for every river basins. In addition, the inspection and monitoring system should be strengthen. Not only the enterprises that cause serious pollution are carefully investigated, the establishment of potential new pollution sources should be strictly banned. The governmental organizations have to carry out regular environmental inspection and investigation; moreover, the government should encourage the enterprises to implement self-monitoring programs and

regulations according to the Law of Environmental Protection (2005). Beside the industrial zones, the local water environmental protection organizations should cooperate to give careful measurements of pollution generated urban domestic activities. The fees on waste water discharged should also revised and issued basing o the principle "polluters pay". The fine collected would then be invested on improving environmental technologies as well as man power in environmental protection organizations. Public awareness is an important part in improving the water environment protection. As the residents in the river basins aware of the conditions of the basins and how that affects their lives, they would be more responsible and participate in protecting the surrounding environment.

In the particular cases of the 3 river basins concerned in this report, the solutions are more specific regarding the different conditions of the 3 basins. For Cau river basin, the immediate action should be to treat waste water released from industrial and mining activities in Bac Kan and Thai Nguyen, waster water from Bac Giang and Bac Ninh craft villages and domestic waste water from cities along the basin. The most serious polluted areas in the basin should be more concerned and controlled and investment permits for industrial activities such as mineral exploitation and paper pulp production should be strictly limited.

In Nhue-Day river case, the treatment of domestic waste water from Hanoi and other cities should be focused on. Moreover, a strict control should be applied to severely polluted areas such as To Lich river. In this basin, 5 industrial types that threaten the water environment (cassava starch processing, basic chemicals production, dying, leather tanning and paper pulp production) should be carefully considered before permission.

Finally, in Dong Nai river basin a similar treatment of domestic waster water should be applied not only to HCM city but also to other cities in the same basin. Several heavily polluted areas like Thi Vai river, Sai Gon river, Tay Ninh canal, etc. should also be strictly controlled like in other basins. However, there are 5 industrial types that should be temporary banned from this river basin instead of limiting like in others. They include cassava starch processing, rubber latex processing, basic chemicals production, dying and leather tanning. At the same time, there are 5 other industrial types whose investment permission should be limited. These are plating industry, fishery processing, agricultural chemicals production and fertilizers production, and paper pulp production in Thi Vai river basin.

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Water Quality Monitoring and Water Quality Situation in Thailand

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Thailand can be divided into four main geographical regions: the North, the Central Plains, the Northeast, and the South. The North is mainly mountainous which serves as the origin of four major rivers (Ping, Wang, Yom, and Nan) which converge to become the Chaopraya River, the lifeline of the Central Plain. The South covers a number of short rivers and coastal areas. The Northeast occupies one-third of the country's total land area and is the most populous and lowest income region. Large parts of this region regularly experience standing with periods of floods and alternating with periods of drought. In term of geographic feature, there are total 25 river basins in the country. The side of the basins is difference from basins to basins.

The results of water-quality monitoring program showed that most receiving waters were still compiled with the national water quality standards. However, rivers in populated areas were polluted due to the excessive discharges of wastewater from various point sources. Thus, mitigation measures such as construction of wastewater treatment plants, solid waste management, agricultural waste management, industrial waste control, and management of other pollution sources are required.

In Thailand, water pollution from land-based activities is largely associated with urbanization, industrialization, and agricultural activities. Thus, the major sources of pollution are domestic sewage, industrial wastes, and agricultural wastes. The main pollutants that pose to natural water quality problems are organic wastes, bacteria, nutrients, and other chemical substances. Observation of water quality for the receiving waters was carried out in terms of dissolved oxygen depletion, fish kills, high ammonia nitrogen, high coliform bacteria, and occurrence of eutrophication phenomena. The major impacts of water pollution are the deterioration of water supply sources, effect on aquatic ecosystem, and public health. As a consequence, sources of water supply become scarce whereas the demand is rapidly increasing. The surveillance and monitoring program of receiving waters are therefore very important to assure the good water quality status for aquatic ecosystem as well as protection the human health effect.

Water Quality Monitoring

There are many water quality variables that causes water pollution problems, such as BOD, nutrients (nitrogen and phosphorus), toxic substances, bacteria, and solids. There are total 28 variables in the National Surface Water Quality Standards. Surface water quality were surveyed and designed for monitoring program. The program has been implemented since in 1980. Sampling stations were identified into two sources: surface and ground waters. There are totally 368 station s in 48 river in the country. Water quality samples were taken 2- 4 times a year covering wet and dry seasons. Water quality parameter measured were physio-chemical parameters (pH, turbidity, conductivity, total suspended solids, total phosphorus, total solids, biochemical oxygen demand (BOD), dissolved oxygen (DO), nitrate-nitrogen, heavy metals), and biological parameters (fecal and total coliform bacteria).

The method of water sampling and analysis procedures were followed the Standard Method for the Examination of Water and Wastewater (1998). The quality assurance/quality control (QA/QC) was also performed during the analysis.

PCD has also operated 28 automatic sampling stations along major rivers in the country. The water quality information can be measured using continuous real time system. Each station measure only basic water quality variable such as temperature, pH, conductivity and DO.

Water Quality Standards

The ambient water quality standards has been established since 1994 and served as guidelines of supposing the receiving waters based on major beneficial uses. The surface water quality standards are classified into 5 classes as follows:

Class 1: Extra clean for conservation purposes
Class 2: Very clean used for (1) consumption which requires ordinary water treatment processes (2) aquatic organism conservation (3) fisheries, and (4) recreation [DO > 6 mg/L, BOD < 1.5 mg/L, Fecal Bacteria < 1000 MPN/100ml)
Class 3: Medium clean used for (1) consumption but passing through an ordinary treatment process and (2) agriculture [DO > 4 mg/L, BOD < 2 mg/L, Fecal Bacteria < 4000 MPN/100ml)
Class 4: Fairly clean used for (1) consumption, but requires special treatment process and (2) industry [DO > 2 mg/L, BOD < 4 mg/L)
Class 5: Waters are not classification in class 1-4 and used for navigation

The details of the National Surface Water Quality Standards are shown in Appendix.

Water Quality Situation

The main pollutants that pose to water quality problems are organic wastes, bacteria, nutrients, and solids especially in the lower parts of the central river basins. The water quality has been less than the Surface Water Quality Standard and its classification. The major water quality problems were high coliform bacteria (in term of total and fecal coliform bacteria, 34 %), high solids (in term of turbidity and total solids, 31 %), total phosphorus (TP, 15%), low dissolved oxygen (DO, 12 %), Ammonia-nitrogen (NH_3-N, 6%), and high organic matter (in term of biochemical oxygen demand (BOD, 2 %), as shown in Figure 1 and 2 (Simachaya, 2002). Generally speaking, these problems were perceived to be most serious during summer low flow periods when there is minimal dilution capability available.

Water Quality Policy

The National Economic and Social Development Plan for 2007-2011 and the National Environmental Quality Plan for 2007-2011 continue to emphasize the rehabilitation of natural resources and the environment by strengthening environmental management and increasing local and community participation. Under the plans, policies for water environment aim to accelerate the rehabilitation of water quality in major water resources, to reduce and control water pollution originating from domestic, industrial, and agricultural activities, to apply the polluter pays principle, and to promote and support private sector investment in solving water pollution problem. The goal of water quality of the water bodies in the country was set up to comply with the ambient water quality standards under fair and good condition of not less

than 85 % of water bodies in the country. Under those plans, area approach for water resources management is concerned. This should be integrated water quantity, water quality and relate resources as a whole basin or a boundary of geographical area. The best practices of water quality management in developed countries are implemented under basin approach. The approach is included the following step: (1) identifying basin uses, (2) setting appropriate water use and water quality targets, (3) determining the current "state of the basin", (4) identifying specific issues and management options, and (5) developing a process for public consultation (Heathcote, 1998).

In Thailand, there is no such integrated approach applied to water environment management since 2000. The management has been separated between the quantity and quality of water due to agency responsibilities and their respective regulations. For major rivers in the country, observed water quality problems were dissolved oxygen depletion, fish kills, high ammonia nitrogen, high coliform bacteria, and eutrophication phenomena. Generally speaking, these problems were perceived to be most serious during summer low flow periods when there is minimal dilution capability available and first flush of high flow periods. Thus, once water quality problems have been identified, it is necessary to develop targets for restoration to undertake the planning exercise on a basin-wide basis (Wijarn, 2000). The strategy and plan should identifies key areas for water quality improvements as well as a framework of actions for interested stakeholders, including: (i) ensuring better environmental governance through institutional restructuring, compliance, and decentralization; (2) introducing a sustainable financing mechanism, i.e Polluter Pays Principle; (3) promoting more active community participation in water resource management ; (4) improving waste and wastewater management in large cities in the country; and (5) improving water environment of the major river basins (World Bank, 2002).

Management Approaches and Implementation on Water Quality

Command and Control

Command and control is usually normal approach to control waste discharges from point sources of pollution which is based on European and American pollution control models. In Thailand, this model has been implemented with the establishment of effluent standards and their subsequently enforcement. The lists of parameters and values of each parameter of effluent standards can be found at http://www.pcd.go.th/. Number of effluent standards from point sources of pollution have be established such as factory, industrial estate, building, pig farm, gas station, and shrimp pond. The size of point source pollution has also been classified and implemented the effluent standards. From the results of monitoring the discharges by PCD, some point sources have not been complied with the effluent standards especially from agricultural activities. Thus, PCD is currently developing a compliance assistance centre to assist the polluters. The pilot program has been established for pig farm.

Wastewater Treatment and Disposal

The Government of Thailand has made slightly progress in collection and treatment of urban wastewater over the past decade compared to other countries in the region. Wastewater management services are currently provided by the local government authorities, although

agencies of the central government play the dominant role in sector planning and funding. Under investment in environmental infrastructure is clearly evident in the municipal wastewater management sector. Only a small proportion of total urban wastewater generation presently receives any treatment. At present, Thailand has 95 central wastewater treatment plants installed in large communities and major tourist attractions. The 70 treatment plants, total capacity about 1.13 million m3/d, are in operation, total capacity about 1.87 million m3/d, are now under rehabilitation and construction. These facilities will finish within the year 2008. As a result, the estimated total capacity about 3 million m3/d of wastewater or approximately 21% of total generated domestic wastewater in Thailand (14 million m3/d by 2003) will be treated properly before discharging into receiving water. However, there are still large amount of untreated wastewater drained into the environment causing many vital water sources to gradually deteriorate.

Although, the government's achievement in addressing urban wastewater management in the country are praiseworthy, there are many problems behind that such as wastewater fee collection, operational and maintenance the facilities, efficient technical staff, and non-functioning equipment. The main problems have been identified as the poor performance in operating and maintaining of wastewater facilities due to the lack of funding and suitably qualified staff. However there are still difficult political and social obstacles to be overcome in the introduction of effective, sustainable funding of wastewater facilities, including the perceived low willingness for beneficiaries to pay for wastewater services and the general unwillingness of the water supply sector to combine collection and billing of charges for water supply and the resulting wastewater. Currently there are three local organization authorities utilizing the wastewater tariffs and a few more are working toward the idea. Due to the economic crisis in Thailand and problems of the large central treatment facilities in Samut Prakarn, implementing wastewater treatment facilities have been reduced.

For industrial source, there are more than 120,000 factories and about 30 industrial estates in Thailand. Industrial wastewater management services are mainly undertaken and funded by individual industries. Only industries located in designated Industrial Estate can discharge their influent, after pretreatment, to the central wastewater treatment facility provided by the Industrial Estate Authority of Thailand (IEAT). From monitoring program by PCD, some treatment facilities are not functional and the discharges are not complied with the effluent standards.

Voluntary Approach

The Cleaner Production (CP) is most popular of voluntary approach that initially starts as a tool for industrial sector to prevent pollution from its sources. Currently, the concept has been expanded into various sectors which include processes, products and services. CP is also the backbone in "Sustainable Consumption and Production" which is the umbrella method supporting sustainable development. The Thai Government has developed the National

Cleaner production Plan for the year 2001-2009. The vision of the plan states that "Principle of cleaner production will be applied to all activities with efficiency for the achievement of production, reduction and control of pollution, natural resources and environmental management, quality of life with benefits from the country development". Since then, CP has been widely applied to reduce waste discharge from industries in pilot areas such as factory in the Thachin and Songkla Lake basins. Ministry of industry has also promoted cleaner production for small and medium enterprises (SMEs). The government is currently developing the green procurement to support waste minimization.

Basin Management

The basin management approach can support the concept of protection of the water environment by keeping pollutant loads to the environment within carrying capacity of the natural purification process. This approach incorporates with water quality and quantity, aquatic resources and land development. Human activities as well as natural events that occur in a basin or watershed can effect water quality throughout the entire system. The basin approach is a coordinated and integrated method to link science, waste discharges under permit system, and other water pollution control and prevention activities to meet the goals or water quality standards. The Pollution Control Department (PCD) has developed master plans for water-quality management for all 25 river basins in Thailand. In the water quality management plans, major river basins were undertaken which mainly include wastewater management in the plans. Priority to construct wastewater treatment facilities in municipalities was principally recommended as well as the controlling of wastewater from industrial and agricultural sources. Water quality modeling and the geographic information systems (GISs) have also been continually developed and used as the tools to help decision-makers in water quality management processes.

Currently, local municipalities carry out the role of river and basin management. There is no single administrative body that takes responsibility for planning and management of the basin as a whole. Consequently, basin management and planning is typically uncoordinated and carried out without due consideration for upstream and downstream effects. Up to now, integrated water resources management such as basin management, has not yet been put into practice in Thailand. PCD has been taken a leading role by firstly developing a water quality improvement master plan at the Thachin River Basin as a whole basin in 1996 and then initiating implementation of the action plan since 2000. Since then, there is not much progress due to the lack of cooperation and budget availability especially for construction treatment facility at the lower part of the basin. Currently, water quality of main stem of the Thachin River is still severely polluted and the quality of water is less than the level of water quality standard especially in the middle and lower parts of the river due to excessive organic loads.

Public Participation

Public participation in water quality management in Thailand is becoming more progressive especially in the water quality monitoring activities. The volunteer or civil society groups were formulated. The volunteer groups monitor the conditions of streams, river and lakes. They want to help for protection of water resources for beneficial uses. Many projects aim at raising awareness of basic water management issues, human and nature links and the importance of water quality to aquatic life, plus integrating local environmental studies into the school's curriculum in line with national educational policy such as in the Songkarm River in the northeastern and the Thachin River in the central parts of the country. Development of water curriculum is also the challenges to encourage school to bring their children to learn about the environment problems situation. When they knew the situation, they will participate to solve the problems. In Thailand, public has been participated as volunteers in various activities such as litter cleanup, water quality monitoring, macroinvertebrate sampling, tree planting, stream inventory, and educational exhibits. The civil society or non government organizations (NGOs) have been established in some areas for implementing some activities related to water issues.

Partnership Formulation

In 2002, the Director General of the PCD, and the four Governors from provinces in the Thachin River Basin agreed to cooperate for restoration the basin by signing the Partnership Agreement of the Thachin River Basin. It aims to cooperate of reducing waste loads from various sources of pollution in their political boundaries, to monitor water quality, to establish the center of Thachin database, to promote and support public participation, and to support for implementing the Thacin Rehabilitation Plan. The meeting of the Partnership was set once a year to evaluate and review of the implementation plan. However, the Partnership Agreement was not maintained and the governors were transferred from the basin. Beside, partnership between government agencies and private sector should also be established especially with major polluters in the basin while public can participate and monitor the progress of action plan implementation (Wijarn, 2003b)

Conclusion

Currently, surface water quality in the most part of Thailand can be considered as fair conditions, while some rivers flowing through large communities are adversely. Water quality problems are affected by domestic and industrial wastewater discharges, agricultural point and non-point source discharges, deforestation, and development projects. In many parts of the country, surface water quality is severely polluted which has affected aquatic resources, water uses for various proposes as well as human health. Enforcement of relating regulations has to be seriously practices. To management water quality in the whole watershed, integrated approaches should be taken into account in future such as ecosystem approach. Public participation should be also promoted.

Thai government has launched many projects to resolve these problems, few of these attempted to take a basin-wide approach. Most actions to date have been local in nature, with the result that water quality continues to deteriorate in the river. Currently, the most urgent water quality problems relate to dissolved oxygen depletion or excessive organic loads and high loadings of ammonia and bacteria, primarily from agricultural and domestic sources. The government has put in place policies, plans and water quality standards in an effort to combat the problem and has embarked on an ambitious program for the management of water pollution generated from various sources especially municipal sources. But a lack of an integrated approach combined with laws that go no enforcement, weak capacity, insufficient investment, and poor operations and maintenance systems have exacerbated the problem. Limited community participation and low involvement of the private sector has further pushed the onus on the government.

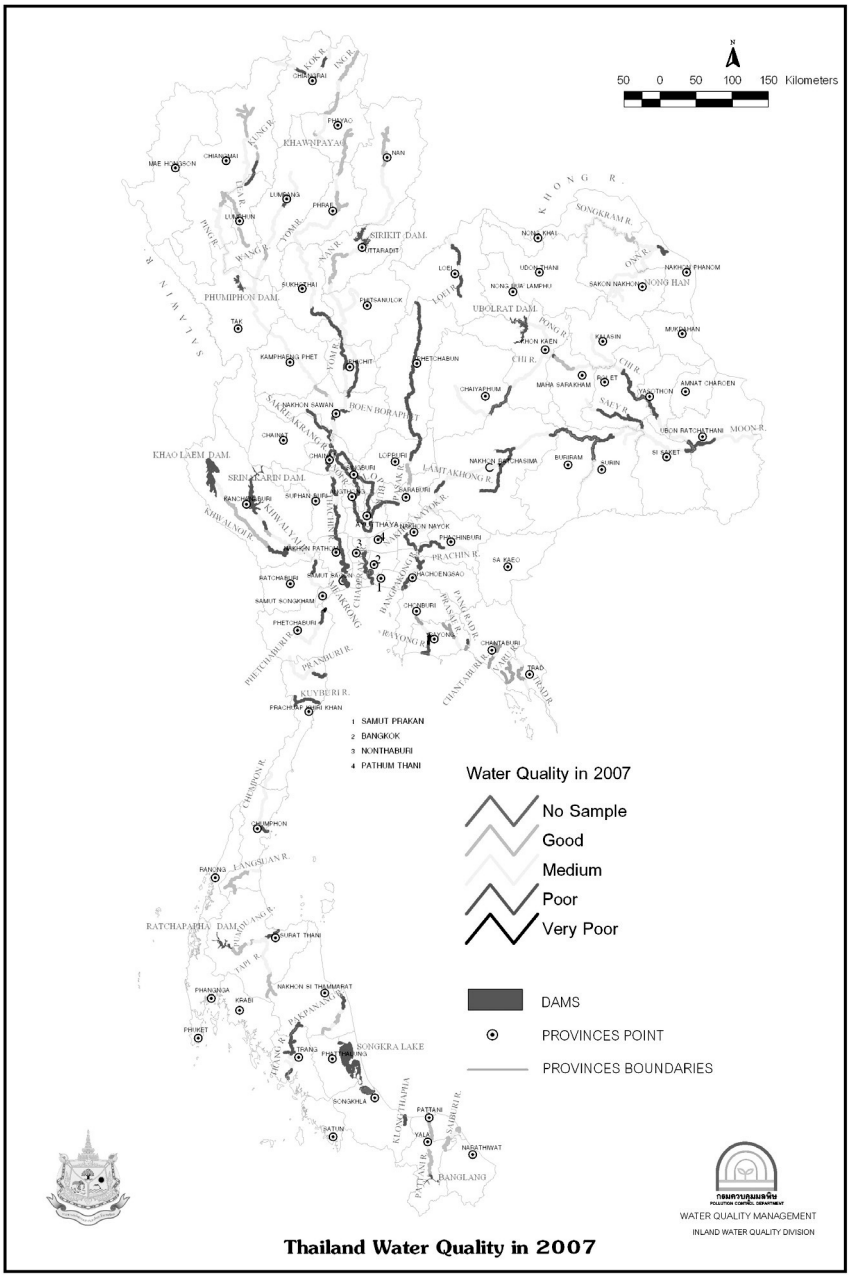
Recommendations

To maintain and improve water quality in major rivers in Thailand, the following recommendations should be considered:

- Since many pollution problems occurred as a result of improper land use in the basin. Regional water quality planning at basin level is required because it provide logical areas for water quality management. Basin is natural system with readily identified boundary. The basin approach for water quality management should be applied because it highlights the connection between land, water, and people. Water quality is impacted by population growth, industrial development, agricultural production, and urbanization and development. This approach incorporates on both point and non-point sources of pollution control. Thus, the implementation of basin-wide total pollutant loads controls should be considered.
- As agriculture is a dominant land use in most of river basin in the country and is thus an important source of pollution to the basin wide. Intensive study of water quality degradation due to non-point sources of pollution is needed to be investigated.
- Waste load allocation should be applied to management wastewater discharges from various sources of pollution. This depends on the assimilative capacity of the receiving water body and guidelines to attaining receiving water quality standards.
- Economic instrument for water pollution control should be applied. These instruments can provide incentive that will result in a changed behavior of water users and polluters such as pricing, tax etc.
- A water quality model and a geographic information system (GIS) should be applied as a tool for water quality management. These technologies can assist stakeholders in evaluating the impact of various management scenarios base on priority or strategies and land use changes on the basin.
- Government should promote public participation on water quality management. Partnership program between government agencies and public or private sector should also be

developed. This will help government agencies for implementing the water quality action plan.

- To address water pollution, Thailand should develop an integrated approach for water resources management. This will involve:
- fostering local community participation in water resources management;
- harmonizing functions and regulations by addressing overlaps in institutions and jurisdiction,
- improving the efficiency of budget allocation and rationalize investments for the wastewater and water resources management sectors; and
- promoting opportunities for private sector participation and public awareness about the state of water environment.



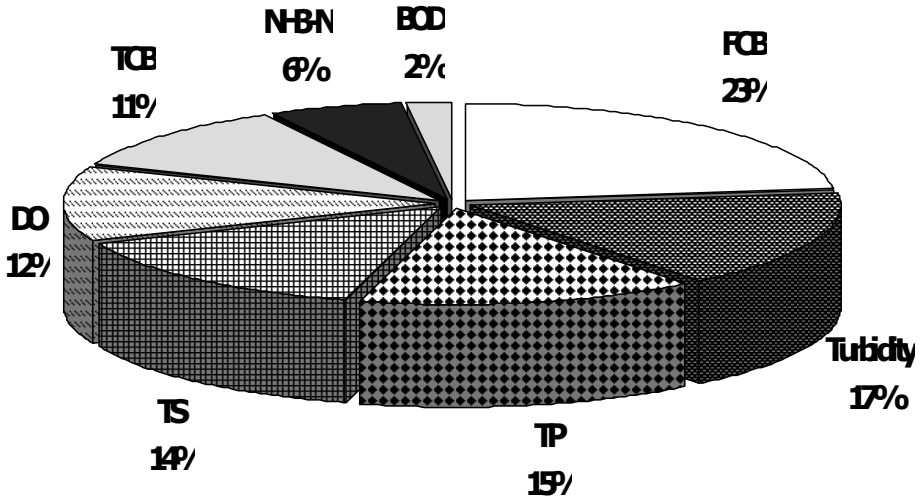


Figure 2 Water Quality Problems of Surface Water in Thailand, 2007

Appendix

Surface Water Quality Standard in Thailand

Parameter	Units	Statistic	Standard Value for Class***				
			1	2	3	4	5
1. Colour, Odour and Taste	-	-	n	n	n	n	-
2. Temperature	C	-	n	n'	n'	n'	-
3. pH value	-	-	n	5-9	5-9	5-9	-
4. Dissolved Oxygen	mg/l	P20	n	6	4	2	-
5. BOD (5 days, 20 C)	mg/l	P80	n	1.5	2.0	4.0	-
6. Coliform Bacteria							
- Total Coliform			n	5000	20000	-	-
- Faecal Coliform	MPN/100ml	P80	n	1000	4000	-	-
7. NO - N	"	P80	n		5.0		
8. NH -N	mg/l	Max.allowan	n		0.5		
9. Phenols	"	ce	n		0.005		
10. Cu	"	"	n		0.1		
11. Ni	"	"	n		0.1		
12. Mn	"	"	n		1.0		
13. Zn	"	"	n		1.0		
14. Cd	"	"	n		0.005*,0.05**		
15. Cr (hexavalent)	"	"	n		0.05		
16. Pb	"	"	n		0.05		
17. Hg (total)	"	"	n		0.002		
18. As	"	"	n		0.01		
19. CN^-	"	"			0.005		
20. Radioactivity	"	"	n		0.1		
- Gross α		"	n		1.0		
- Gross β	Becqurel/l	"	n		0.05		
	"	"					
		"					

Surface Water Quality (Continue)

Parameter	Units	Statistic	Standard Value for Class*** 1	2	3	4	5
21. Pesticides(total)		”					
- DDT	μg/l	”	n		1.0		
- α BHC	”	”	n		0.02		
- Dieldrin	”	”	n		0.1		
- Aldrin	”		n		0.1		
- Heptachlor & Heptachlor epoxide	”	”	n		0.2		
- Endrin	”	”			none		

Note : P = Percentile value
n = naturally
n' = naturally but changing not more than 3 C
* = when water hardness not more than 100 mg/l as $CaCO_3$
** = when water hardness more than 100 mg/l as $CaCO_3$
*** = Water Classification

Source : Notification of the Ministry of Science, Technology and Energy (B.E. 2537 (1994.)), published in the Royal Goverment Gazette, vol. 111, No.16ง, dated February 24, B.E. 2537 (1994)

Water Quality Monitoring and Management in Lao PDR: The Case Study of Nam Ngum River Basin

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Introduction

Lao PDR is in the midst of relatively rapid economic growth and natural resource development. Hydropower, mining and forestry are major areas of activity, while tourism, agriculture and fisheries are also developing and changing. Urban areas are also growing as population shifts and commercial and industrial development takes place. As a result there are increasing pressures on the environment and an increasing need to manage natural resources in a sustainable manner.

The country is generally rich in water resources. Total available surface water resources (including the flow of the Mekong River and its tributaries) are 55,000 m^3 on an annual per capita basis, the highest in Asia. However, little of the national water supply has been developed. Total storage capacity of large reservoirs is less than 3% of annual surface flow.

Up to the present time the focus of water quality work in Lao PDR has been on general environmental monitoring, project-related environmental protection (EIAs, EMPs, etc) and public awareness and education. The current rapid development of water resources and impacts on watersheds is now bringing about greater risks for water quality deterioration. Recommendations have been made in various contexts for improved water quality monitoring, modeling and other technical strengthening. However, rather than addressing individual areas of weakness, there is a need for a more systematic approach.

The objectives of this discussion paper are to:

- give a brief description of general situation and the issues affecting water quality in Lao PDR and particularly in the Nam Ngum River Basin;
- make recommendations regarding institutional arrangements on water quality monitoring and management, and other water quality related activities for further technical strengthening.

Water Quality Situation in Lao PDR

The Water Quality Laboratory of the Ministry of Agriculture and Forestry reports that over the past 15 years of monitoring, water quality in Lao PDR has generally been good and is not significantly affected by human activities. This is in agreement with a Mekong River Diagnostic Study by MRC which indicated that "water throughout the Mekong River Basin is generally of good quality, but there are localized exceptions."

However, with the pressure of rapid demographic growth, economic development and urbanization, water quality is increasingly likely to deteriorate. The major issues which may arise include:

- The installation of hydropower schemes pose some important water quality problems or risks. In most deep-water reservoirs in the tropics, in the first few years following impoundment, oxygen depletion will take place in the lower part of the reservoir. This situation is mainly due to thermal stratification and the decomposition of submerged biomass or organic matter (overhead vegetation and carbon contained in the soil). Water quality in the downstream river is strongly affected by water quality variations in the reservoir. If the turbined water comes from a single, low-level discharge from the reservoir, it will be low in dissolved oxygen (anoxic) and may be high in noxious compounds (methane, mercury, etc).
- Lao PDR is rich in mineral resources and is increasing its exploitation of these resources. In a number of parts of the country exploration, planning and actual mining are underway. Mining uses water in both the mining and ore processing stages, although little information is currently available on the amount of water which is consumed. Water use is not included in mining licenses. In some cases mines, processing areas and mine tailings (waste) storage areas are close to rivers and reservoirs.
- Population growth in cities, towns and villages leads to extensive municipal waste and organic matter release to waterways. No urban centers have access to comprehensive piped sewerage systems. Treatment and disposal of urban waste water is generally not satisfactory; most households rely on soak pits for wastewater disposal. Urban drains act as secondary sewers, carrying industrial discharges and septic tank seepage and overflow in the rainy season. As a result, water in the drainage system is invariably contaminated with faecal matter from latrines and coliform from septic tank effluent.
- The growing number of industries has increased the incidence and risk of pollution. The larger mills and industries of concern in Lao PDR are pulp and paper, timber, food processing, garment manufacturing and cement factories and gravel pits. Most of these have only limited wastewater treatment systems for reducing waste concentrations and loads in the final effluent discharge to waterways.
- Organic and nutrient pollution and sediment can be discharged from agricultural areas. These contaminants tend to increase during the rainy season's high runoff and river flows. The use of agricultural chemicals in Lao PDR is still relatively low and is expected to remain so during coming years, apart from areas of more intensive, commercial production, including animal production. Increased irrigation can lead to increased nutrients, pesticides and sediment entering waterways through agricultural drainage. An increase in the extent of irrigation can also open new areas for waterborne disease vectors (mosquitoes, snails).
- In mountainous areas, forest cover has been reduced by slash-and-burn agriculture, conversion of land to agriculture, road construction and logging. The main trend in slash-and-burn systems has been a rapid decline in the length of fallow periods due to an increased demand for land and resources. Rotational cycles have declined to as low as 3 – 5 years. Such short rotations ultimately degrade the soil and increase the time that steep slopes are exposed and susceptible to serious erosion, leading to sedimentation, changes in the downstream flow pattern and other impacts on the downstream water ecosystem.

If special precautions are not taken, pollution discharges and the resulting reduction of ambient water quality will increase in frequency and impact. Aquatic ecology will be particularly affected.

Water Quality Management Capacity in Lao PDR

Institutional Arrangements

The water resources in Lao PDR have been developed and managed by a number of line agencies. As part of this multi-sectoral system, some agencies carry out water quality monitoring, laboratory services, management of EIAs and other functions. The main agencies with responsibilities for water quality management together with the respective sampling stations and parameters monitored at their target sites are shown in Table 1 and table 2, respectively.

Water quality issues may be very important at a local level and involving small streams and other water bodies. These local issues may have a large impact on the safe water supply for human consumption and other uses, fisheries and other aspects of the environment. The most effective way to identify and deal with these local water quality problems may be through watershed planning and management.

Water quality monitoring is an important part of environmental monitoring under the MRCS Environmental Program. Water quality monitoring has been carried out for many years throughout the Mekong River Basin. MRCS has supported the monitoring and laboratory work of the Water Quality Lab (WQL) in the Department of Environment. Samples have been taken from a network of 19 monitoring stations throughout Laos and 18 parameters have been analysed.

Water quality data is forwarded on a monthly basis from WQL to MRC and forms part of the MRC water quality data base for the Mekong basin.

Table 1. Water Quality Management Agencies

National Agencies	**Roles and Responsibilities**
Department of Environment, WREA	DOE is responsible for providing overall environmental guidance and reviewing and approving environmental assessment reports. The Department sets ambient water quality standard and also effluent standard for domestic waste water.
Environment Quality Monitoring Center, ERI, WREA	Monitors and inspects environmental parameters such as: water, soil, air, radiation, noise, etc. in respect to development activities for adherence to environment standards.
Water Quality Laboratory, Irrigation Survey Design Center, Department of Irrigation, Ministry of Agriculture and Forestry	Operates a network of 19 water quality stations on the Mekong River and tributaries. Stations collect periodic samples and test for approximately 17 parameters. Data is forwarded monthly to the MRC Secretariat. Sampling and analysis methods are standardized among the four lower Mekong countries through a Water Quality Monitoring Network supported by MRCS.
Department of Meteorology and Hydrology	In some cases water quality samples are taken by DMH staff and forwarded to the WQL in the Department of Irrigation.
National Center for Environmental Health and Water Supply (Nam Saat), Ministry of Health	Control and management of environmental health related issues in both rural and urban areas, and rural water supply in country wide. The Center is in charge of (i) providing technical support, coordination and services in rural water supply and urban and rural sanitation based on the sectoral policies enacted by the Minister of Health, (ii) control the quality of drinking water in rural areas and (iii) planning and design of rural water supply and sanitation systems
Factories Environment Division, Department of Industry, Ministry of Industry and Commerce	Responsible for environment in factories, pollution control, inspection and monitor including environmental audit program, Environmental Impact Assessment. The Division also sets regulations for the control of wastewater discharge from factories.
Waterways Administration Division, Bridge and Road Division, Ministry of Public Works and Transport	Responsible for hydrological data collection and water quality sampling at some hydrological station (e.g. Luang Prabang, Savannakhet and Pakse) Samples are forwarded to the Water Quality Laboratory, MAF.
Food and Drug Quality Control Center, Ministry of Health	Analysis of chemical contaminants in food and also in drinking water samples.
Water Supply Authority, Department of Housing and Urban Planning, Ministry of Civil Work and Transportation	draft sector policy, regulation, standards, technical specifications and performance indicators regarding the urban water supply and waste water management.
National University of Laos, Faculty of Civil Engineering and Department of Chemistry	Providing technical knowledge on water quality analysis through academic programs, including practical researches and services
Private Sector (Developers)	responsible for water quality monitoring and management and are required to submit the environment monitoring program report to the Environmental Impact Assessment Division, Department of Environment, WREA. Details of the water quality monitoring requirements of other major projects (dams, mines, etc) are contained in the (Environment Management Plans (EMPs) of individual projects.

Table 2. Agency Water Quality Monitoring Activities

Institution	Types of samples	Number of stations	Parameters monitored
Dept of Irrigation (MAF) Analysis conducted in Water Quality Laboratory	Surface water Ground water Industrial waste water	23 (surface water, 17 of which are part of MRC WQMN) Ad hoc samples taken from surface, ground and waste water as required	Gasses: DO Dissolved salts: Ca, Mg, Na, K, Cl, SO_4 Nutrients: (NO_2 & NO_3), NH_4, PO_4, TP, SiO_2 Organic Matter: COD_{Mn}, COD_{Cr} Inorganic trace elements: None at present, but plans for As, Hg, Cd, and Pb
Environment Dept. (STEA)	Waste water (urban/industrial)	11 (Vientiane municipality) 3 (Vientiane province)	TSS, TDS, BOD, pH
M. Industry and Commerce (MIC)	Industrial effluent (samples collected by Dept. of Irrig or STEA)	*Ad hoc* sampling (*Project specific or for special purpose*)	Parameters monitored are mainly related to industrial waste monitoring.
M. Energy and Mines	Surface water from Hydropower dams	*Ad hoc* sampling (*Project designed upon specific purpose such as hydropower dams*)	Parameters monitored are almost temperature, pH, EC, major ions, nutrients, DO, Si and COD.
M. Public Health	Rural water supply	*Ad hoc* testing for ground water and newly drilled bore holes, and surface water sources used in public water supply	Fe, Cu, Ba, pH, EC, TDS, NO_3
M. Public Health, Pesticide Laboratory	Surface water	(*Ad hoc* testing)	Organic Compounds: Pentachlorbenzene, Hexachlorbenzene, Haptachlor. Endrin, Dieldrin, α-HCH, β-HCH, γ-HCH, p,p-DDE, p,p-DDD, p,p-DDT, o,p-DDT, α-Endosulfan, α-Chlordane, γ-Chlordane, Pentachloroaniline, Quintozene and Diazinon, plus 3 organophosphorous pesticides: Mevenphos, Dichlorvos, and Parathion.

Source: The Water Quality Monitoring Network – Water Quality Analysis, Vientiane Laboratory

Policy and Legislation

The major policy and legislation on water quality is the Law on Environmental Protection (LEP) (adopted 3 April 1999) and related legislation.

Water and Water Resources (adopted in 1996) determines principles, rules and measures relative to the administration, exploitation, use and development of water and water resources. In water quality context, it states that the Government will set standards for waste water discharge. It prohibits the discharge of waste and waste water which lowers the quality of the

receiving water source. The relevant Government agencies must set standards, must take into account the classification of the receiving water source, that water resource development is in accordance with approved plans, and that regulations are followed. This implies a complete water quality monitoring, planning and inspection / enforcement process.

Ambient water-quality guidelines for surface water have been expressed in the Draft Regulation for Adoption of Ambient Environmental Standards (1999) of the former Science Technology and Environment Agency (STEA).

Drinking water quality guidelines have been developed by the Ministry of Health in conjunction with WHO / UNICEF. The Decision on the Management of Quality Standards for Drinking Water and Household Water Supply (2005) defines standards for drinking and household water supply, including bacteriological, physical-chemical (aesthetic), and health-significant chemical parameters.

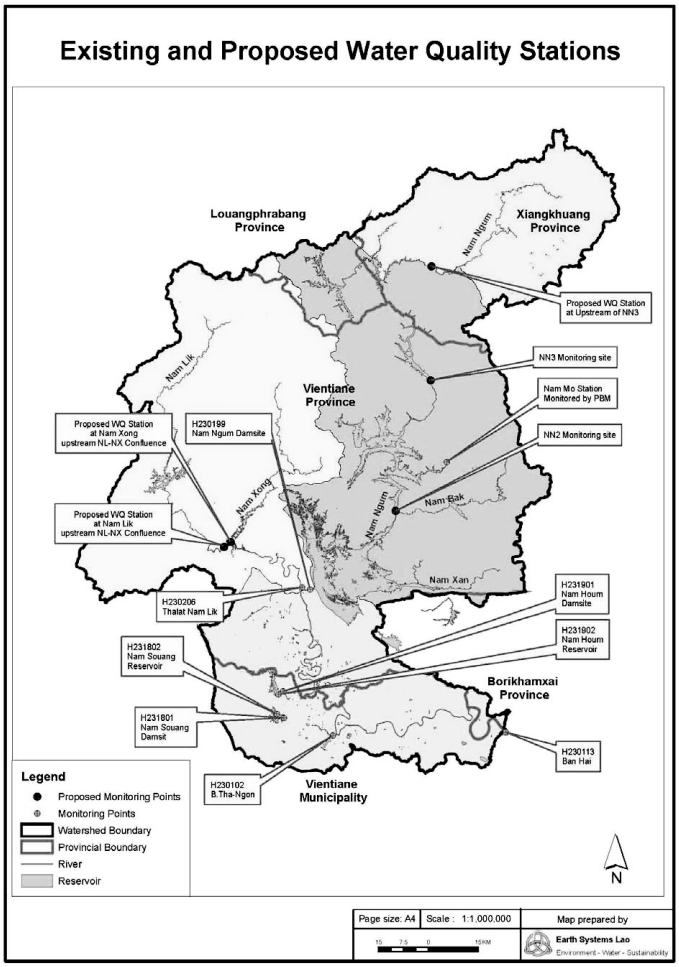
At the Mekong River Basin level, the Chiang Rai Agreement on Mekong River cooperation (1995) elaborates the international agreement to make every effort to avoid, minimize and mitigate harmful effects that might occur to the environment, especially the water quantity and quality, the aquatic (eco-system) conditions, and ecological balance of the river system, from the development and use of the Mekong River Basin water resources or discharge of wastes and return flows.

Water Quality Monitoring and Management in the Nam Ngum River Basin

General features

Nam Ngum River Basin is the forth largest sub-basin of the Mekong River within the territory of the Lao PDR. The basin is one of the most important in Lao PDR in terms of population, economic activity, water resources and water resource development.

The existing water quality monitoring sites in the Nam Ngum River Basin is shown in Figure 1 and the locations, parameters measured and length of record of the permanent monitoring network is shown in Table 3. Of the existing water quality monitoring stations in the Nam Ngum basin, four are on irrigation reservoirs off the main stream of the Nam Ngum and only two are on the main river – one on the Nam Ngum itself, below the NN1 dam, and one at Thalath (on the lower Nam Lik). One site (Tha Ngon) has been discontinued. The station at Ban Hai is on the Mekong River and not within the Nam Ngum basin.



Source: NN3 Cumulative Impact Assessment, Appendix C

Figure 1. Existing and Proposed Water Quality Stations, Nam Ngum 3 Cumulative Impact Assessment Study

Table 3. Description of Water Quality Monitoring Sites in the Nam Ngum River Basin

Code/ River/ Station	**Initiation**	**Parameters**	**Remarks**
H230199/ Nam Ngum/ Damsite	10/5/85	Temperature, pH, conductivity, major ions, nutrients, DO, Si and COD.	Samples are collected from the tailrace just behind the power station. The monitoring at this particular place aims at observing the behavior of the water quality discharged from the Nam Ngum reservoir throughout the year. Meanwhile, population in the upstream part is becoming denser and activities more diverse, including shifting cultivation, agriculture of various types, tourism, domestic use, mining productions and industries.
H230206/Nam Lik/ Thalath	14/3/88	Temperature, pH, conductivity, major ions, nutrients, DO, Si and COD.	There are intensive agriculture activities, including shifting cultivation is occurring near the sampling site. More agricultural activities are likely to happen upstream of the site in future. Additionally, mining quarries will be opened for lignite extraction and cement factories may be constructed. Water sampling will be maintained here.

Code/ River/ Station	Initiation	Parameters	Remarks
H231801/ Nam Souang/ Damsite	13/2/95	Temperature, pH, conductivity, major ions, nutrients, DO, Si and COD.	This sampling site was set up to monitor water quality used for irrigation and agriculture, fishery and domestic use. Water is always clear. Water in the reservoir is stored during wet season and released during dry season to enable a secondary crop. About 50% of the water flow through the canal discharges into the Nam Ngum river some 10 km from this point. Agriculture is practiced and consists of paddy rice field and grazing land. The major water quality development issues upstream of this sampling station now, or in future are likely to be tourism development, future resort facilities, fish cage culture and livestock farming. Water from sewage and wastewater could also enter the water body if not properly designed.
H231802/ Nam Souang/ Reservoir	19/6/96	Chemical Analysis	
H231901/Nam Houm/ Damsite	13/2/95	Temperature, pH, conductivity, major ions, nutrients, DO, Si and COD.	This station is identified as a local or secondary station. During the dry season from mid December to April water is discharged from the reservoir and flows through the canal. During the wet season the water is stored for secondary crops in dry season. In the immediate area of the sampling site, there are paddy rice fields with livestock rearing. There are tourist resorts but of relatively small size. Future development of tourism, fish cage culture and livestock farming are likely. Monitoring will be continued to ensure water quality is maintained for domestic, irrigation, agriculture, and fishery uses.
H231902/ Nam Houm/ Reservoir	19/6/96	Chemical Analysis	
H230102/Nam Ngum/ Tha Ngon bridge	15/5/85	Temperature, pH, conductivity, major ions, nutrients, DO, Si and COD.	The main purpose of this station is to provide information on the impacts of upstream development. There are villages on both sides of the river. There are, floating restaurants, fish cages, livestock husbandry, tourism, agriculture with pumping irrigation system. A village is producing 2,000Kg of salt per day about 10 km upstream of the station. Continued observation is needed due to rapid upstream urbanization, hydropower development, tourism and agriculture expansion. Problems related to microbiological hazards or eutrophication may arise in the future and contamination to the Mekong mainstream is possible. A new water supply treatment plant of 40,000m^3 per day for Vientiane city is planned near this station.
H230113/ Mekong/ Ban Hai			

Source: Water Quality Analysis Laboratory, (MAF), 2006

Note: H230102 is no longer monitored although there is an historical record of water quality data

Water Quality Conditions in the Nam Ngum River Basin

The Water Quality Laboratory report indicates that over the past 15 years of monitoring, water quality in Lao PDR is still good and is not significantly affected by human activities. There has been no significant change in water quality for all stations recorded.

Total suspended solids are variable during the year and generally loads increase during the high water season. Likewise, the high organic and high nutrients parts follows a seasonal pattern. Erosion and sediment transport are increasing at some sampling sites. The use of chemicals is still modest and will be so in the short term due to lack of money for investment and hence low demand.

The effect of urban and industrial activities in Lao PDR affects small local areas, and is not an immediate threat to water quality mainly due to the relatively large flows of the Mekong River and its tributaries, even during the dry season.

Water quality monitoring near mining sites is absent and is needed as more mines quarries are being established. Those new water quality monitoring sites will allow collection and monitoring on water quality parameters that might be harmful and hazardous from the waste water discharge and disposal of dangerous chemical agents. There has been at least one serous release of hazardous chemicals into Lao rivers in recent years.

Water quality management in Lao PDR is at an early stage of development in regard to the institutional frame work, standards and experiences. The main constraints are poor facilities and lack of financial support, limited human resources, need of efficient management including data evaluation and calibration to assure reliability of reports.

Recommendations

The Water Resources and Environment Administration (WREA) needs to play an active and leading role in water quality management in line with its mandate on water resources and environment. Up to the present time the Department of Environment (DoE) and the Environment Research Institute (ERI) have made progress on general environmental assessment, environmental regulation (through the EIA / EMP process) and public awareness. Provincial offices have been established and some capacity building has been carried out.

The formation of WREA now means that the roles of DoE and ERI as well as DWR and DMH need to be clarified. Water quality monitoring, lab analysis and information need to be strengthened. Stronger water quality policies and strategies are needed to deal with the rapid development of water resources and possible impacts on water quality and ecosystems. The updating of the National Water Resources Policy and Strategy and the possible review of the Law on Water and Water Resources will provide the opportunity for this policy and strategy development.

A "Water Quality Task Force" should be set up with representatives of each of the WREA departments / institutes and other water quality related agencies. The Task Force should prepare an action plan which should include subjects such as:

- Carrying out an assessment of water quality labs and making recommendations on coordination and upgrading;
- Setting up new water quality monitoring sites where needed, ensuring that data is forwarded from other government agencies and from private projects;
- Development of a national water quality information system;
- Inclusion of water quality in the National Water Resources Policy and Strategy and the Lao IWRM Support Program;
- Inclusion of water quality in watershed planning;
- Carrying out a training needs assessment and preparing a training plan, including all of the main water quality agencies. Also providing a water quality awareness courses.

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Community Participation in Pollution Abatement and Water Quality Conservation through Bio Monitoring

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Abstract
Bang-Pa canal located in Ratchaburi province is a natural waterway passing through different communities with its various usages. An alteration in canal's geography due to the development of industrial estate coupled with the pollutant discharges by upstream community has hindered the use of canal water for the downstream community who depends on the canal most. This research project is carried out to mobilize stakeholder's participation on environmental issues of Bang Pa canal. It involves capacity building of the community in water quality conservation through water quality monitoring and biological assessment using macroinvertebrates. For this, 60 volunteers from four sub-districts were actively involved. The integrated results of water quality and macroinvertebrates analysis show that the upstream water quality of the Bang-Pa canal is better as depicted by physico-chemical and biological parameters (water quality index). As the canal passes through the community, the quality deteriorates as the polluted water flows into the canal through alternative paths. The activities of the project have been integrated with the ongoing environmental efforts of the villagers on the conservation of the canal to maximize the effect. The involvement of local administration was rated as satisfactory by the community towards the issues of the canal. However, participation especially from the women residents is further required for conservation of water quality.

Keywords: Water quality, biomonitoring, macroinvertebrates, community participation, capacity building.

Introduction
Bang-Pa canal is a natural waterway located in Ratchaburi province, a fast growing peri-urban community 80 kilometers southwest of Bangkok. The canal has a total length of 37 kilometers spanning from Potharam District to Muang District of Ratchaburi Province. The canal passes through six sub-districts, namely, Klongkoi, Chedsamean, Don Sai, Sam Ruan, Pikulthong, and Bang-Pa. The uses of Bang-Pa canal varies as it passes through one community to another. During the past decade, the geography of the canal is altered due to the construction of Ratchaburi Industrial Estate located in Chedsamean sub-district where parts of canal were filled up in order to create land area set aside for future development. Nowadays, the canal blockage has hindered the usages of canal water in the surrounding areas where the waterway is prone to discharge from industries and also as a channel to receive wastewater discharged from household and livestock farms on daily basis by the villagers (Ongsakul, R. and Thongbhakdi, A., 2006).

The eminent pollution problem not only create burden and loss for those who rely on the uses of canal water but also creates conflict on transboundary social issues among the stakeholders; especially in the downstream area of Sam Ruan Sub-district since people here

depend on water from the canal for their daily activities. Many villagers are engaged in the ornamental fish business (for export), fruit, vegetable and rice farming. An initial effort was made with the collaboration of PDA (Population and Development Association) through the establishment of conservation clubs as community based organizations (CBOs) for "Conservation of Bang Pa Canal" which is funded by Ratchaburi Power Plant. Their activities are confined to plantation of trees, establishment of small parks along the banks, growing grass as natural water treatment system, and collecting garbage and weeds. However, the conservation groups organized in each village do not have good coordination of their activities among each other. As a result, the core problems remain in place and the pollutions in Bang Pa Canal continue to persist.

The project is carried out in the lower part of Bang Pa canal covering 4 sub-districts namely: Don Sai, Sam Ruan, Pikulthong and Bang Pa, with the collaboration of PDA focusing on the development and capacity building of community for water quality monitoring system using biosensors for water quality conservation. Sam Ruan sub-district was the main focus area of the project and the other 3 sub-districts were considered as the dissemination area.

Methodology

Preliminary survey was performed through questionnaire distributed to the members of local conservation clubs and local people randomly in order to identify the linkages between community and their activities with respect to the existing canal condition. Questions were also asked to verify the level of satisfaction of the community towards the various aspects of local governmental actions on canal conservation. Opinions were distinguished based on gender equality.

The project had identified volunteers through series of meetings based on the existing conservation clubs, active groups such as: women groups, local school and local governmental agencies for the mobilization of local community within their own villages. During the meetings, activities to be conducted were presented for prioritization by the participants. Prioritized activities maximized the level of public participation in the project through their own decision making according to Appreciation Influence Control Process (AIC) which helped in better implementation the of project activities. However, for each group of volunteers, different activities were developed in order to integrate the activities into their own agenda or annual plan based on "Conservation of Bang Pa Canal" funded by Ratchaburi power plant. These volunteers participated in water quality assessment, monitoring, and determination techniques.

A total of 11 sampling points (identified as RA1-RA10) had been determined and all recorded with GPS coordinates which includes; 1 reference sampling point (man-made irrigation canal) and 10 sampling points located along the canal and waterways which passes through the 4 sub-districts. A detail sketch of the canal and waterways including 10 sampling points is given in figure 1.

Field analysis of physico-chemical parameters for water quality was conducted with the active participation of volunteers. Parameters that were measured include pH, Dissolved Oxygen (DO), Conductivity, Total Dissolved Solids (TDS) and Temperature using onsite using portable field instruments. Phosphate analysis was done in the laboratory. Apart from water quality analysis using physico-chemical parameters, biological samplings for

macroinvertebrates were carried out in Sam Ruan sub-district to develop a biological community based water quality monitoring system.

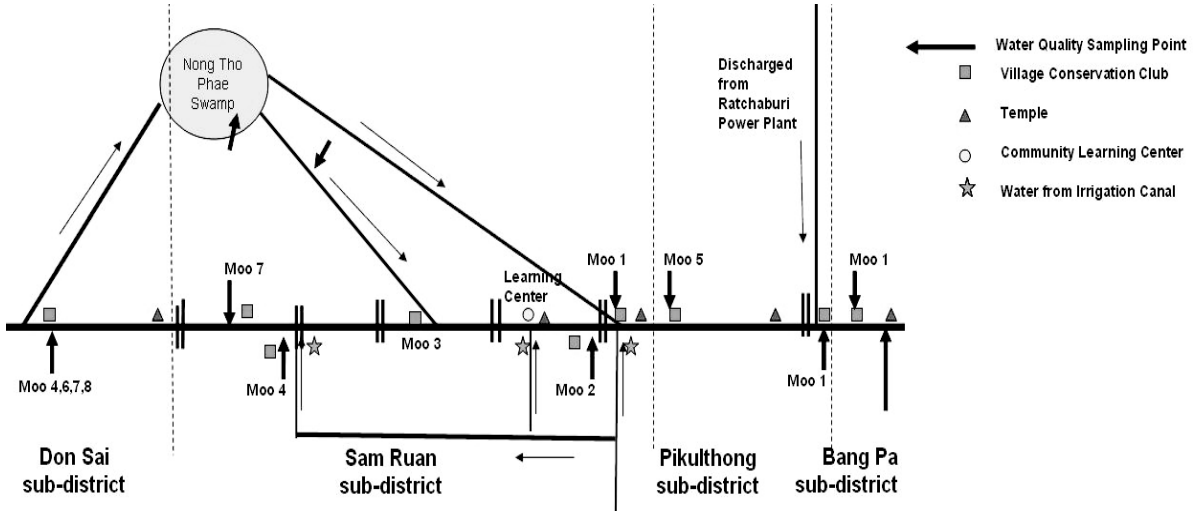

Figure 1. Schematic sketch of Bang Pa canal and the location of 10 water sampling points.

This was carried out along the water sample collection with the collaboration of PDA, local volunteers and project team. Samples of macroinvertebrates collected were identified on-site using a reference guide (Tilling and Kanjanavanit, 2000). Unidentified samples were preserved in 90% ethyl alcohol and taken back to be identified at the laboratory. Water Quality index was developed based on giving pollution score to the macroinvertebrates and assessment of water quality was done by using the water quality index (Tilling and Kanjanavanit, 2000).

Training on water quality monitoring for the local community was conducted by the development of a learning center at the local school for their technical capacity building. The center was developed as a base for information system and laboratory for water quality analysis. The center provides learning resources based on the skilled level of the community regarding water quality monitoring and the management of environmental issues raised by the community members. Volunteers were trained at first at their respective conservation clubs during water and macro invertebrates sampling. The formal training was performed at the learning center for the school children, volunteers of each village PDA officers and the community with the presentation of results of water quality monitoring.

Results and discussion

Bang Pa canal plays an important role in livelihoods of people living along the entire path of the canal, especially in Sam Ruan sub-district. Due to its flat topography, the area is suitable for agriculture. Villagers are involved in ornamental fish farming (Moo 3), vegetable and rice farming and cattle farming. The canal is therefore used as an input of water for fish pond, vegetable gardens and paddy fields.

It was found from preliminary survey that there is still high level of dependency on the use of canal water (73%). Among them 74% are male and 26% are female. Canal water is utilized primarily for domestic use (cooking, laundry, dishwashing) and also for bathing and other uses such as plant watering, car washing. Only 47% of the respondents who use canal water do pre-treatment before using. Around 44% of the whole population is involved in canal conservation activities (32% male, 12% female) such as removal of aquatic weed, clean up along the canal, providing environmental knowledge to the community and improving environmental surroundings along the canal. The villagers opinion towards the local governmental agency Tambon Administration Organization (TAO) about the pollution issue was some how satisfactory in terms of priority but the satisfaction level decreases when considered the policy and promotion done by TAO.

Water quality assessment through physico-chemical and biological analysis

A total of 60 volunteers were identified by the project team from 4 sub-districts during the meetings for the community based water quality monitoring. They are the members of the conservation clubs, heads of villagers, local public health officers, members of women groups, ornamental fish farm owners, senior elders, members of local government agency (TAO), public health officers, local school teachers and students.

Bang-Pa Canal is classified as "Surface Water Type 2" under PCD's (Pollution Control Department) Surface Water Quality Standard. Water depth in the canal is generally more than two meters with some exceptions where the canal passes through the main communities, water depth is decreased due to large amount of sediments. The canal channel is wide (> 6 meters) with the shape of stream bank steeply sloped. The bottom of the stream is muddy.

There are several species of aquatic plants covering the surface of the canal. The dominant species is water hyacinth which hinders the flow of water in the canal. Stream sides are being used as grazing area for cattle. The sites are also used as place of waste dumping and open-burning near the houses. Water flow is interrupted at the upstream of Sam Ruan sub-district by the development of a blockage between Don Sai and Sam Ruan sub-districts in order to prevent the flow of polluted water from upstream communities into Sam Ruan sub-district.

The dissolved oxygen concentrations of Bang Pa canal varied from 1.53-4.04 mg/l. The lowest value (RA1:1.53 mg/l) was measured at the blockage point of Don Sai (Don Sai side) sub-district where water is totally stagnant. Dissolve oxygen values were higher at the upstream of the canal (RA2:4.04 mg/l, RA3:3.96mg/l) in Sam Ruan sub-district where upstream polluted water could not pass through from Don Sai to Sam Ruan (Figure1). Additionally they are located near irrigation canal which receives clean water from Tha Rab sub-district. But as it passes through the community of Sam Ruan, water quality deteriorates (lowest RA5: 1.81 mg/l, near Nong Tha Pae swamp) as the water from upstream flows into the canal through alternative paths (Nong Tho Pae swamp) along with the pollution from community.

Conductivity was measured together with the determination of Total Dissolve Solid (TDS) in water. In general, conductivity values measured (ranging from 337 to 1042 µs/cm) were higher than the established standard of type 2 (< 500 µs/cm). The highest value was obtained at the point of lowest DO (RA5). Higher values were obtained from two sampling points: RA1 (994µs/cm) and RA2 (999 µs/cm) which are situated at the opposite site of the blockage point.

The nutrient loading in terms of phosphate concentration varied from 0.1566 to 0.5058 mg/l within Sam Ruan sub-district. The upstream of Moo 4 had the lowest value. The results of macroinvertebrates sampling were translated into Water Quality Index (WQI) and assessment of water quality was done based on that index. Table 1 and 2 shows WQI developed based on the number of total macroinvertebrates found during the survey conducted by the project team with the identified volunteers and the assessment of water quality based on that. The assessment shows that the water quality varies from average to rather clean water. When the results of physico-chemical analysis were integrated with the results of macro invertebrates, it showed that the quality of upstream water in Sam Ruan sub-district of Bang Pa canal is better. This is mainly due to the location of the blockage point and the irrigation canal. Although polluted water cannot pass through the blockage but the people still experiences the pollution at the downstream through alternative paths.

Table 1. Assessment of water quality based on WQI score

WQI Score	Assessment of water quality
5.1-7.5	Rather clean-clean water
2.6-5	Rather dirty water- average
1.0-2.5	Dirty water
0	Very dirty water (no life at all)

Table 2. Macroinvertebrates and pollution score in Sam Ruan sub-district

Macroinvertebrates found and pollution scoring		Villages			
		Moo 7	Moo 4	Moo 2	Moo 1
Intermediate/ Low Pollution Tolerant Species (6-10)	Stonefly nymphs (10)	n/a	n/a	n/a	n/a
	Mayfly nymphs (10)	n/a	n/a	n/a	n/a
	Caddisfly larvae (10)	n/a	4	2	n/a
	Dobsonfly larvae (9)	n/a	n/a	n/a	n/a
	Dragonfly nymphs (6)	3	6	n/a	n/a
	Damselfy nymphs (6)	n/a	n/a	6	n/a
	Freshwater limpets (6)	n/a	15	n/a	n/a
	Swan mussels (6)	n/a	10	n/a	n/a
	Pagoda snails (6)	30	7	15	35
Intermediate/ High/ Very High Pollution Tolerant Species (1-5)	Waterbugs(non-classified) (5)	10	30	3	n/a
	Water boatman (5)	50	20	n/a	15
	Beetle larvae (5)	15	n/a	n/a	n/a
	Freshwater shrimps (5)	50	50	20	15
	Other snails (3)	18	5	20	33
	Leeches (3)	n/a	n/a	5	2
	Segmented Worms (1)	n/a	2	n/a	3
	Mosquito Larvae (1)	10	n/a	5	3
	Fly Larvae (1)	2	n/a	5	3
Total Number of Animals		188	149	81	106
Total Score		889	785	346	474
Water Quality Index (WQI)		4.73	5.27	4.27	4.47
Assessment of Water Quality		Average-Rather Clean Water			

*n/a= not available

The training (figure 2) was conducted covering all the basics technical knowledge of water quality monitoring through classroom activities for volunteers from conservation club as well villages, PDA officers and school children. The technical capacity of the individual was build

during the training by lending the equipment and analyzing the samples for water quality and macroinvertebrates by themselves. Apart from the classroom lessons, field survey were conducted around the community and environmental management sites, which made them able to identify the sources of pollution and best sustainable solution for the management of the canal. These were also discussed during the training. The training allowed the project to find the strength and weakness of each community so that, the strength of one community become a valuable knowledge to be transferred and shared with other communities and enhance inter-community participation.

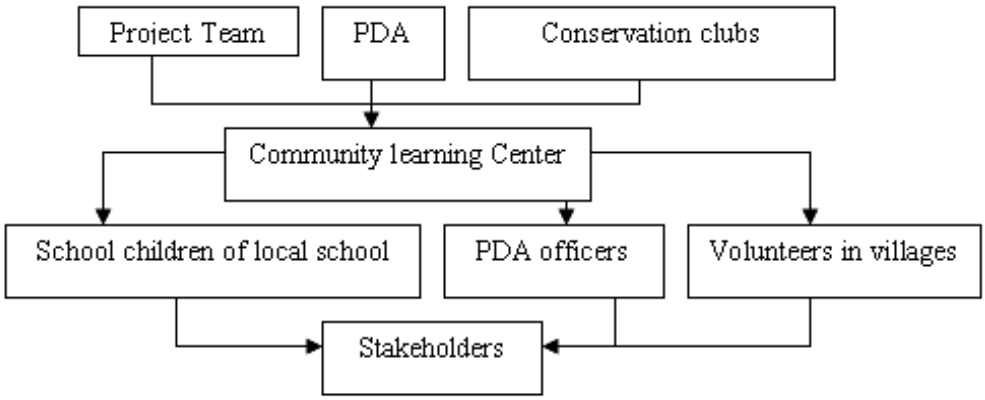

Figure 2. Flow diagram for training

Conclusions and recommendations

The obtained results imply that water condition in Bang Pa canal has been deteriorated dramatically at some points within Sam Ruan sub-districts (DO value 1.81 mg/l) from anthropogenic point sources and non-point sources (agricultural runoff) due to the daily activities of the villagers. The better quality of upstream water is due to the human made interruption of water flow. Conversely, the results from questionnaires show that there is still high dependency on the use of canal water. An effort was made by the project to implement a low cost simplified method of biomonitoring technique and to maximize the public participation on canal conservation activities through training.

Since its initiation, the project has brought together many different stakeholders from various sectors including local communities, governmental agencies and community based organizations in pollution prevention and canal conservation.

The increase in interest in water quality domain can be made through stakeholders/local community participation. It is necessary to increase local community involvement including both genders in water projects as this participation helps to ensure public perception in terms of environmental awareness, trust and ownership towards the initiation of community driven water quality monitoring program.

Acknowledgements

This research project was supported and funded by SEA-UEMA project of Asian Institute of Technology through Canadian International Development Agency (CIDA).

Water Quality along a Mekong Tributary in Northern Lao PDR

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Abstract

Access to sufficient amounts of clean water is both a fundamental human need and right. Yet, more than 1 billion people worldwide can not access clean water and 2.6 billion people live without adequate water sanitation (UNDP 2006). Improving the access of poor people to water has the potential to make a major contribution towards poverty eradication. In Lao PDR where 78% of the population is rural, many inhabitants are likely to be exposed to water quality-related hazards due to lack of access to potable water and/or water sanitation. In this context, this study focuses on stream water quality along a Mekong tributary that flows within a mountainous, composite land-use catchment of northern Lao PDR. Water quality was found to vary greatly depending on **(i)** the location along the stream **(ii)** the prevailing rainfall conditions and **(iii)** stream flow conditions. Overall, water quality reflected the balance between the stream self-cleaning potential and human pressure on the riparian zone. Besides these human induced pollutions we also noted spontaneous enrichments in metals in swampy areas fed by dysoxic groundwater. Based on our survey, we propose recommendations to improve or maintain stream water quality and for environmentally friendly management of surface water resources in the uplands of northern Lao PDR.

Keywords: Riparian area management; Payment for Environmental Services; Upland communities; Laos.

Introduction

More than 60% of developing countries' rural populations (i.e. more than 2 billion people as per 2004) lack access to sufficient amounts of clean water (WHO-UNICEF 2006) and are at risk of exposure to water quality-related hazards such as infectious diseases and intoxication by chemicals and/or radio-elements. In Lao PDR, 78% of the population is rural, living standards are very low overall and numerous communities still lack adequate water supply and sanitation infrastructures. A decade ago, the United Nations (UN 1998) concluded optimistically on stream water quality in Lao PDR. This conclusion was partly based on a limited dataset (34 measurements made in the country's main rivers), and on the fact that the country's population density is low. While the population density remains low today (24 people per km^2; NSC 2005), we undertook this survey to test whether water quality assessment based on main rivers only properly reflects water quality as experienced at the community level. The Mekong basin includes hundreds of waterways upon which many rural communities rely to fulfil their daily needs. Most such waterways get very turbid during periods of storm flow (Maniphousay and Souvanthong 2004), which greatly increases the occurrence of infectious diseases and intoxication, *via* particle-bound transport (Lamaningao

and Sugiura 2004). Our survey was conducted in a typical composite land-use catchment of northern Lao PDR, near the city of Luang Phrabang, along a perennial third order stream passing through villages close to the Mekong corridor but having no direct access to the main waterway. While, we did not intend to identify and analyse all factors and processes contributing to surface water quality, we tried to identify the main causes contributing to the spatial variability of some water quality indicators in the context of northern Lao PDR. Among the underlying factors studied, we paid attention to (i) land use along the riparian area; (ii) wastewater discharge along the stream and (iii) suspended sediment loads during floods.

Materials and methods

The Houay Xon catchment

The study was conducted along the Houay Xon stream, part of the Mekong basin in northern Laos (Luang Prabang Province). This stream drains a catchment of about 22.4 km^2 and flows into the Nam Dong River before its confluence with the Mekong (Figure 1). The 10.6 km long perennial stream flows down along a mountainous environment representative of the sloping lands of the Mekong valley. Within the catchment, altitudes range from 280 to 1336 m, with a mean slope gradient of about 31%. Composite land uses typical of northern Lao PDR occur within the catchment. The Houay Xon flows through five villages, successively. The overall land use units (Figure 1) roughly match the catchment's main morpho-hydrological units: (1) the south-eastern Phu Phung massif predominantly covered by old secondary forest; (2) the upland areas of the north-eastern and south-western parts, under shifting cultivation with short fallow; (3) the residential areas surrounded by teak plantations found along the main stream; and (4) the irrigated gardens in the peri-urban area of Luang Prabang, located on an alluvial terrace of the Mekong. The mean annual rainfall recorded at Luang Prabang from 1960 to 2006 is 1263 mm, about 77% of which falls from mid-May to mid-October, with high inter-annual variability (SD 345 mm, coefficient of variation 27%, min. 444 mm, max. 2100 mm). In 2007, the year this study was completed, the annual rainfall was 1139 mm.

Field survey

To relate water quality data to the catchment's spatial features (land use, human activities, etc...), we made spatially distributed measurements. Temperature (T), pH, electrical conductivity at 25ºC (EC), redox potential (Eh), and dissolved oxygen content (DO) were measured using a YSI MPS (Multi Probe System/Data Logger) meter. All sensors were checked daily before starting measurements. DO data were transformed to oxygen saturation (DO-sat) in %, using the formula of Hua (1990). To analyse the effects of land use on water quality at baseflow, 109 point-observations were made along the Houay Xon (83, 100-m apart stations) and its main tributaries (26 stations), at the end of the dry season (31 May 2007) until the confluence with the Nam Dong River. To examine the impact of floods, regardless of domestic wastewater discharge, 11 observation stations were established 20 metres apart, within the Houay Pano catchment (upstream Houay Xon). These stations were sampled once during a low flow period prior to the rainy season (28 May 2007) and then again during the first storm flow of the rainy season (4 Jun 2007) (Table 1). The sampling point locations were approximated using a portable GPS (GARMIN XL12) and an altimeter (SUUNTO Instrument). Stream discharge at the different sampling points was estimated by chemical tracing (Silvera et al 2007).

Water sample collection and laboratory analysis

Seventy water samples were collected to determine the suspended solid load (SL) and total colony count at 37ºC (CC37). Samples were collected on the day or the day after each of the physico-chemical surveys described above. Samples were collected by immersing bottles, neck pointing upstream, so that there was no contamination by bed sediments. SL, expressed in mg l^{-1}, was estimated as the weight of solid retained on a pre-weighed 0.45µm membrane after filtering a known volume of sample (about 1 litre). Sampling was always carried out at the same time of the day, i.e. mid morning to early afternoon. Water samples for total flora determinations were stored in a cool, dark ice box and delivered to the Nam Papa Lao laboratory in Vientiane within 12 hrs. CC37 was estimated following the standard pour plate method. The results are expressed as colony forming units (CFU) per ml.

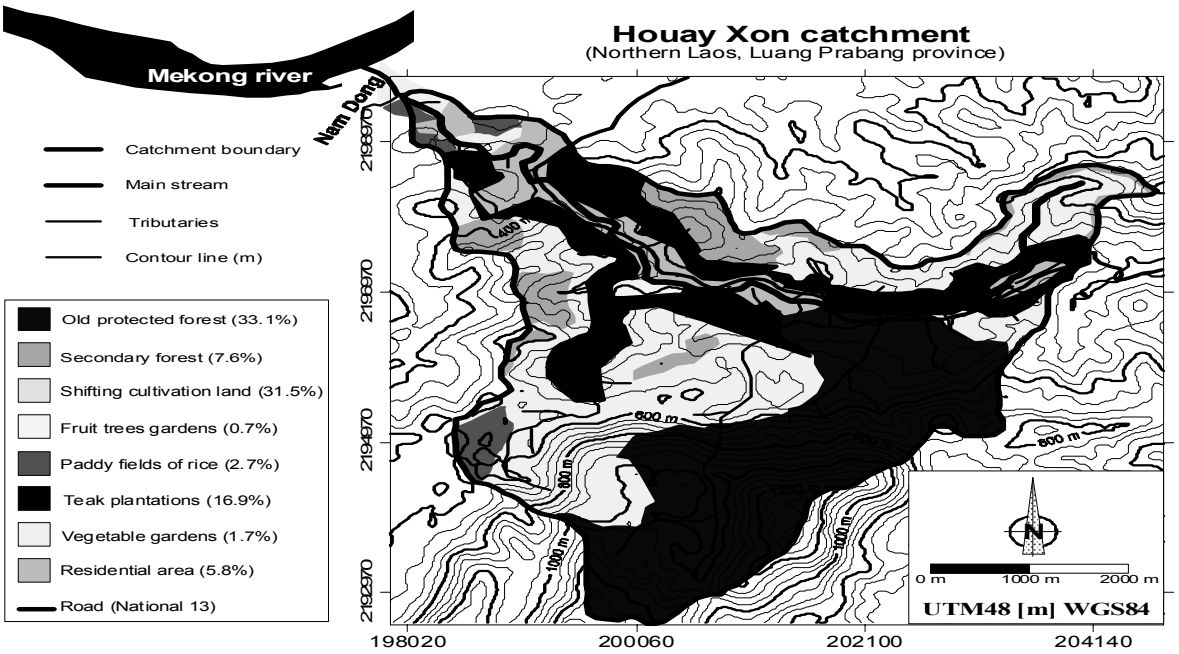

Figure 1. Main land uses (percentage of the total catchment area), contour lines and permanent stream paths within the Houay Xon catchment in 2007.

Results and discussion

Potential hazards due to naturally contaminated groundwater

In the upper part of the catchment (Houay Pano stream, land under shifting cultivation), orange-coloured iron oxide flocculated at several points within the stream channel. These metal-rich colloidal features occurred at a location where reducing conditions prevail: DO-sat of 12 % (triangle 1, Figure 2), pH=6.9 and Eh=88 mV. The Eh-pH measured at this station is compatible with the presence of soluble ferrous iron hydroxides ($FeOH^{+}$) in stream water, corresponding to local ex-filtration of subsurface water (Ribolzi et al 2005). Soluble iron compounds are common in soil solutions with high levels of organic matter (1-6 % in Houay Pano soils). When dissolved organic matter enters groundwater, the water may become anaerobic and iron becomes soluble. During the ex-filtration process, aeration of the Fe^{2+} charged groundwater leads to the precipitation of amorphous oxides, due to the rapid oxidation of Fe^{2+} at near neutral pH (Stumm and Morgan 1981). This in turn alters the pH in the vicinity of groundwater inflow sites. Oxidizing bacteria may accelerate this flocculation

process. The presence of dissolved iron or colloidal features in streamwater should not be considered hazardous in itself; yet, it indicates local physico-chemical conditions under which toxic metals can be mobilized (e.g. Cu, Cd, Zn, As). Farmers commonly use such groundwater sources for various purposes: fish ponds; drinking water; small irrigation; watercress beds. Such practices may not be innocuous as streambed sediments, stream water and aquatic vegetation exposed to subsurface inflows can accumulate metals. To avoid this risk, such seepage waters should only be used after aeration and deposition of their metallic ions (e.g. into streambed sediment).

Table 1. Descriptive statistics of some hydrological characteristics of the Houay Pano stream during baseflow and stormflow periods for 11 selected observation points: median; arithmetic mean; standard deviation (sd); minimum (min) and maximum (max) values of stream discharge; temperature (T); electrical conductivity at 25°C (EC); pH; redox potential (Eh); dissolved oxygen content transformed to oxygen saturation (DO-sat); suspended load (SL); total colony count at 37□C (CC37). Differences between base flow and storm flow (threshold of significance: □/2 = 0.025) are significant for all the parameters (Wilcoxon test, paired samples) except DO-sat. Mean pH is calculated from H^+ concentrations. CFU.ml^{-1}, colony-forming units per ml.

Flow regime		**Discharge**	**T**	**EC**	**pH**	**Eh**	**DO-sat**	**SL**	**CC37**
(date)		l/s	°C	µS.cm^{-1}		mV	%	g.l^{-1}	CFU.ml^{-1}
BASE	median	0.4	25.6	388	8.3	163	70.6	0.23	808
(28 May 2007)	mean	0.4	25.7	374	7.8	158	67.1	0.38	1152
	sd	0.1	0.8	31	−	25	21.3	0.50	861
	min	0.3	24.4	309	6.9	88	12.0	0.06	186
	max	0.6	26.9	417	8.5	181	91.8	1.85	2760
STORM	median	5.0	23.9	195	7.6	227	81.2	8.66	19000
(4 Jun 2007)	mean	4.4	23.9	196	7.6	226	73.1	8.80	42469
	sd	1.4	0.2	16	−	8	23.8	3.98	55984
	min	2.4	23.7	170	7.5	216	23.9	2.42	3840
	max	5.3	24.5	232	7.9	238	93.4	18.72	183000

Impact of land use and human activities along the riparian area on water contamination

Livestock roaming

In the upper catchment under shifting cultivation, livestock was seen roaming close to and in the stream causing sediment particles to be mobilised and SL values to reach up to 2 g.l^{-1} (Figure 2, triangle 2). This increased turbidity was associated with local microbiological pollution (CC37>2000 CFU ml^{-1}). This is consistent with previously reported correlation between faecal bacteria (*Escherichia coli*) load and turbidity at near-base-flow in a mixed-use watershed (Randall et al 2006). Stream water contamination by faecal coliform through soil leaching also seems higher in areas partly or fully covered with pastures than in forested and cultivated areas (George et al 2004). In the Houay Xon, bacterial contamination was very local, most probably due to dung piles rolling down from a livestock shelter into the stream. It is noteworthy that, due to the filtering effect of aquatic plants, acceptable levels of suspended

solid content and sessile (attached) bacteria were recovered a short distance (~100 m) downstream from the contamination point.

Use of fertilizers

In addition to increased sediment load in the river (Valentin et al., 2008), water quality in the Houay Xon is affected by a variety of pollution sources. Upstream Herbicide use amongst upstream farmers has recently become more common. The chemicals used are principally Paraquat Dichloride and glyphosate-isopropylamonium. Paraquat is classed as toxic for humans and presents a serious risk to aquatic environments.Glyphosate-isopropylamonium is less toxic for humans and the environment but there is still the potential for the water table to become contaminated (PAN, 2007). While fertilizers are not used in the Houay Pano catchment, their use is widespread the market gardens where at least two types of fertilizers are used. Downstream, rice growers frequently use chemical and organic fertilizers. The most common chemical inputs are urea (N46 P0 K0 and N16 P20 K0). Manure is extensively used because it is 5 times cheaper than chemical fertilizers. Fertilizers often end up in the stream, either during application in plots adjacent to the stream or through runoff, soil erosion and the occurrence of landslides.

Fish breeding activities

Fishponds found in Ban Lak Sip and Ban Donkang are filled by diverting the stream or by placing a pond directly in the course of the stream, which means that wastewater flows directly into the Houay Xon. None of the fish farmers own equipment or have set up a system for collecting or treating the wastewater. The waste consists primarily of fish food and excrements. Whilst the food is mostly organic, fish excrement, affects the microbiological quality of the stream by encouraging the growth of coliform bacteria. Thus this economic activity poses a serious risk to the health of the surrounding villagers. Measurements of the E. coli concentration, an indicator of health risk, show that after Ban Lak Sip the stream is unsuitable for swimming/washing, with a level of 230 MPN/100mL, more than double the safe standard. It is difficult to calculate the volume of wastewater released by the ponds, especially since 80% of the informants leave the ponds open to the stream permanently. Given that the system for managing the water level in the ponds is approximately the same in the studied area, we can calculate an average outflow of > 80 m3 per week per fish farm. The pollution caused by the fish farms is thus of a relatively small scale in terms of toxicity but the amount of waste is large.

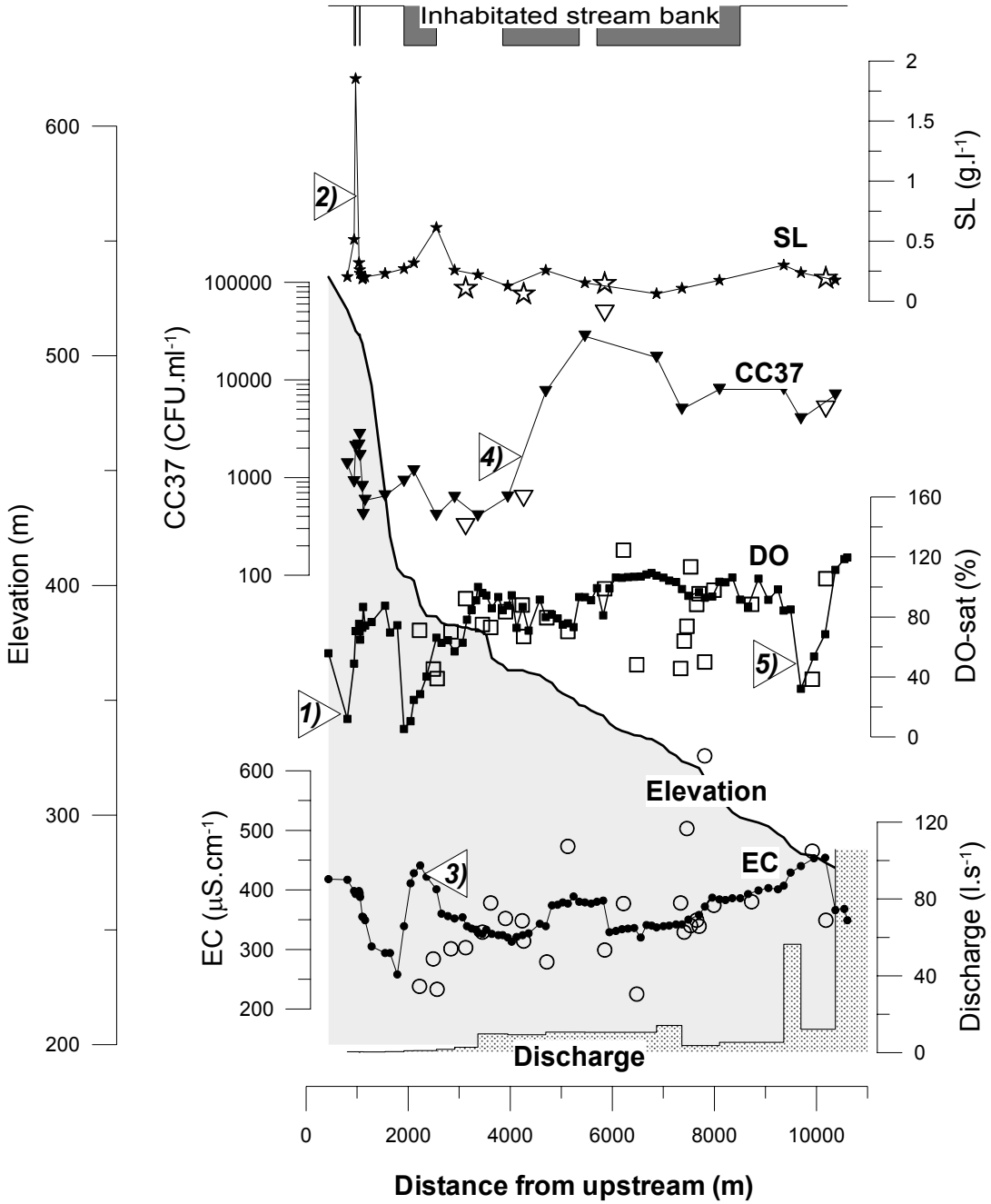

Figure 2. Morpho-hydrological characteristics of the Houay Xong river (solid black symbols) and its tributaries (hollow symbols) at the end of the 2007 dry season (i.e. low flow regime): elevation; main river discharge; electrical conductivity at 25°C (EC); dissolved oxygen content transformed to oxygen saturation (DO-sat); total colony count at 37°C (CC37); suspended sediment load (SL); location of the inhabited areas along the stream bank. Triangular labels indicate striking positions along the stream: 1) Reach with subsurface seepage; 2) Livestock straying within the riparian zone; 3) Domestic wastewater discharge; 4) Urbanized area along stream banks; 5) Agro-industrial discharge.

Domestic wastewater and household refuse

The physico-chemical characteristics of the stream water changed dramatically when it passed through the first upland village (Ban Lak Sip): DO-sat decreased from 88 to 5%, CC37

doubled, EC increased from 298 to more than 400 µS.cm^{-1} (Figure 2, triangle 3), temperature increased from 26.0 to 30.2 µC, pH decreased from 8.2 to 7.2 and Eh decreased from 220 to less than 120 mV. These changes were clearly related to (I) domestic wastewater discharge, (ii) human and animal excrements and (iii) household refuse accumulation in the stream bed. These factors, in association with low stream discharge conditions, led to organic matter enrichment of the stream and a decrease in the stream velocity, which in turn induced anoxic conditions (Figure 2). After a distance of about 1km downstream from Ban Lak Sip, natural filtration and other processes led to the recovery of stream quality back to its initial characteristics (Figure 2). Then, in and up to 900 m downstream from ban DonKang, DO-sat remained high (i.e. between approximately 80 and 110%) in spite of numerous waste water discharge points and domestic activities. This rather steady oxygenation rate is due to the stream being fed by oxygenated tributaries (dilution effect) and, above all, a turbulent flow regime that maintains aerobic conditions. Further downstream, the DO-sat suddenly decreased down to 32% because of organic-rich waste water discharge from an alcohol distillery (Figure 2, triangle 5). Once again, it took approximately 1 km for the DO-sat to return to its original level. Contrary to DO-sat, CC37 increased considerably from Ban Donkan onwards (Figure 2, triangle 4), and remained high until the confluence with the Nam Dong. Tributary inflows did not lower the CC37.

Impact of floods on water contamination

The stormflow measurements described below were conducted within the Houay Pano catchment during the first main runoff event of the 2007 rainy season. This event occurred a short time after the farmers of Ban Lak Sip had slashed and burned approximately 42% of the catchment area for annual cropping. Almost all the riparian zone and large hillslope areas were therefore bare; the soil surface and stream banks were unprotected, hence exposed to erosion. This flood was the result of a sudden intense downpour of 54 mm (maximal rainfall intensity of 110 mm.h^{-1} calculated over 6 min time steps) that produced considerable amounts of suspended sediments at the main outlet of the Houay Pano catchment (1.7 Mg ha^{-1}, i.e. ~23 % of the annual suspended yield). Table 1 presents a comparison between base and storm flow observations. No significant differences between base and storm flow were found for DO-sat (P value > 0.025). In contrast, stream flow dilution by rainwater lowered T, EC and pH during storm flow, while Eh increased significantly. Unsurprisingly, SL was much higher under storm flow conditions, corresponding to i) soil erosion in inter-rill areas (Chaplot et al 2007), rills and gullies (Chaplot et al 2005) and ii) the washing-out of free aggregates and some of the fragmented organic matter accumulated at the soil surface throughout the dry season. All the samples collected during the flood and one collected at base flow had SL >1 g/l, values which may greatly affect water usage and aquatic life, from phytoplankton to fish, by limiting light penetration. SL, especially when particles are small (less than 63µm), carry many substances that are harmful or toxic. In rivers, these fine particles are a food source for filter feeders which are at the base of the food chain, leading to biomagnification of chemical pollutants in fish and, ultimately, in humans. High SL also limits reservoir life through sedimentation of suspended matter. Microbiological studies of waterways are usually not carried out during rainfall-runoff events. Even though, during and after such events, there are often significant increases in turbidity and suspended solid loads, which are frequently interpreted as an indication of bacteriological contamination. Table 1 also shows that CC37 soared under storm flow conditions. These observations are consistent with those of George et al (2004) who reported that, in small streams, fecal coliform bacteria were linked to particles and that their abundance was proportional to the suspended sediment content.

Conclusions and recommendations

The expansion of Luang Prabang and its population growth pose a major challenge to city planners. In the near future, it will lead to an increased demand for sanitation infrastructures and freshwater resources, notably for irrigated peri-urban market gardens. The current expansion follows a centrifugal dynamic that radiates from the historic peninsular city and proceeds uphill along the course of waterways. The following recommendations are suggested in order to reduce or mitigate potential negative impacts of this urbanisation process on water quality:

- Riparian zones along streams and rivers should be managed in an environmentally friendly and sustainable manner.
- Extraction of stream water for industrial and irrigation purposes should be managed according to estimates that take into account rainfall variability and upstream land use. Over-extraction of stream water will place freshwater resources under stress.
- Authorities should encourage the development of community-based water sanitation systems as unprocessed domestic wastewater discharge is currently rising.

To support the above mentioned recommendations, we suggest that an agreement between the city of Luang Prabang and the surrounding villages be implemented. This agreement may follow the Payment for Environmental Services (PES) concept: rural dwellers could loosen the pressure on riparian areas in return for which the urban citizens could finance sanitation infrastructures upstream *via*, for example, the taxation of profits made on certain tourist activities in Luang Prabang. Finally, our study raises the issue of the spatial scale relevance of field observations regarding the question that needs to be answered, i.e. do upland people of northern Lao PDR have access to good quality surface water? Strategies that consist in monitoring large rivers generally provide a smooth integrated fingerprint of entire watersheds (e.g. UN 1998). This is unquestionably useful for global water resource management at the regional scale. However this approach may mask system internal variability and hence part of the local community level reality. Conclusions from such large scale studies should therefore be considered with the greatest care.

Acknowledgment

The present work is part of MSEC (Management of Soil Erosion Consortium) in Lao PDR, a joint scientific programme involving NAFRI (National Agriculture and Forestry Research Institute), IRD (Institut de Recherche pour le Développement) and IWMI (International Water Management Institute). It was supported by DRV (Département des Ressources Vivantes) of IRD and CIAT (International Center for Tropical Agriculture).

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The Implication of Environmental Legal Tools to Water Environment in Cambodia

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Abstract
The Kingdom of Cambodia has tremendous water resources and natural assets, which kept as major tools to the national development. Besides these resources, agricultural sector is recognized to importantly support the socio-economic development, meanwhile more than 85% of people are farmers. Industrial, tourist, transportation, etc., are also crucial sectors for the national development. Significantly, these kinds of development require necessarily to abide by the environmental legal instruments to ensure the environmental sustainability. It means that the maintenance and protection of water environment should be considered and implemented in parallel with development concept. Vice versa, the water environment might by deteriorated or polluted by unsound environmentally development, that means to destroy ourselves, our benefits, including our next generations.

The water pollution concerns were identified, and there are still gaps in: (i) our understanding of the integration of water environment management into sectoral development; (ii) our ability to recovery of degraded water environment and water quality decline we have done to it; and (iii) our knowledge of the cost of failing to take appropriate action to abate its degradation.

Up to now, it is still less possible to assess the state of water environment and water pollution at both national/ provincial levels, including its management, and the Royal Government of Cambodia, is now taking much attention to deal with the water environment management and protection we already know exist. Series of related legal instruments, strategic development plan and policies, and their applications ─ all are evident implicating to above captioned targets.

Carrying out these legal instruments, under the collaboration with key stakeholders, the MoE is taking action to regularly monitor and control various activities which harm to water environment and human health. During the implementing, the MoE still confronts with many constraints that require improvement. Capacity building, institutional strengthening, technological transfer, key stakeholder participation as well as the cooperation among concerned ministries/ institutions, international organizations and NGOs, and with other countries in the region, all these are key elements aiming at minimizing and phasing out the above constraints.

Background
Cambodia lies in Southeast Asia in the southwestern part of Indo-Chinese peninsula. It is located between latitudes 10° and 15° North and longitudes 102° and 108° East in the

Tropical North, and covers an area of 181,035 Km^2. Cambodia shares its 2,438 km border with Thailand, Laos PDR, and Vietnam. The country maximum extent is about 580 km from east to west and 450 km from north to south. The total boundary of the country is 2,600 km of which approximately 5/6 is land and 1/6 is coast.

The country receives abundant water quantities from the Mekong River, Tonle Sap River, Bassac River, Tonle Sap Great Lake, their tributaries in between rainy season, but more parts of the country are confronted to water shortage for household uses and irrigation during the dry season, due to an insufficiency of water storage, canal and irrigated systems, meanwhile farmers are accounted for 80%. Water resource is determined as an invaluable natural asset for Cambodians with multi-functions for the development of various sectors such as: agriculture, fisheries, industry, tourism, navigation, hydropower, transport, etc., which is the crucial resource for poverty alleviation. Of course, with these tremendous water resources and richness inundated habitats, Cambodia becomes the home of endangered and rare wildlife species, especially waterfowls and fish species in Tonle Sap Great Lake (waterfowl camp), freshwater dolphin in Mekong River (Stung Treng and Kratie Provinces).

Up to now, the exploitation and aquatic resources based development, commonly recognized to be caused severe concerns to the environment and loss of biological diversities, including water pollution, unless the environmentally sound management and practice was applied. Therefore, the implementation of environmental norms/standards is absolutely required by the environmental law and related statutes in order to ensuring sustainable and/or richness conditions of water and its natural resources, as well as the promotion of public and/or community participations. It means the conservation and protection of water environment and its related resources should be considered and implemented in parallel with the development concept.

Pollution aspects to water environment

In a brief, some kinds of development activities in Cambodia are being caused pressures to water environment and human health of which the Ministry of Environment (MoE) and line institutions are paying attention in parallel the taking action to intercept and minimize through the application of real countermeasures[1] and public awareness raising. The occurrence of negative effects resulted from many types of activities as follows:

a) Both treated and untreated effluents from industrial sector are being discharged into receiving waters;

b) Agricultural development by using agro-chemical which is more popularly consumed in paddy fields, specially in gardens along and/or closed to watercourses;

c) Rapid growth of urbanization which is beyond the land use planning, and without a central wastewater treatment, therefore, domestic wastewater are directly discharged into sewage system, and finally run off to retention pound to take the treatment process by natural conditions;

d) Activities of gold mining and other mining are closed to water sources;

[1] *Based on the environmental legal tools*

e) Solid and liquid wastes discharge from slaughterhouses, poultry, piggery farms, and the like;

f) High sedimentation load resulted from soil erosion at upstream and local watersheds[2], including river bank collapse;

g) Fuel-oil transportation by waterway without adequate safety facilities and emergency planning. Floating oil stations/selling are found to locate in dense-floating communities along main watercourse, e.g. Bassac river, and Tonle Sap Lake; and

h) Transboundary water pollution resulted from various development activities at upstream riparian countries.

Environmental Legal Tools and Their Application

The series of environmental legal instruments including relevant statutes have been entered into forces which aim to protect and conserve water environment and its related resources. These include such as: (i) Law on Environmental Protection and Natural Resources Management; (ii) Law on Water Resources Management; (iii) Sub-Degree on Water Pollution Control; (iv) Sub-Degree on Solid Waste Management; (v) Sub-Decree on EIA Process; and (vi) Sub-Decree on Air Pollution and Noise Disturbance Control. To abide by these legal frameworks, stakeholders (both public and private sectors) pay more attention to implement them based on their functions, and the national strategic plan (NSDP, 2006-2010) to contribute the application of poverty alleviation in parallel with the initiative of environment and the sustainable development.

Sub-Decree on Water Pollution Control

In the context of specific water environment protection and conservation, this report is focused mainly on the Sub-Decree on Water Pollution Control[3], e.g. its stipulations and application to various activities and/or sources, which cause the degradation of water quality and aquatic life as well. The Sub-Decree on Water Pollution Control (SWPC) has established based on the stipulation in Article 13, Chapter 5 of the Law on Environmental Protection and Natural Resources Management.

The Sub-Decree aims to minimize and phase out various activities that tend to pollute and/or polluted public water areas, including improve wastewater management for sustaining good water quality suitable to human desires. The standard for discharging of effluent into public water areas or into sewer, and the standard for water quality at public water areas for biodiversity conservation and for public health protection.

To abide by the SWPC, MoE officials do a monitoring and control programme at various pollution sources such as: factories, handicrafts, hotels, etc. Two sub-programmes are being implemented at pollution sources: (i) a routine effluent monitoring at normal factories, hotels, etc., is conducted within an interval period of 90 days; and (ii) a routine effluent monitoring at factories those use chemicals and/or chemical compounds for their production, is taken in an interval for 45 days. This application is done in order to ensure treated wastewater which is discharged to receiving sources without impact to the environment and public health, as

[2] *It may cause from forest clearing and shift cultivation*
[3] *It was approved by the Council of Ministers on April 06, 1999*

stipulated in the Article 19 of the SWPC: *"The Ministry of Environment shall take sample at every discharge point of pollution sources. The owner or responsible person of pollution sources shall collaborate with and facilitate the environmental official to take sample while carrying out their technical task"*.

MoE officials within the monitor and/or control programme, take effluent samples and analyze in order to identify a nature quality of discharged effluent at respective pollution sources. If discharged effluents were found to be exceeded the standard, the MoE, in complying with the Article 23 and Article 24 of the SWPC, has to instruct owner to properly treat those effluents before discharging to receiving sources, and vice versa, a penalty will be done by case.

Article 23: The owner or responsible person of the pollution sources as stipulated in the article 11 of this sub-decree shall:

- *be responsible for determining the method of the treatment and the discharge of their effluent so that it responds to the effluent standard as stipulated in the article 4 and article 5 of this sub-decree as well as the standard of pollution load as stipulated in the article 7 of this sub-decree;*
- *have enough facilities and means to prevent the pollution of the public water area when there is eventual danger caused from his/her pollution source; and*
- *hold the responsibility for installing an equipment for measurement of flow, concentration and amount of pollutant contained in his/her effluent and also keep the result for record keeping.*

Article 24: Even if it is found out that the discharge of effluent from any pollution source do not respond to the effluent standard as stipulated in the article 4 and article 5 or is not in consistence with the pollution load standard as stipulated in the article 7 of this sub-decree, the Ministry of Environment shall:

- *issue a written order requiring the owner or responsible person of such pollution source to correct the violation activities immediately within a specified time period, if that activity has not caused a harmful impact to human health or an adverse effect to the water quality yet; and*
- *issue a written order requiring the owner or responsible person of such pollution source to stop his/her activities temporarily until the violation is corrected, if that activities cause an adverse impact to human health and water quality.*

On the other hand, based on the Article 31 and Article 32, in Chapter 6 of the SWPC, if water environment at public water areas[4] are polluted, MoE officials have to do an inspection and assessment the scope of water and environmental pollution in order to effective take action to minimize and eliminate these negative impacts, in closed collaboration with inter-ministries and local authority.

Article 31: Where if there is complaint or report that any source of pollution discharges effluent containing substance which cause danger to animal or human health or public property or causes pollution to any public water area, the Ministry of Environment, in collaboration with concerned ministries, may enter the site of this source of pollution and conduct inspection and take sample for testing.

[4] *River, sea, lake, stream, creek, pond, canal and so on*

Article 32: In the case of serious accident or imminent danger resulting from pollution at public water area, the Ministry of Environment shall make urgent inspection on the above problem and shall inform the concerned ministries and local authority.

Besides effluent control and monitor[5], MoE officials applies the Article 26 and Article 29 of the SWPC, to monthly monitor/control some main watercourses are located surrounding Phnom Penh Municipality (Mekong river, Bassac river, Sap river) and Chhnok Tru area (Tonle Sap Lake).

Article 26: The Ministry of Environment shall regularly control and monitor the situation of the water pollution at public water areas throughout the Kingdom of Cambodia in order to take measure to prevent and reduce the water pollution in public water areas.

Article 29: Even if it is fount that any public water areas is suffering of pollution which could threaten human life or bio-diversity the Ministry of Environment shall immediately notify the public about this danger and shall take measure to prevent the water pollution and to restore the water quality of such public water areas.

The MoE also provided a license/permission towards the discharge of solid and liquid wastes as requested by factory/enterprise owner, after finding the discharging does not impair to the environment based on the environmentally sound management.

Law on Water Resources Management

The Law on Water Resources Management was prepared by the Ministry of Water Resources and Meteorology (MoWRAM), and it has adopted by the National Assembly in 2007. The general purposes of the law aim to foster the effective management of the all kind water resources of Cambodia to attain socio-economic development and the welfare of the people. Relevant activities to water quality management were found in the Article 22, Chapter 6 of the Law. This Article stipulated as below:

> *"Various discharge, disposal or storage of hazardous substances or wastes which might impact to water quality, human health, animals and plants shall ask for a permission or license.*
>
> *Above captioned hazardous substances or wastes by types and technical standard for effluent discharge will be identified by the Sub-Decree. All application of this Article, the MoWRAM shall consult with inter-ministries."*

Under the support of water quality monitoring network[6], officials of the MoWRAM has taken water sample at designated sampling stations to analyze since 1993. Historically, the programme has commenced since 1993 under the MRC support: (i) 05 stations were operated in 1993; (ii) 06 stations were operated in 1995; and (iii)there are 11 stations are being operated. Remarkably, the stations are classified to primary and secondary stations. There are: (a) 19 stations so-called as primary station (10 existing and 9 new proposed stations); and (b) 2 stations for secondary network (1 existing and 1 new proposed stations). The primary

[5] *Discharging from various pollution sources*
[6] *One main MRC Programme*

station was set up to monitor and control various transboundary issues, basin-wide significance.

Conclusion

The efforts in protecting and conserving the environment and water environment are being conducted under closed collaboration with stakeholders, including international communities with remarkable outcomes. However, some constraints are recognized and required to improve from now on such as: (i) capacity building and institutional strengthening; (ii) technical supports from international communities/donor; (iii) public awareness raising by other doable means and public participation; (iv) strengthening the carrying out of environmental legal instruments; and (v) closed cooperation among countries in the region.

From Data to Policy
(Ciliwung River Water Quality Management)

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Introduction

The Ciliwung River Basin with an area encompassing 347km2 starting upstream at Tugu Puncak, Bogor Province until downstream at the Jakarta Bay area which acts as the River Basins outlet. The growing development at the River Basins, from the upstream area until the downstream area is extremely rapid due to the increasing rate of population caused by the high developments in the JABODETABEK (Jakarta, Bogor, Tanggerang and Bekasi City) area.

The development that is being done inside the Ciliwung River Basin area causes the decrease of the lands capability in absorbing water, and thus lowering the surface protection of the land from erosions, which in the end causes the rate of runoff and erosions. The floods in Jakarta, the decrease of river water quality, landslides and droughts happens to be an indicator of failure in managing natural resources for the population.

On the other hand, the usages of water resources from the Ciliwung River have not yet reach an optimum level. For example, the clean water usage in DKI Jakarta reaches 413 million cubic meters a year, but the clean water supply from the District Water Utility DKI Jakarta's reservoirs is limited at 200 million cubic meters each year. In short, the rest of the 213 million cubic meters of clean water needed by DKI Jakarta is dependent on underground water reservoirs. Based on a yearly debit count, the water resources from the Ciliwung River, to be exact 500 million cubic meters of water each year, is wasted to the ocean. The same also happens to the Grogol, Pebauran and Pesanggerahan Stream that posses the combined potential of 300 million cubic meters a year. To sum it up, over 800 million cubic meters worth of water resources that is wasted to the ocean.

The other problem is the change of land development happening around the River Basins Area. The change in land development around the River Basin Area during the last three decades happens very rapidly, the conversion from the land full of vegetations into housing and tall buildings increased without control. The results are the decreasing quality of support from the ecosystem thus creating critical lands, the decrease in land fertility and water quality, drought during the dry season and floods during the wet season. Seen from the amount of flow rate, evapotranspiration and infiltration alongside the debit fluctuation index, planting vegetations in open lands like bush fields, meadows, and unused land, are the most viable and effective choice to defend the hydrology functions of the River Basins.

The Capacity Limit of Pollution in The Ciliwung River

The entire length of the Ciliwung River from upstream until downstream reaches 89 kilometers. Flowing through a District two Cities and one Province, which are; The District of Bogor, The City of Bogor, The City of Depok, and the Province of DKI Jakarta.

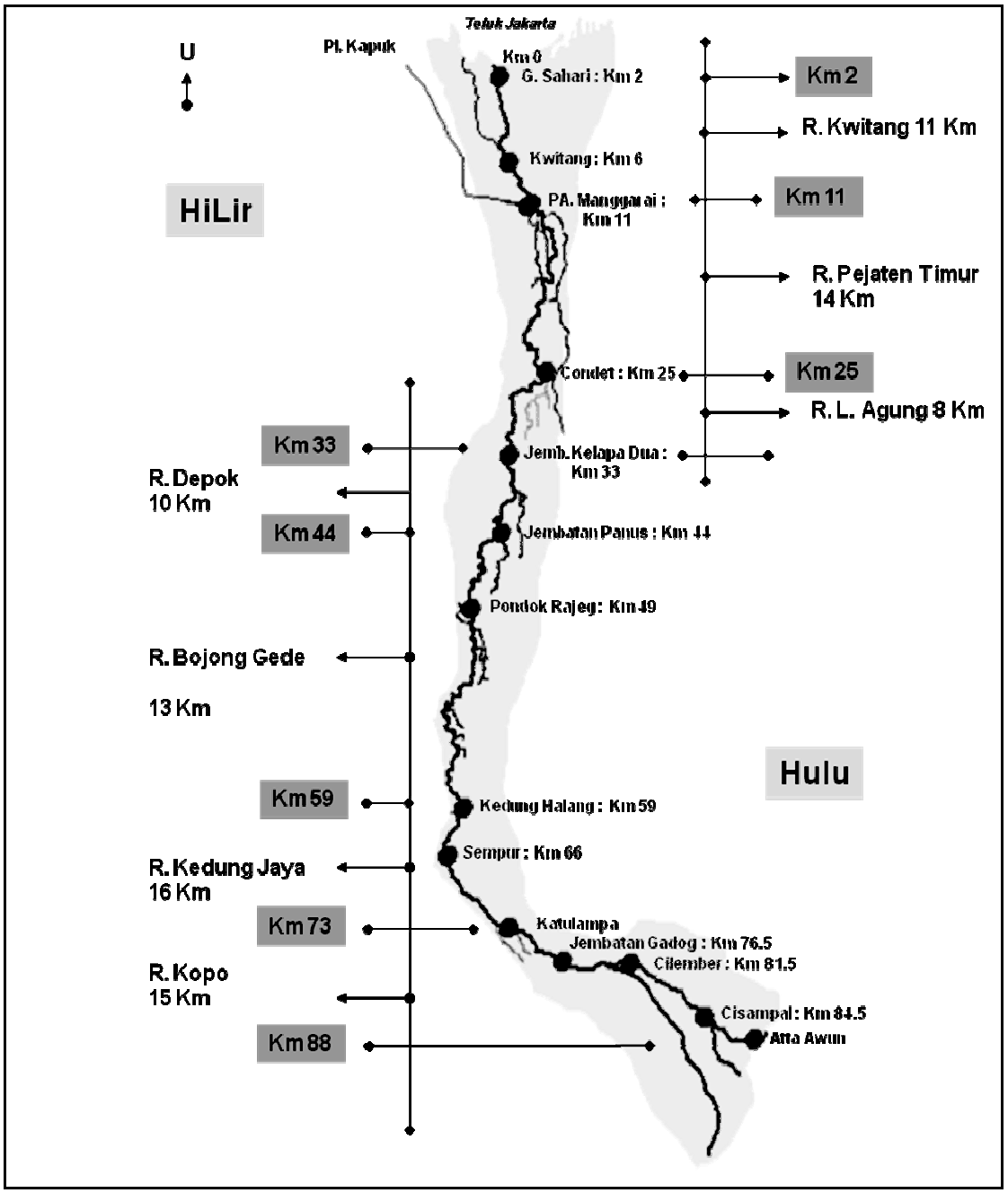

Figure 1. Map of the Ciliwung River Basin.

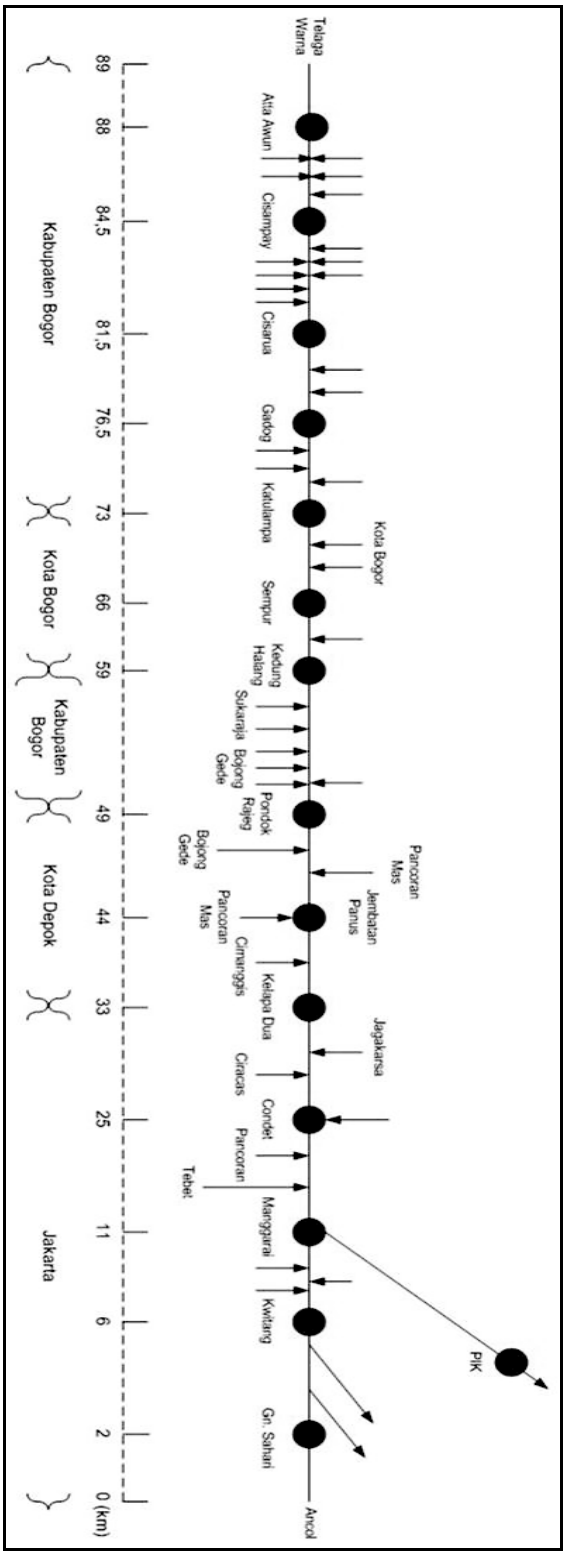

Figure 2. A Sketch of Ciliwung River.

Based on the monitoring data results during the year 2004-2006 on 14 locations, the BOD and COD parameters tend to rise the closer it gets downstream.

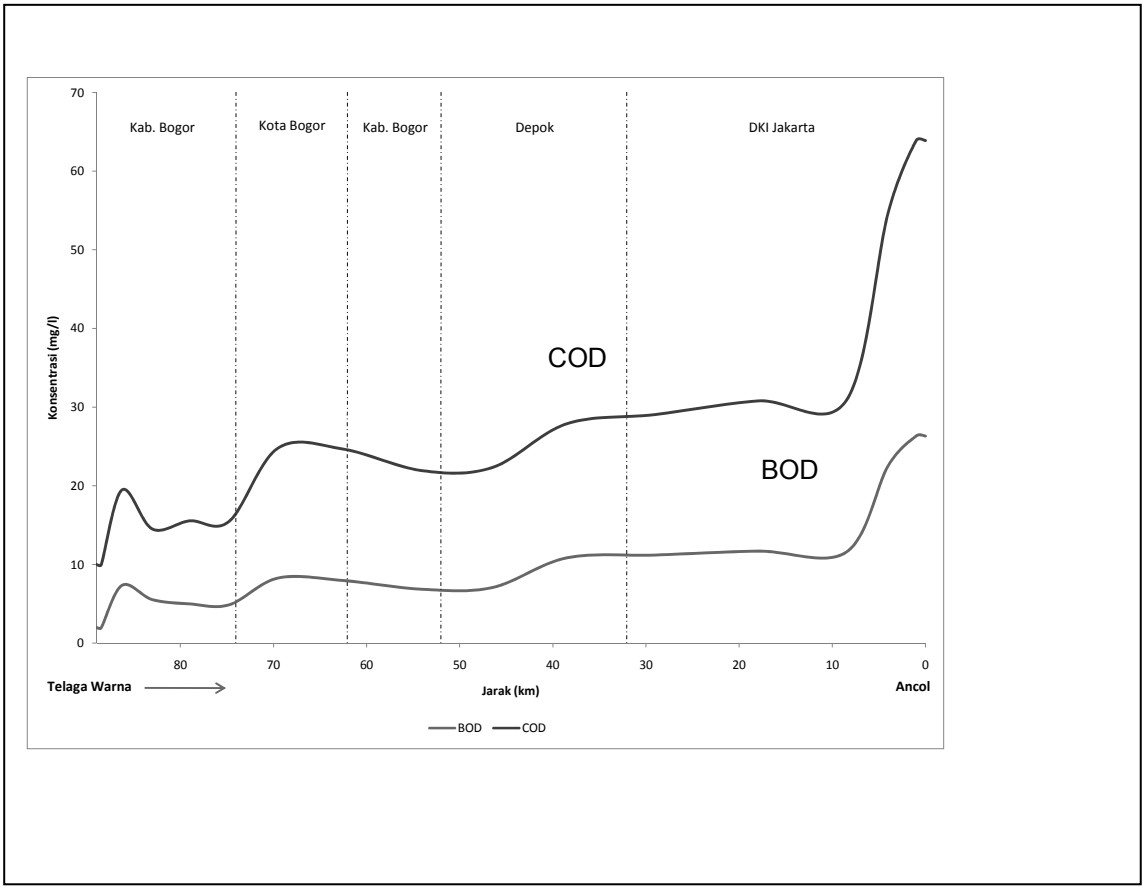

Figure 3. The Water Quality Tendencies for BOD and COD parameters.

The rise of BOD and COD concentration in the Ciliwung river is caused by the introduction of liquid waste from the District of Bogor, The City of Bogor, The City of Depok, and the Province of DKI Jakarta. The estimated total weight of the BOD and COD that entered the Ciliwung River are, each, 33.8 ton an hour and 73.8 ton an hour. The estimated weight distribution of the BOD and COD is based on segments (administrative areas) can be seen on the table below.

Table 1. Weight Distribution on BOD and COD based on Segments (Administrative Areas)

No.	**Segment**	**Load (kg/Hour)**		**Remarks**
		BOD	**COD**	
1	Bogor District	2.592	6.678	Segment 1 (Telaga Warna - Katulampa)
2	Bogor City	2.970	7.920	Segment 2 (Katulampa - Kedunghalang)
3	Bogor District	180	360	Segment 3 (Kedunghalang - Jembatan Panus)
4	Depok City	4.680	7.560	Segment 4 (Jembatan Panus - Kelapa Dua)
5	Jakarta	23.400	51.300	Segment 5 (Kelapa Dua - Ancol)
Total		**33.822**	**73.818**	

The estimated location of the waste sources and other sources that enters the Ciliwung River can be seen at the table below.

Table 2. The estimated location of the waste sources and other sources in Ciliwung River

No.	Location (km)	Load (kg/Hour)		Remarks
		BOD	COD	
1	88	1.800	3.960	Point source
2	85	216	432	Flashing
3	82	288	576	Flashing
4	78	108	1.350	Flashing
5	72	810	3.240	Point source
6	67	2.160	4.680	Point source
7	60	180	360	Flashing
8	34	3.600	5.760	Point source
9	25	540	2.160	Point source
10	6	6.480	12.960	Point source
11	49-35	1.080	1.800	Non point source
12	33-28	1.080	2.160	Non point source
13	20-10	1.800	2.520	Non point source
14	5-0	13.500	31.500	Non point source

Pollution Assimilated Capacity

Assuming, or targeting that Ciliwung River's segment 1 is class I, segments 2, 3 and 4 are class II, and segment 5 is class III, so the BOD and COD pollution carrying capacity parameters for each segment are as it follows:

Table 3. BOD and COD Pollution Carrying Capacity based on Segments (Administrative Area)

No.	Segment	Assimilated capacity (kg/Hour)		Remarks
		BOD	COD	
1	Kab. Bogor	792	3.114	Segmen 1 (Telaga Warna - Katulampa)
2	Kota Bogor	891	3.960	Segmen 2 (Katulampa - Kedunghalang)
3	Kab. Bogor	180	360	Segmen 3 (Kedunghalang - Jembatan Panus)
4	Kota Depok	684	3.420	Segmen 4 (Jembatan Panus - Kelapa Dua)
5	Jakarta	4.518	18.324	Segmen 5 (Kelapa Dua - Ancol)
Total		**7.065**	**29.178**	

With the Carrying Capacity showed on table 3, the water quality for the Ciliwung River's BOD and COD parameters can be seen on Image 4 and Image 5.

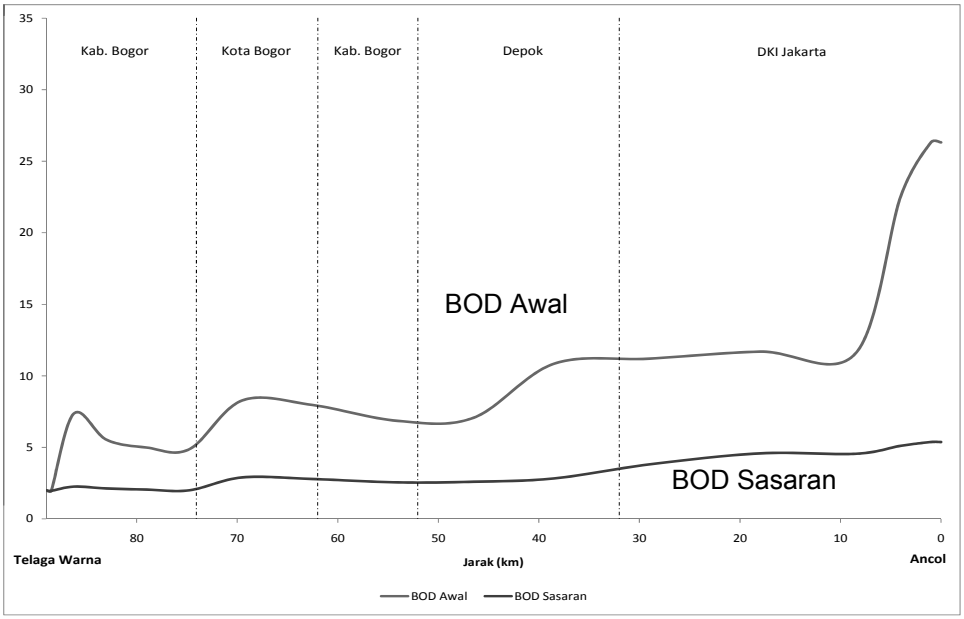

Figure 4. Ciliwung Rivers Water Quality Based on Class target for BOD Parameters.

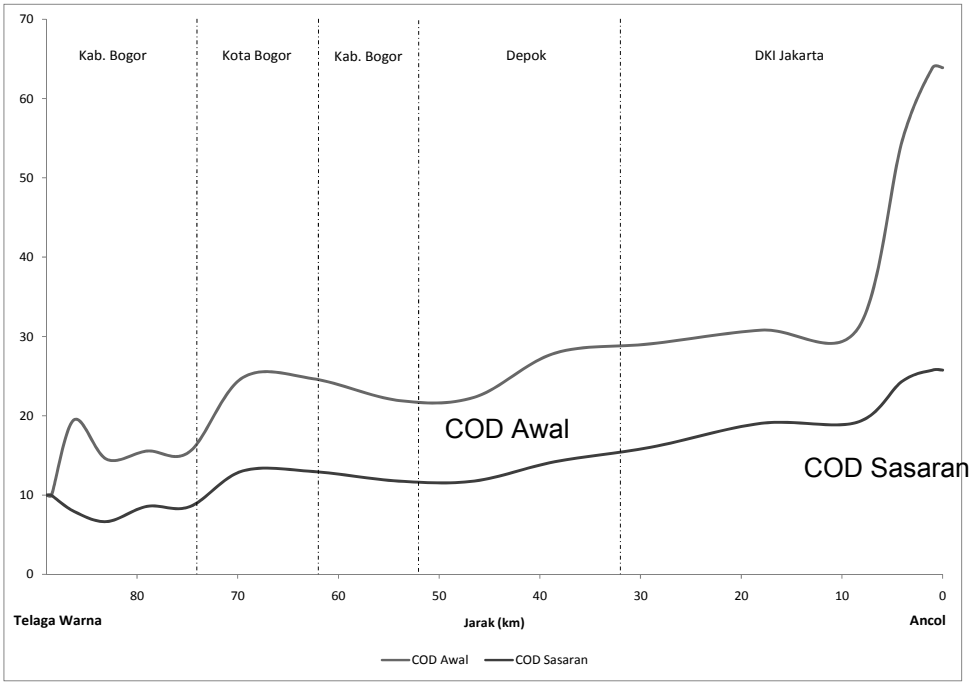

Figure 5. Ciliwung Rivers Water Quality Based on Class target for COD.

Parameters decreased by, each, 79% and 50% with the decreasing levels distribution as follows:

No.	Segment	Load Reduction (%)		Remarks
		BOD	COD	
1	Kab. Bogor	69%	53%	Segmen 1 (Telaga Warna - Katulampa)
2	Kota Bogor	70%	50%	Segmen 2 (Katulampa - Kedunghalang)
3	Kab. Bogor	0%	0%	Segmen 3 (Kedunghalang - Jembatan Panus)
4	Kota Depok	85%	55%	Segmen 4 (Jembatan Panus - Kelapa Dua)
5	Jakarta	81%	64%	Segmen 5 (Kelapa Dua - Ancol)
Total		**79%**	**60%**	

The entire scope of the rivers pollution can be taken care of all at once from upstream until downstream, from all the source of pollutions. In the stages done to reach the desired quality of water, the measures taken to achieve this can be done with a variety of combinations and decreasing the pollution weight limit from the sources. Scenarios in the attempt of recovering Water Quality based on the results of Dynamic System Analysis (Data Attributes). The results of the Dynamic System Analysis for each scenario are assumed to be a water recovery process that is done by using an incinerator, liquid waste disposal and handling, husbandry waste handling, market waste decomposition and household waste handling.

Removal of Arsenic and Manganese in Underground Water by Manganese Dioxide and Diatomite Mineral Ores

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Abstract

A methodology has been developed for the removal of arsenic (As) and manganese (Mn) from underground water using natural manganese dioxide (MnO_2) and diatomite mineral basing on the adsorptive process. The results showed that 90-96% concentration of As and/or Mn had been removed from water samples by MnO_2 and diatomite adsorbent materials. After treating, the concentration of As and Mn is lower than Vietnamese underground water quality standard (0.05 mg/L for As and 0.1 mg/L for Mn). Natural MnO_2 and diatomite mineral are able to remove a total of As (III, V) without the oxidation reagents. The removal of As and Mn by using diatomite is more efficient than using MnO_2. Using the nature MnO_2 and diatomite mineral are extremely efficiency for removing As and Mn in the underground water.

Keywords: Arsenic, Manganese, Manganese dioxide, diatomite mineral, underground water, adsorptive method

Introduction

Arsenic contamination in underground water was found in various countries in the world as Bangladesh, India, China, Mexico, America and ect. About 30-40 million people of Bangladesh, 13 million people in America, are now at risk of Arsenic contamination. Arsenic and concentration at higher level than WHO recommended value is found of 51% in the tube-wells in Bangladesh [1]. The geology of the Red river delta in Vietnam, like the geology of Ganges River in Bangladesh, also has been finding the arsenic contamination in underground water in some provinces as Hanoi, Hatay, NamDinh, HaNam and etc. New investigations have shown potential problems related to the presence of arsenic in alluvial deposits in the Red River region and in tube wells pumping water from lower aquifer. This requires further study and careful assessment. In addition, manganese level above the admissible standards are found both in the Red River and Mekong River Delta [2].The arsenic contamination survey data in 351 tube wells, the results showed that 351 water samples in which 25% have 0,05 mg/l higher concentration of arsenic contaminated and 68% are 0,01 higher than permitted Vietnamese standard [3].Using arsenic and manganese contaminated water source for a long time will cause tiredness, affect nervous system, even stomach cancer and other internal organs [4,5].

To eliminate arsenic and manganese from water source, development of feasible technologies to their treatment process as well as house-hold scale is essential requirement in Vietnam [6, 7].Therefore, study and assessment of the nature MnO_2 and diatomite mineral adsorptive abilities to treat Mn and As total in underground water was carried out. Those processing technologies are

simple, low-priced, and easily-operated. Utilizing mobile and statically absorptive ability is a method of assessing the arsenic and manganese eliminating process from underground water by dermining the maximum adsorption capacity into the nature MnO_2 and diatomite mineral which is investigated with hopes to contribute a part of technology and science to solve this urgent problem.

Experimental

The MnO_2 and diatomite mineral were pulverized from available raw materials. Arsenic and manganese solutions were prepared by diluting the initially standard solution of 1 g/L concentration from Merck Chemical Co. Ltd. All other chemicals were of analytical reagent grade. An atomic absorption spectrophotometer system (AAS) using graphite and flame techniques was used to measure As and Mn.

Determination of As and Mn by statically absorptive method

Adsorption isotherm is a kind of graphic representing the relation between 1/a and 1/c (inversion of adsorption capacity of adsorbent material and inversion of concentration of adsorbent at the level point). This diagram can present the maximal adsorption capacity and constant Longmuir K_L for every material. Basing on experimental result, the adsorptive isotherm of metal ions (As and Mn) and the maximal adsorptive capacity are established. The adsorption isotherm of As (V) on every material can be drawn and the maximum adsorption capability is of Arsenic. Therefore, adsorbent capacity of Arsenic on different material is able to be assessed.

Preparation of sample (2.1):*

Firstly, 1g of MnO_2 and /or diatomite mineral was poured in to a beaker, which previously contained 100 mL of a mixed solution of 0.1 mg/L arsenic and 4 mg/L manganese. The solution was mixed and stirred gently with constant speed for 3 hours. Filtering this solution, As and Mn were determined in extracted solution.

Secondly, 1g of MnO_2 and /or diatomite mineral was poured in to a beaker, which previously contained 100 mL of 0.1 mg/L arsenic solution or 1 mg/L manganese. Next, the solution was stirred gently with a constant speed for 72 hours. Filtering the solution, As and Mn were determined in that extracted solutions.

Determination of As and Mn by mobile absorptive method

Prepare experiment: Put 10 g materials (means 7.5 cm^3 for capacity) to column, which contained glass wool. The solution, having As and Mn is poured into the column with flow rate as 1.6 mL/min. After every 24 hour, check sample and analyze content of Arsenic and Manganese. This experiment is illustrated as the below figure 1.

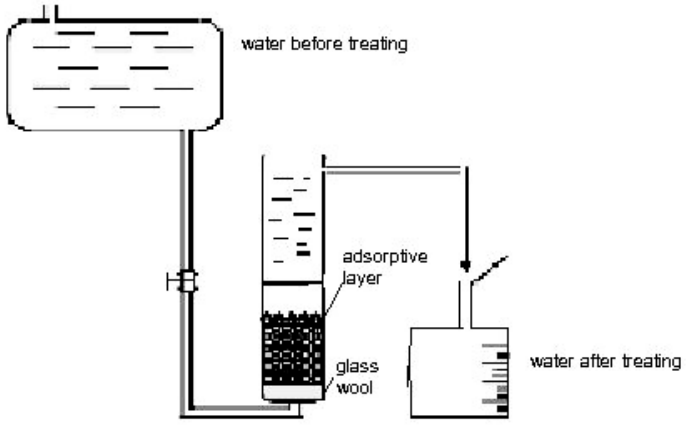

Figure 1. Sketch of As and Mn treated system by adsorptive method.

Results and discussion

Investigation of the adsorptive ability of MnO_2 for removing arsenic and manganese in under ground water by mobile adsorptive method

The experimental condition for Manganese treatment:
The material is of 1mm for the diameter. The weight is 10 g. Input Manganese content (Co) is 1 mg/L. Flow rate through glass tube is 1.6mL/min. Mnd1-00; Mnd1- 02, …, Mnd1-20 are the sample mark, corresponding to adsorbent reduction time. The results in table 1 showed that about 99% of Mn ion has been removed after 1day. Indicating that almost Mn was adsorbate into MnO_2 ore. The concentration of Mn after treatment is lower than Vietnamese standard limit. The treatment productivity is of 99.9%.

Table 1. The result of treatment of Manganese by MnO_2 ore

Time (hour)	Sample mark	Output concentration of Mn C_1 (mg/L)
0	Mnd_1-01	1
2	Mnd_1-02	0.7
4	Mnd_1-04	0.5
8	Mnd_1-08	0.3
12	Mnd_1-12	0.1
16	Mnd_1-16	0.06
20	Mnd_1-20	0.01

Table 2. The result of Arsenic treatment by MnO_2 ore

Time (hour)	Sample mark	Output concentration of As C_1 (mg/L)
1	Asd1-01	0.100
2	Asd1-02	0.100
10	Asd1-10	0.093
20	Asd1-20	0.091
48	Asd1-48	0.060
120	Asd1-120	0.057
168	Asd1-168	0.058
240	Asd1-240	0.051

The experimental condition for Arsenic treatment:
The condition for As treatment is quite similar. As initial concentration (C_0) is 0, 1 mg/l. Asd1-01, Asd1-02 ... Asd1-240 is the sample mark, corresponding to adsorbent reduction time. The results in table 2 shows that the concentration of As has not much been removed

after 10 days for using MnO_2 ore. This result indicated that almost As was not adsorpted into MnO_2.

Investigation of the adsorptive ability of MnO_2 and diatomite ore for removing arsenic and manganese in the under ground water by statically adsorptive method

For determination of Mn: Sample using diatomite natural coded Do-Mn-03 and another using manganese dioxide coded M-Mn-03. Soak 1g materials into 100mL of Manganese solution which has 4mg/L of concentration. The procedure is described above (2.1*). The results in table 3 indicated that Manganese was well treated by Manganese dioxide and diatomite natural. It means MnO_2 and diatomite ores are very good at treating Mn in the water. MnO_2 is not only oxidized but also adsorbent material.

Table 3. The result of statically adsorptive process for treating of Mn by some materials			The result of statically adsorptive process for treating of As by some materials (C_0 = 0,1mg/l)			
Name of material	Sample symbol	Mn concentration after treating C_1 (4 mg/l)	Name of materila	Symbol sample	Output of As C_1 (mg/l)	Treatment productivity (%)
Diatomite	Do-Mn - 03	<0.01	Diatomite	Do-As-03	0,0054	94,62
MnO_2 ore	M-Mn - 03	<0.01	MnO_2 ore	M-As-03	0,0031	96,95

For determination of As: The condition for As removal is similar as Mn. 100mL Arsenic with concentration of 0,1mg/L is stirred with constant speed in 3 hours. Result in table 4 showed that the absorbent ability of As into MnO_2 was very good. Processing efficiency was nearly 97% and concentration of Arsenic in sample after treatment was below Vietnamese standard. Arsenic is well treated by diatomite due to the high As adsorption capacity of diatomite. Possibility, diatomite natural was made up of many other mineral materials like Al_2O_3, Fe_2O_3, betonies and ect.

Gauge adsorbent isotherm and determine maximal adsorption capacity of As and Mn onto some materials

To make the calculation of adsorptive of material, it is necessary to identify the maximal adsorption capacity of substance on materials basing on adsorbent isotherm. Figure 2 is illustration of adsorbent isotherm of As onto MnO_2 while figure 3 is that of As onto Fe_2O_3/diatomite natural. Adsorbent isotherm of Manganese on MnO_2 ore is in figure 4 and figure 5 is that into diatomite natural.

Study results showed that As treatment efficiency was high up to 80% with adsorbent capacity calculated by Longmuir formula 1:

$$A_m = 2,08 mg/g \ (y=1,535x+0,48) \qquad (1)$$

The adsorptive of Fe_2O_3/Diatomite is dependent on ·OH group, which adhesion onto diatomite surface, can be replaced As in that. The adsorbent ability of arsenic into diatomite is higher than that intoMnO_2. The maximal adsorbent capacity (am) can be calculated by formula 2

$$A_m = 2,5 \ mg/g \ (y= 20,03x + 0,406) \qquad (2)$$

Figure 4 can be explained that MnO_2 is oxidability and minus chargeable, therefore, it can be attracted Mn2+ ion and created Mn_2O_3. Maximal adsorption capacity calculated by Longmuir formula 3:

$$A_m=12,7mg/g\ (y= 10,29x + 0,079) \quad (3)$$

Therefore, the adsorptive of Diatomite natural onto Mn is apparent (Fig. 5). At the moment of investigation, Oxidized Mn^{2+} and dissolved oxy possibly appeared in this solution, even low concentration of Mn^{2+}.

It is due to adsorption and flocculation ability of Diatomite or $Mn(OH)_4$ which was created through oxidization process which played an important part for Mn oxidization process. Adsorbent capacity of Mn is calculated by Longmuir formula 4:

$$A_m=15,15\ mg/g\ (y= 7,508x + 0,066) \quad (4)$$

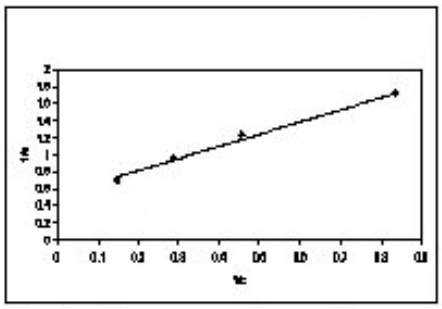

Fig.2: Adsorption isotherm of As into MnO

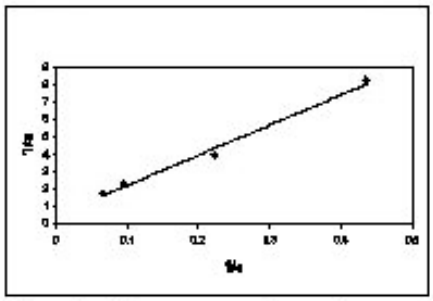

Fig. 3. Adsorption isotherm As into 1%Fe O diatomite

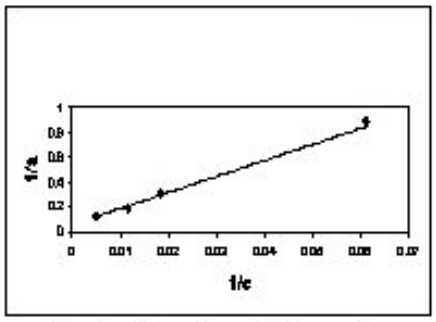

Fig. 4. Adsorption isotherm of MnO for Mn

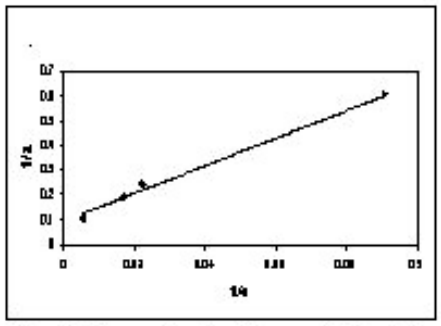

Fig. 5. Adsorption isotherm of Mn into diatomite

Conclusion

The adsorptive ability of MnO_2 for manganese removal in underground water by mobile adsorptive method is very good. Using 10 g material, it can treat 1mg/L Mn with the treatment productivity is of 99.9%.This method can not applied to As case.

The adsorptive ability of MnO_2 and diatomite ore for arsenic and manganese removal in underground water by statically adsorptive method is excellent. It means MnO_2 and diatomite ores are very good for Mn treatment in the water. Manganese dioxide is not only oxidized but also adsorbent material. Arsenic is well treated by Diatomite due to the high As adsorption capacity of Diatomite.

Those above results proved that natural manganese dioxide, diatomite mineral were potential adsorbent materials which could be applied to treat Mn and As in water source. Using manganese dioxide and diatomite mineral would concurrently treat both Mn and As in the supply water.

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Isotopic and Hydrochemical Signatures in Characterizing Pollutants Movement in Overexploited Groundwater Aquifers of Delhi State

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Abstract
Over the last two decades, intense urbanization in Delhi area created several cut slopes of the rugged topography. Iso-contours and multi-component mixing models of pollutants and isotopic composition of groundwater provided a unique understanding of the pollutants dynamics in groundwater. Over 60% of the wells have become vulnerable to increased chloride and nitrate contamination based. The major sources of chloride and nitrate are anthropogenic wastes, landfills, sewage irrigation and sewage treatment plants, turf grass fertilizer and surface water runoff. ^{18}O isotope and major elements that accompany in the groundwater may distinguish sources of nitrate with less ambiguity, under different land use conditions. Cl, Na, Mg, Ca, SO_4 and NO_3 show promising results as nitrate tracers on ternary diagram and through element vs. element plots. Additional Ca^{2+} may be released to groundwater by corrosion of subsurface concrete materials. Guidance has been provided on the overall approach for protection of groundwater resource.

Keywords: Pollutant, groundwater, hydrochemical, Delhi.

Introduction
Over the years, increase in population, urbanization and industrialization in Delhi area created several cut slopes of the rugged topography. Indiscriminate disposal of anthropogenic wastes and leaching of pollutants from these resulted in an ever-increasing threat to the quality of ground water resource base. Large-scale groundwater withdrawal for domestic, irrigation, and industrial purposes lead to widespread decline of ground water table. For protection of groundwater from pollution, it is a matter of concern for the planners and decision makers to clearly characterize the groundwater renewal, quality of water and causes of its deterioration, sources of pollution, trace the movement of pollutants and containment of spreading from known sources. The characteristics of pollutants level and transport in groundwater are associated with variations in one or two parameters at one scale and several parameters at another scale. While, a broad qualitative understanding of most of the aforementioned effects is known, most of the various parameters and physico-chemical process as a whole in the hidden complex groundwater system are not completely understood. Iso-contour diagrams and multi-component mixing models of pollutants and ^{18}O isotopic composition of groundwater along the flow path provided a unique understanding of the groundwater flow system and its vulnerability.

Physiography, Geohydrology and Climate
The semi-arid Delhi region (Figure-1) (area: 1483 Sq.Km. between 28^{o}24'17"-28^{o}53'00" N and 76^{o}50'24"-77^{o}20'37" E), situated on the banks of the river Yamuna which flows from north to south, is a part of the Indo-Gangetic Alluvial Plains.

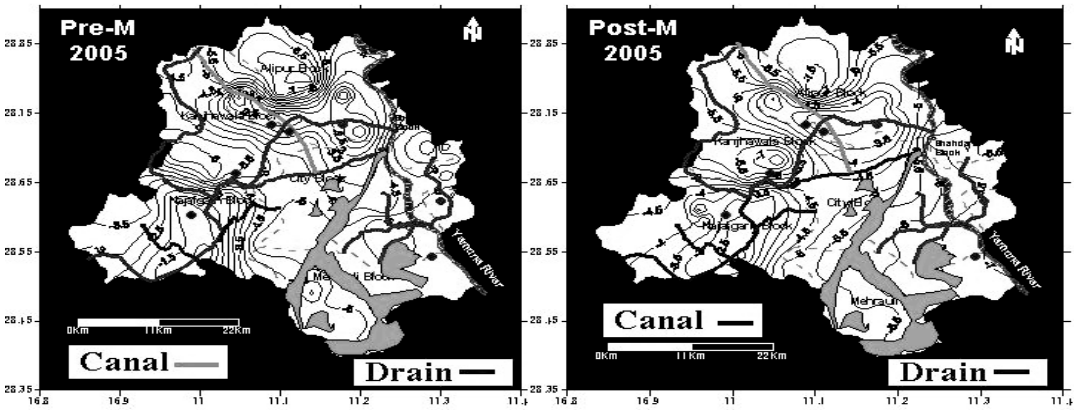

Figure – 1 Model of d^{18}O (‰) distribution in groundwater of Delhi region. Groundwater in Pre-monsoon 2005 and 2004 is isotopically similar, indicating depression focused recharge from isotopically enriched rainfall. Post-monsoon 2005 is relatively depleted, suggesting dilution effect due to lateral flow from surrounding areas.

The aquifer disposition in the area is overlain predominantly by sand in the top 20-30 m, and clay and kankar below that. The Alluvium thickness in the area varies from 100 m to more than 300 m and groundwater occurs under semi-confined conditions. The hydrogeological situation is characterized by the occurrence of alluvial and hard rock formations.

The climate of the region is semi-arid. The average annual rainfall (1931-99) is 711 mm, most of which falls between June to September and is generally erratic, infrequent and heavy sometimes. The average normal rainfall during July, August and September is 192.3 mm, 192.4 mm and 139.6 mm respectively. The mean minimum and maximum temperatures are 18.7^{O}C and 30.5^{O}C respectively.

Analytical Methods

Through extensive field survey and topographic survey, representative sites under changing land use were selected, geographically equitably distributed covering the area, representing various geohydrological conditions. Groundwater samples were collected at sixty-seven different locations during June-July, 2003; at hundred different locations during June, 2004, at 84 locations during March, 2005 and at 84 locations during October, 2005.

Temperature, pH, specific conductance were measured in the field. The samples were analyzed as early as possible for the major anions (HCO_3, Cl, NO_3 and SO_4), cations (Na, K, Mg and Ca), and electrical conductivity by standard methods. The analytical precision for the measurement of major ions is generally kept within ± 5% and expressed in mg/l or meq/l. The $^{18}O/^{16}O$ ratio was measured following a modified Epstein-Mayeda technique and using Micromass Isotope Ratio Mass-Spectrometer, by equilibrating a tank CO_2 gas at 25°C. The isotopic composition of water samples is expressed in terms of per mille deviation (δ ‰) with respect to the isotopic ratio of the reference Standard Mean Ocean Water (SMOW). The analytical reproducibility of the laboratory standard is ± 0.1‰.

Groundwater isotopic and chemical composition

The isotopic data reveals that the aquifer in the studied area does not constitute a homogeneous system in its lateral extent. The groundwater recharge variation (<1% to 66.0%) from location to location, and pumping induced groundwater intermixing through different flow pathways (Datta et al, 1996), result in wide range of spatial variations in the stable isotope (^{18}O) signatures of groundwater, with $\delta^{18}O$ values as highly enriched + 0.59‰ to as depleted as – 7.59‰ during 2003-04; from –0.60‰ to –7.70‰ in March, 2005, and –1.80‰ to –8.10‰ in October, 2005. In general, the groundwater isotopic composition is relatively enriched as compared to the long-term weighted average value (-6.09‰) of Delhi rainfall (Datta et al, 1991). The groundwater are mostly alkaline with pH ranging from 6.9 to 7.7, and are moderately to highly saline, with EC ranging from 567-10340 umhos/cm in northern parts; 440-11944 umhos/cm in northwestern parts; 810-15370 umhos/cm in western parts; 680-2420 umhos/cm in southern parts; 550-3231 umhos/cm in eastern parts and 764-6950 umhos/cm in City parts. The Chloride levels range from 10-7160 mg/l in northern parts; 10-4100 mg/l in northwestern parts; 50-860 mg/l in City area; 60-6080 mg/l in western parts; 10-280 mg/l in southern parts and 10-830 mg/l in eastern parts.

Large part of the area to the west of the ridge is severely affected by nitrate pollution of groundwater (Datta et al, 1997), exceeding the WHO prescribed maximum permissible limit (45 mg/l) in drinking water at many places. During 2003, the Nitrate levels in groundwater ranged from <1-135 mg/l in northern parts; <1-159 mg/l in northwestern parts; 2-32 mg/l in City area; 2-716 mg/l in western parts; 19-303 mg/l in southern parts and 1-69 mg/l in eastern parts. During 2004, the Nitrate levels in groundwater ranged from <1-197 mg/l in northern parts; <1-193 mg/l in northwestern parts; <1-433 mg/l in City area; 1.5-445 mg/l in western parts; 2.2-173 mg/l in southern parts and <1-158 mg/l in eastern parts. During March 2005, the Nitrate levels in groundwater ranged from <1-250 mg/l in northern parts; <1-220 mg/l in northwestern parts; 4.9-958 mg/l in City area; 7-504 mg/l in western parts; 24-465 mg/l in southern parts and <1-144 mg/l in eastern parts. During October 2005, the Nitrate levels in groundwater ranged from <1-7.4 mg/l in northern parts; <1-14.5 mg/l in northwestern parts; 1.6-387 mg/l in City area; 2.5-82 mg/l in western parts; 2.5-26 mg/l in southern parts and <1-35 mg/l in eastern parts. EC, Chloride and Nitrate levels show an increasing tendency during the last decade in the northern parts, in the southwestern parts and in the western parts. Chemical composition of the groundwaters, in general, remained more or less the same from year to year.

Isotopic distribution and chloride dynamics in groundwater and recharge zones

Superimposition of $\delta^{18}O$ (‰) distributions on the Surfer-8 based topography model suggests that the pattern of $\delta^{18}O$ (‰) distributions has remained unchanged from year to year (Figure-1). But, groundwater in 2004 and pre-monsoon 2005 is highly saline, contaminated and isotopically enriched, as compared to rainwater mean δ–value of -6.09‰, suggesting selection effect in favour of isotopically enriched rainfall in contributing depression focused recharge, with longer time stay on low elevated land. Post-monsoon 2005 is relatively depleted, suggesting dilution effect due to lateral flow from surrounding areas, as observed earlier (Datta et al, 1994).

In the aquifer, adjacent to the western bank of the Yamuna river at some stretches, similarly enriched ^{18}O composition of both river water and groundwater compared to that of rainwater during pre-monsoon, 2005 suggests that the river water recharges the groundwater after being subjected to evaporative effects. However, relatively depleted ^{18}O composition of both river

water and groundwater during post-monsoon suggests fresh rainfall recharge to the groundwater in these locations, and possibly contributions from the transport of the top layers of the groundwater from the nearby surrounding areas, as induced by pumping. A simple mixing model (Datta and Tyagi, 1995), based on the spatial and depth variations in $^{18}O/^{16}O$ ratio of groundwater and canal/river water, considering equal inflow of groundwater through the screens of the tubewells, indicated that canal/river water contributes to the groundwater recharge upto 5-10m depth of the aquifer adjacent to the canal/river.

Moderate to highly saline groundwater occurrence suggests that the rainfall recharge is very limited and that groundwater flushing is incomplete. Iso-contouring of chloride and nitrate dynamics (Figure-2 & 3) indicates that from 2003 to 2005, there had been lateral extension of high pollutants plumes towards the central urban parts along specific flowpaths, possibly induced by withdrawal not in balance with recharge. The chloride distribution further suggests that due to excessive concretization of the region, recharge area from direct infiltration of rainfall has reduced considerably and changes from 2003 to 2005, and the potential recharge zone remained confined only in the piedmont areas of southern parts. During 2003, there are small patches of potential recharge zone along the western Yamuna canal almost on the boundary separating the northern and northwestern parts and adjacent to the Yamuna river in the northern parts. Another recharging zone is along the southern and eastern boundary of southern parts.

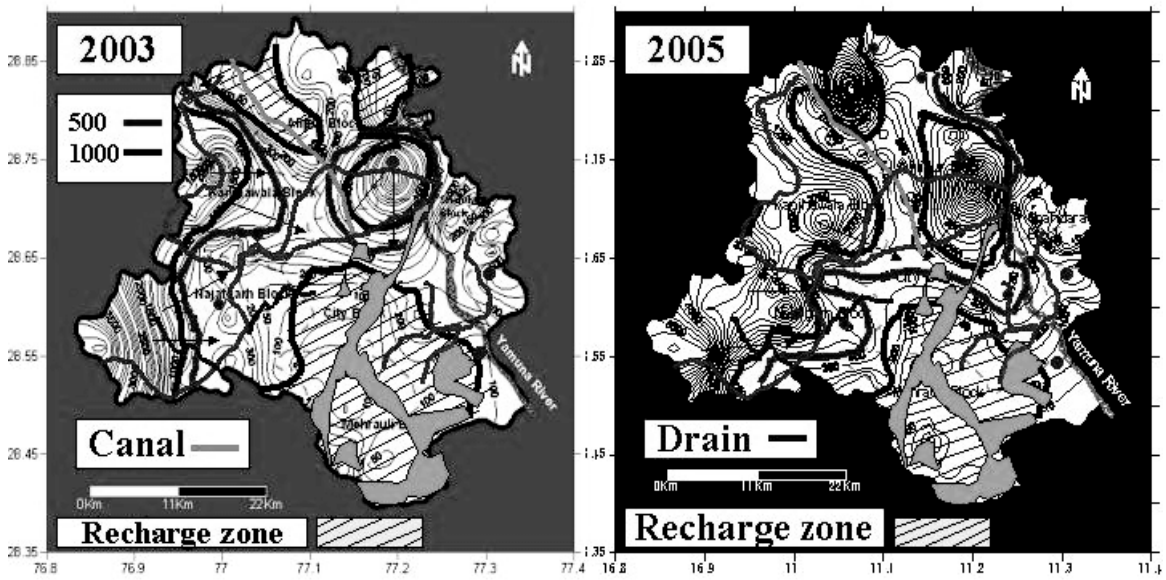

Figure – 2 AQUACHEM Model of High Chloride (mg/l) Plumes Dynamics in Groundwater of Delhi Region. Groundwater is moderately to highly saline, with lateral extension of high salinity plumes towards the central urban parts along specific flowpaths, induced by withdrawal not in balance with recharge.

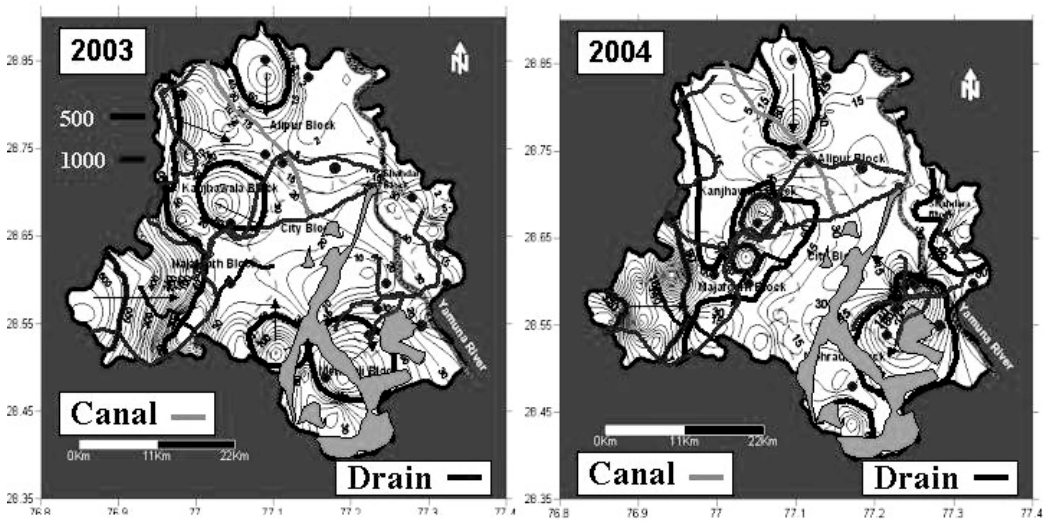

Figure – 3 AQUACHEM Model of High Nitrate (mg/l) Plumes Dynamics in Groundwater of Delhi Region

On a regional scale good positive straight-line relationships between groundwater Cl and $\delta^{18}O$ (Figure- 4) indicate multiple source of high salinity groundwater mixing with good quality water along two or more visualized specific flow pathways, due to changes in the hydraulic heads (Datta et al, 1996), induced by indiscriminate pumping. Except in southern parts, eastern parts and City area, significant variation in groundwater chloride with almost no change in ^{18}O isotopic composition suggests salinity increase contributed by vertical infiltration of chloride containing chemicals in soil with rainwater or irrigation water. The lateral flow water also carries contaminants alongwith it through specific flow-pathways (Datta et al, 1996), influenced by mixing and the extent of the hydrodynamic zones (as indicated by small isotopic gradients).

Identification of sources of recharge based on major ion chemistry

AQUACHEM based major-ion trilinier diagrams (Figure-5) indicates that the groundwaters have different chemical compositions, viz., Ca-Mg-HCO_3; Na-Ca-HCO_3-Cl; Mg-Na-HCO_3; Na-HCO_3; Na-Cl-HCO_3; Na-Mg-Cl; Na-Cl and Ca-Mg-Cl. While, Calcium bicarbonate water is originated as rainfall-derived recharge, over decades to centuries, Calcium-sodium bicarbonate water, are more likely derived from recharge of rainfall that carried saline water mixing alongwith. Since, the clay mineralogy of the area indicates presence of 60% to 80% Illite (Datta and Tyagi, 1996), which apparently is highly resistant to weathering process, the abundance of (Ca+Mg) in most of the groundwaters in the Delhi area can be attributed to mainly carbonate weathering, as observed from earlier studies (Datta and Tyagi, 1996). Presence of 'Kankar' carbonates in the alluvial sediments and occurrence of metamorphosed dolomitic limestones in Delhi Aravalli rocks could favour this process.In addition to this, the groundwater chemistry seems to be significantly affected by the dissolution of concrete materials. Additional Ca2+ may be released to groundwater by corrosion of subsurface concrete materials such as building foundations and basements.

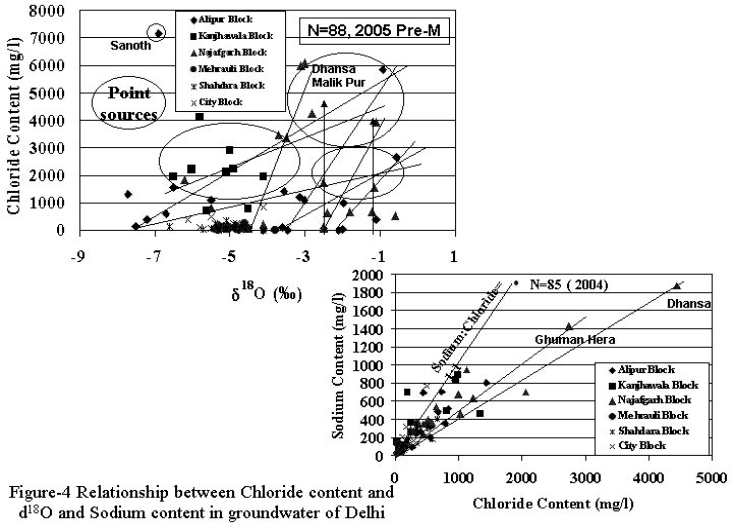

Figure-4 Relationship between Chloride content and d^{18}O and Sodium content in groundwater of Delhi

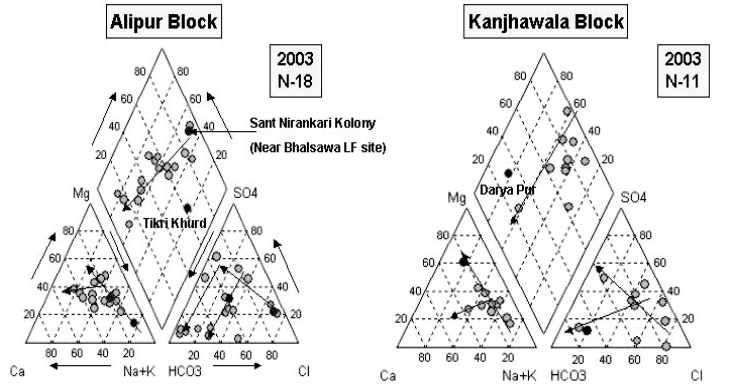

Figure-5 AQUACHEM Model of Chemical Composition of Groundwater in Delhi Area

Very highly saline waters (EC>10000 µmhos/cm) are of Na-Cl type. Moderately saline groundwaters (EC: 3000-6000 µmhos/cm) are of Na-Mg-Cl type. However, sodium shows no correlation with salinity (Electrical conductivity). Highly correlated linear trend between Na and Cl (Figure-4) indicates mixing of two groundwater bodies with different end member composition (i.e. fresh and saline). It is interesting to observe that in every year, most of the groundwater samples lie below the equiline in the scatter diagram of Na vs. Cl, suggesting influence of anthropogenic activities. Groundwaters with low SO_4 and high Cl probably indicates localized SO_4 reduction. The very high Cl and SO_4 concentrations in some of the groundwaters may be related to the long history of evaporation and to oxidation of reduced sulphur gases from land in the relatively lower elevations of flood plain regions, (Datta and Tyagi, 1996). Further the possibility of contribution from anthropogenic sources can not be ruled out.

In ground water of the northwestern and southwestern parts, Sodium-chloride water might have been acquired by mixing with a large component of relict saline water in the deep aquifers (60-200ft) during geologic time. Calcium-magnesium-bicarbonate-sulfate water genesis may be due to longer periods of weathering in contact with aquifer sediments. The groundwaters, plotted on the trilinear diagram on a mixing line between Calcium-sodium

bicarbonate and Sodium-Chloride waters, represent the continuum between rainfall-driven recharge, and relict saline water. The ground waters with mixed cation- bicarbonate and mixed-cation bicarbonate-chloride water, found in surface water or shallow ground water, represent mixtures of various waters (Figure-6). In contrast, mixed-cation bicarbonate water with "depleted" stable isotopic signature, were found both very shallow (15 ft) and relatively deep (60 ft or greater). The deeper mixed-cation bicarbonate water might have evolved by geochemical interactions with aquifer sediments. Ternary diagrams of the major cations and major anions show that agricultural land use produces calcium-sulfate type water due to liming and the application of fertilizers. Residential land use produces water more enriched in sodium and either chloride or bicarbonate, due to an increased contribution of road salt, and in part to the elevated levels of these ions in sewage plumes.

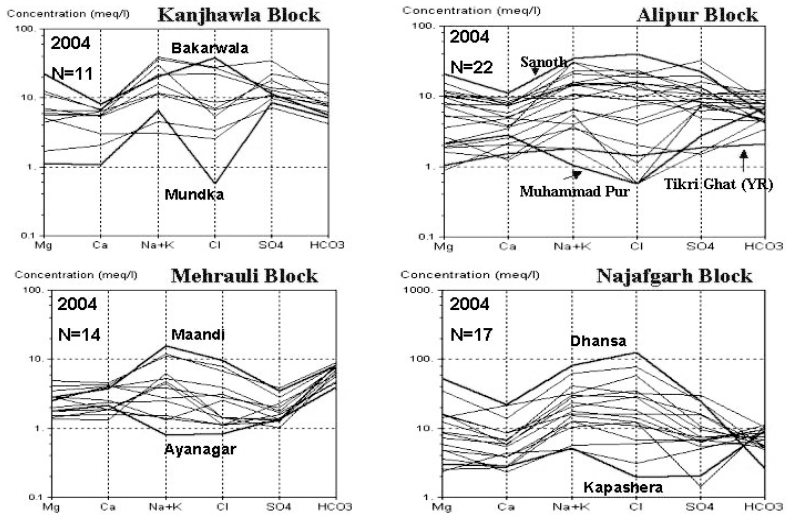

Figure-6 AQUACHEM Multi-Component Model of Groundwater Intermixing

Concluding remarks

The study establishes that groundwater has become more vulnerable to contamination and isotope studies should be conducted as part of comprehensive geohydrological and hydrochemical investigation of ground water vulnerability. There are indications of pollutants transport from the western, northwestern and southwestern areas to the urbanized and overexploited parts. In the northwestern and western parts, there is evidence of increasing ground water pollution and leachate transport to ground water through surface drainage. Further systematic research is needed on hydrogeologic characteristic of the groundwater flow under natural and stressed conditions, dynamics of groundwater contaminants, and its linkage with spatial and temporal variability in concentration, depth variation in contaminants level in relation to well structure and casing conditions, denitrification potential of soil and geohydrology in limiting contamination. Iso-concentration maps of contaminants levels in groundwater should be prepared and revised time to time, in relation to the changes in landuse pattern. The scope of this study has broader significance, since urbanization can place similar pressures on the water resources worldwide.

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Introduction of Kumamoto City, Home of the Richest Groundwater in Japan: To our Asian Neighbors

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Abstract
Kumamoto City is located in the center of Kyushu, the southernmost major island of Japan. Kumamoto City is blessed with rich greenery and abundant groundwater. It is particularly worth noting that thanks to the abundant groundwater, all the drinking water for our 670,000 citizens is covered by groundwater. Kumamoto is the only city which supplies all drinking water with completely natural groundwater among the cities in Japan which have populations of more than 500,000. This has earned Kumamoto the title "The home of the richest groundwater in Japan". We have been undertaking various efforts to maintain our abundant, pure and crystal-clean groundwater so as to pass down this treasure to our future generations.
We strive to spread awareness of water-related problems in Asia and are considering sharing the information and message of our programs for groundwater conservation to other parts of the world.

Keywords: Kumamoto City, groundwater conservation, mechanism of groundwater, rainwater percolation, Japan water grand prix

Introduction
Kumamoto City is located in the center of Kyushu, the southernmost major island of Japan. We have a glorious view of Mount Aso to the east of the city, and to the west, the city faces the Ariake Sea. Kumamoto City is blessed with rich greenery and abundant groundwater.

It is particularly worth noting that thanks to the abundant groundwater, all the drinking water for our 670,000 citizens is covered by groundwater. Kumamoto is the only city which supplies all drinking water with completely natural groundwater among the cities in Japan which have populations of more than 500,000. This has earned Kumamoto the title "The home of the richest groundwater in Japan".

We have been undertaking various efforts to maintain our abundant, pure and crystal-clean groundwater so as to pass down this treasure to our future generations.

Actions for groundwater conservation
(1) Declaration of the Groundwater Preservation City
Our actions for ground water conservation have started with the adoption of the "Declaration of the Groundwater Preservation City" by the city council in March, 1976. Protest movements against apartment construction sites near the source of our drinking water stimulated the city council to adopt said declaration. The following year, we enacted the Groundwater Preservation Ordinance, organized an official office to oversee the groundwater system and extraction, and began to establish observation facilities.

(2) The mechanisms of groundwater
Our analysis from a team of researchers, representing Kumamoto City, Kumamoto Prefecture and outside research groups, have revealed much information regarding water circulation in the area.
*Groundwater is shared by 14 municipalities （hereinafter referred to as Kumamoto Region） including Kumamoto City, as well as a layer formed by Mount Aso's eruption provides the main aquifer for our groundwater.
*The Kumamoto Region receives 2 billion cubic meters of precipitation a year; approximately one third of it evaporates, another one third of it flows into river, and the remaining one third of it, around 600 million cubic meters, forms groundwater.
*Of the total of 600 million cubic meters of groundwater, 46% are cultivated in paddy fields, 41% are cultivated in dry fields or grass fields, and 13% are cultivated in mountainous areas. In other words, our agricultural land serves as the main source of the groundwater.
*Groundwater takes about 20 years to reach Kumamoto City from the outer rim of Mount Aso.

(3)Mount Aso and the feudal lord Kato Kiyomasa
The volcanic Mount Aso experienced violent eruptions with pyroclastic flows four times from 270,000 years ago to 90,000 years ago, when the pyroclastic flow deposited and accumulated to more than 100 meters in thickness, which would later serve to foster our groundwater.

In addition, about 400 years ago, Kato Kiyomasa, the feudal lord of Higo, present day Kumamoto, promoted cultivating paddy fields in the surrounding land, which is easy to permeate with groundwater. This concept worked considerably well and allowed Kumamoto access to a far greater amount of clean water.

In other words, the achieved system of creating groundwater in Kumamoto can be said to be a combined balance of the "natural system" of Mount Aso and the "human efforts" made many individuals such as Kato Kiyomasa.

(4)The current status of our groundwater
According to the municipal observation report, Kumamoto's groundwater flow has been steadily decreasing. There are two main reasons for this. One is the advancement of urbanization; the other factor is the adjustments in rice production.

After the Second World War, the central urban area broadened with economic development. Vast areas were laid with concrete or asphalt for urban expansion and it became difficult for rainwater to naturally absorb into the earth. Groundwater has become harder to accumulate in recent times.

In addition, as rice consumption in Japan has decreased, the amount agricultural land used as paddy fields has also been reduced by 50 percent. This is a serious problem for Kumamoto because our paddy fields are a major source of groundwater.

We have officially recognized the actual state of groundwater via observations, which have revealed the nature of these problems, and have begun to promote effective groundwater conservation measures which are in accord with the natural groundwater system.

(5)Groundwater cultivation which fully utilizes paddy fields
First of all, I would like to mention our programs of groundwater cultivation which utilize paddy fields.

Science proves that the ancient paddy fields, which were cultivated by Kato Kiyomasa, that are located in the towns of Ozu and Kikuyo, neighboring towns of Kumamoto City which lie towards the center of the Shirakawa River, are precious groundwater recharge areas for Kumamoto City. The city therefore concluded an agreement of groundwater conservation with these two neighboring towns in January 2004. Furthermore, we have established a subsidy system which encourages farmers to irrigate their rice fields even after these fields were no longer to be used to produce rice under the production adjustments. Currently, with the aid of more than 400 farmers, we create more than 1,000 cubic meters of clean groundwater a year. We also work with a coalition of upstream sites regarding these ancient and influential paddy fields by arranging exchange programs and promoting “local production for local consumption”.

(6)Maintenance of watershed protection forests
Secondly, I would like to expand upon the maintenance of watershed protection forests. Irrigation water for paddy field in the central part of the Shirakawa River is all derived from Shirakawa River. To ensure a stable river flow and to create sufficient groundwater, we have concluded an agreement for forest maintenance with our neighboring towns and villages and strive to maintain 656 hectares of watershed protection forest. In addition, we aim for local forest development with the support of volunteer citizens.

(7)Fostering a rainwater percolation
Third of all, we have addressed the issue of groundwater cultivation in order to foster a rainwater percolation in the urban areas. We have also implemented an original subsidy system for installing this rainwater percolation equipment or PVC greenhouses in dry fields which help rainwater get adequately absorbed. Moreover, we revised the “Kumamoto City Groundwater Preservation Ordinance” last July in order to ordain the practice of implementing the equipment or facilities to foster rainwater percolation even when constructing new buildings, an approach that has never been used before in Japan.

(8)Development of the citizens’ movement for water conservation
Next, I will tell you about the citizens’ movement for water conservation.
The quantity of groundwater extraction in Kumamoto City is on a downward trend after peaking in 1984. The quantity of the extracted water for industrial or agricultural use has also declined; however, groundwater for use in everyday life, which accounts for 70 % of groundwater extraction in Kumamoto City, has not declined in quantity.

We have been promoting this water conservation movement and working towards efficient water-saving methods at home with citizens since 2004. We have also made July a campaign period for water conservation, having reported citizen water usage everyday, which we aim to reduce the total amount by 10 % in 5 years.

(9)The Kumamoto Water Heritage Registration Program
I would like to continue by introducing you to the Kumamoto Water Heritage Registration Program.
This program is designed to maintain the various local cultures and trades which are deeply

linked with our water, such as architecture, customs, or food, for future generations to come. So far 43 concepts have been registered, and the bus tour to those Water Heritage sites is quite popular among citizens.

(10)Establishment of the Kumamoto City Official Water Examination
Next, I would like to explain about the challenges faced in establishing the official water examination. To conserve our water culture and pass it down to the next generations after us, it is vital that we instill awareness into citizens about our current water situation of Kumamoto. We have established the official water examination of Kumamoto City, with which you can enjoy learning about water of Kumamoto, and have been implementing this program since last August.
With this examination, we can spread the knowledge about our water culture and enlighten people about the challenges involved in maintaining our precious water supply. We promote groundwater conservation while advertising Kumamoto City as a pure groundwater city.

(11)Environmental education and lifelong learning programs
We also work hard to provide environmental education and lifelong learning programs.
We created and regularly distribute supplementary readers for elementary students to learn about water. Regarding lifelong learning programs, we have arranged some courses of water that citizens can take at home as well as offering them in various locations. These courses contain topics such as Kumamoto's groundwater, Kumamoto's rivers, water conservancy, Kumamoto Water Heritage, and the official water examination of Kumamoto. City employees present these materials at schools or community centers.

(12)Kumamoto City won this year's highest national award for water resource management, the Japan Water Grand Prix.
This prize is to be given to a person or an organization who improve the distinguished programs regarding revitalizing water circulation and aim to achieve a Japan in the 21st century where all water is safe, clean, and enjoyable.
This is because we are highly praised with our cross-administrative-district work for groundwater conservation over the past 30 years combining citizens and businesses, such as the establishment of the Groundwater Preservation Ordinance, groundwater cultivation programs which fully utilize our watershed forests and paddy fields, and involve citizens' movement for water conservation.

(13)The 100 best waters of the Heisei Year in Japan
The Ministry of the Environment has selected Suizenji Lake Ezu springs and Mount Kinpo springs in Kumamoto City as two of the 100 best waters of the Heisei Year.
These two springs were valued because of not only their water quality and size but also because of the communities' or NPO's proactive and continuing conservation activities for them.

Message from Kumamoto City, home of the richest groundwater in Japan, to our Asian neighbors
As we have explained above, Kumamoto City is the most groundwater rich city in Japan. However, there are currently many people who cannot obtain safe drinking water in Asia. We strive to spread awareness of such water-related problems in Asia and are considering sharing the information and message of our programs for groundwater conservation to other parts of the world.

This year marks 400th anniversary of the completion of Kumamoto Castle, which was originally built by the feudal lord Kato Kiyomasa. Honmaru Goten Palace has been restored and it attracts many visitors from both Japan and abroad. You can see panoramic views of downtown Kumamoto City as well as Mt. Aso from main tower of the castle.

We hope everyone attending this forum today will visit Kumamoto someday, enjoy the Kumamoto Castle or Lake Ezu or Mount Kinpo springs, and even enjoy tasting our groundwater that we feel so passionate about.

Factors Influencing Farmers' Willingness to Protect Groundwater from Nonpoint Sources of Pollution in the Lower Bhavani River Basin, Tamil Nadu, India

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Abstract
Farmers' perceptions about groundwater and drinking water quality are important, which influence their willingness to adopt protection measures either individually or collectively. This study attempts to capture the factors influencing farmers' perceptions and their willingness to protect groundwater from nonpoint sources of pollution, and their willingness to support the local government to supply drinking water through alternative arrangements. Six villages are identified in the Lower Bhavani River Basin, Tamil Nadu, India on the basis of their long-term groundwater nitrate concentrations and sources of irrigation. A pre-structured questionnaire survey (face-to-face interviews) has been administered to 395 farm-households across six villages during June-July, 2006. Results show that farmers' perceptions of risks related to groundwater nitrate pollution vary across the villages, and mimic the actual groundwater nitrate situation. Estimated results of binary choice Probit models show that farmers from comparatively high groundwater nitrate contaminated villages are willing to protect groundwater as compared to farmers from less affected villages. Demand for safe drinking water varies across the villages, based on the variations of socio-economic characteristics of the sample households and groundwater quality of the villages.

Keywords: Groundwater Quality, Nonpoint Source Pollution, Willingness To Protect, Rural Water Supply, Subjective Risk Assessment, India.

Introduction
Pollution abatement strategies for water resources in India and other developing countries have given priority to point sources of pollution. However, it is increasingly becoming evident that improvement of quality of surface and ground water resources will also require the control of pollution from nonpoint sources (NPS). Nonpoint source water pollution control is particularly crucial in rural areas where groundwater is an important source of drinking water. In several parts of India, growing access to irrigation facilities along with unbalanced and overuse of nitrogenous fertilisers, unlined and open storage of livestock wastes, and insanitary disposal of human wastes have led to high concentration of nitrate in groundwater. There is limited information on the level of pesticide contamination of water sources. However, there is substantial secondary information on the level of nitrate in groundwater as well as surface water.

Consumption of nitrate contaminated drinking water poses various short and long term health hazards to various age groups (Fewtrell, 2004; WHO, 2004). Nitrate (NO3) concentration in water used for drinking should be less than 50 milligram per litre (mg/l) (WHO, 2004). In

India water having nitrate levels greater than 100 mg/litre is considered to be harmful, if used for drinking (ISI, 1991).

Nonpoint Source Pollution Control Options

Due to large number of sources and diffused entry points, it is technically difficult and financially infeasible to monitor the contribution of individual nonpoint sources to the ambient concentration (Dosi and Zeitouni, 2001). Though monitoring and taking regulatory measures to protect groundwater is the responsibility of the Pollution Control Boards (Trivedy, 2000), there is no legal provision to regulate individual polluters. As a result, pollution control of nonpoint sources is mostly neglected in India. Economic instruments like nitrogen and pesticide taxes are not feasible in the Indian context at this time, although they have been used in some European countries (Zeijts and Westhoek, 2004 and Rougoor et al., 2001). In India, nitrogenous fertilisers have been subsidised to encourage use by farmers. This has led to overuse of fertilisers by farmers and the consequent problem of nitrate pollution of the groundwater (NAAS, 2005). Proper pricing of fertilisers may lead to more careful use (Chelliah et al., 2007). Voluntary approach like collective action to adopt best management practices (BMPs) by the farmers may be a long-term solution to control NPS groundwater pollution. Collective action is needed to ensure that restraint in the use of fertilisers is practised by all the farmers in a particular village or area.

Environmental Sustainability of Sources of Drinking Water

One of the targets of the United Nations' Millennium Development Goals (MDGs) is to "halve by 2015 the proportion of people without sustainable access to safe drinking water and basic sanitation" (Target 10 of MDGs). Pollution from nonpoint sources (NPS) makes groundwater resources unsuitable for drinking. Thus environmental sustainability of safe sources of drinking water for future generations is at stake.

Environmental and natural resources conservation from quantitative depletion and qualitative degradation, should be an integral part of any economic and development policy, which is also one of the targets of United Nations' Millennium Development Goals (Target 9).

Both qualitative and quantitative aspects of protection of drinking water sources need to be addressed to meet the drinking water needs of the people. Major challenges that rural water supply sector in India is facing today are not only to meet the large investment requirement to augment the water supply, but also additional investment burden to tackle the water quality related problems. Achieving equity and greater access to safe drinking water for a large section of the populace will remain a distant dream, if we cannot protect our drinking water sources from all possible sources of pollution. Since groundwater serves as a decentralised source of drinking water in rural areas, the rural population become vulnerable to various water-borne diseases when groundwater is polluted. And it is mostly the poor and marginal section of the population who suffer the most, as they cannot afford to protect themselves from the impacts of pollution.

Access to safe drinking water is vital for human well-being (UNDP, 2006). People exposed to polluted drinking water are vulnerable to various water borne diseases. Costs associated with mortality and morbidity of water-borne diseases are high. For example in India water borne diseases annually put a burden of USD 3.1 to 8.3 million in 1992 prices (Brandon and Hommann, 1995).

The Comptroller and Auditor General of India (2000) reports that about 10 per cent of water sources in the state of Tamil Nadu are not potable due to excessive nitrate. The nitrate-affected belt is mainly in the western districts of Tamil Nadu. Foster and Garduño (2004) reported elevated concentration of nitrate in drinking water wells during dry season at numerous locations in Tamil Nadu. In Coimbatore and Dharmapuri districts of western zone, more than 20 per cent of drinking water wells had nitrate concentration greater than 50 mg/l and in large number of wells nitrate concentration exceeded 100 mg/l. They attributed infiltration or leaching of nitrate from human and animal excreta as the major cause of groundwater nitrate in those areas. Controlling pollution from nonpoint sources will be the first step towards sustainable access to safe drinking water in rural areas. In this study, we use the Lower Bhavani River Basin in Tamil Nadu as a case study of nonpoint source pollution.

Nitrate Pollution in the Lower Bhavani River Basin, Tamil Nadu

The Bhavani river is the second largest perennial river of Tamil Nadu, and one of the most important tributaries of the Cauvery river. The Lower Bhavani River Basin is an extensively irrigated area, and farmers apply nitrogenous fertilisers way above the doses recommended by the Tamil Nadu Agricultural University (Shanmugam and Mukherjee, 2004). As a result high concentration of nitrate has been reported both in shallow and deep aquifers. Secondary data on groundwater quality indicates that the level of nitrates in the groundwater is high (> 100 mg/liter) in many pockets of Coimbatore and Erode districts of Tamil Nadu in which the basin is located. Due to growing incidence of groundwater nitrate concentration in the basin, the environmental sustainability of safe drinking water sources is at stake. In some instances the public water supply authority has provided drinking water from alternative sources to nitrate affected rural habitations. However, a large section of the society is still dependent on decentralised drinking water systems and exposed to high nitrate contaminated drinking water. It is expected that drinking nitrate-contaminated water may have various short and long term health impacts. However, due to inadequate secondary health information it cannot be confirmed.

Objectives

Community participation in environmental conservation is a new area of research and it is in this regard that this study attempts to understand (in *ex ante*) individual farmers' perceptions about groundwater quality, and factors which influence his/her individual decision to protect groundwater either individually (through adoption of agricultural BMPs) or collectively - by supporting local government to supply safe drinking water through alternative arrangements. This is the first step to study the possible emergence of collective action. The decision to cooperate in collective action is an individual's decision where his/her economic motives, socio-economic background and other factors play a crucial role. Apart from individual specific factors, social connectivity (social capital) and factors like information/consultation sources play a crucial role in his/her decision.

Methodology

To capture the spatial variations across the basin, we have selected six villages on the basis of their water availability, sources of irrigation, intensity of agriculture (as measured by total cropped area as a percentage of total area), intensity of irrigation (as measured by irrigated area as a percentage of total cropped area), long-term groundwater nitrate concentration and level of urbanisation. The villages differ in their sources and access to drinking water.

However, all the villages have access (to a limited extent) to safe drinking water from TWAD Board's Combined Water Supply Schemes (CWSS) running from the Bhavani river. Among the 6 villages two are from the Lower Bhavani Project (LBP) canal command area – Elathur (ELA) at the head reach of the canal and Kalingiam (KAL) at the middle reach of the canal, two are from the old system – Kondayampalayam (KDP) depends on Arrakankottai canal for irrigation and Appakoodal (APP) depends on the Bhavani river for irrigation and two are from rain fed and groundwater irrigated area – Madampalayam (MDP) and Kembanickenpalayam (KNP). Apart from the sources of irrigation, villages differ with respect to their level of urbanisation and socio-economic status. Appakoodal, Elathur and Kembanickenpalayam are Town Panchayats (TP) and Kalingiam, Kondayampalayam and Madampalayam are Village Panchayats (VP). Out of six sample villages from three irrigation systems – old system, new system and rain fed area - one TP and one VP falls under each of the system (Table 1). Groundwater data analysis shows that Appakoodal, Kembanickenpalayam and Madampalayam have comparatively higher groundwater nitrate concentration - more than 50 per cent of the samples have NO_3 concentration more than 50 mg/l. Elathur, Kalingiam and Kondayampalayam have comparatively lower groundwater nitrate concentration - less than 25 per cent of the samples have NO_3 concentration less than 50 mg/l. Average groundwater nitrate concentration for Madampalayam is comparatively higher (for all seasons) than other five villages selected for our case studies.

Table 1. Groundwater Nitrate Pollution in the Study Villages

Name of the Sample Location	**Source(s) of Irrigation**	**NO_3 Concentration (in mg/l)**		**% of observation having NO_3 Concentration**	
		Average	**Range**	**>50 mg/l**	**> 100 mg/l**
Appakoodal (APP) (Rural Town Panchayat)	The Bhavani river and groundwater (open wells and deep bore wells)	50.0	10 – 105	53.8	3.8
Elathur (ELA) (Rural Town Panchayat)	The Lower Bhavani Project (LBP) canal and groundwater (open wells and deep bore wells)	34.5	1 – 120	23.1	11.5
Kalingiam (KAL) (Village Panchayat)	The LBP canal and groundwater (open wells and deep bore wells)	24.3	0 – 134	13.0	4.3
Kembanickenpalayam (KNP) (Rural Town Panchayat)	Small dam, groundwater (open wells and bore wells) & river pumping	47.9	0 – 106	50.0	4.5
Kondayampalayam (KDP) (Village Panchayat)	The Arakkankottai canal and groundwater (open wells and deep bore wells)	49.7	2.7 - 115	44.0	4.0
Madampalayam (MDP) (Village Panchayat)	Mostly rain fed and groundwater (open wells and deep bore wells)	128.7	0 – 320	77.3	54.5

Source: Census of India (2001), TWAD Board, Chennai and Primary Survey

A detailed questionnaire survey has been carried out among 395 farm households spread across six villages in the Lower Bhavani River Basin during June to July, 2006. Both qualitative and quantitative information collected through face-to-face interviews with the head of the farm households. On an average 60 farm households were selected randomly from each of the six villages on the basis of their availability of own agricultural land and interest in the subject of our research. Voluntary participation of the farm households was sought for interviews, based on their availability of time. Both the information leaflet and household

questionnaire schedule were translated into Tamil, and a background of the objectives, scope and coverage of this study was described before starting the interviews. Apart from household questionnaire survey, various information related to land use pattern and drinking water schemes/systems of the villages were collected from the village agriculture office and village *panchayat* office respectively.

Results

The estimated results of binary choice Probit models show that:

- Farmers from comparatively high groundwater nitrate contaminated villages correctly perceive (subjective) their groundwater quality and they are willing to protect groundwater quality as compared to farmers from less affected villages. Therefore, it shows that any groundwater quality protection programme from nonpoint sources of pollution should take into consideration the site characteristics and socio-economic characteristics of the stakeholders.
- Farmers' groundwater quality perceptions vary across the villages and mimic the actual groundwater nitrate situation. Households depending on their socio-economic characteristics, social- and information-network and the characteristics of the resource (alternative sources and quality of drinking water) derive a subjective risk assessment of their groundwater quality. Regular monitoring of groundwater quality, assessment (objective) of risks of consuming contaminated groundwater and communication of risks to the stakeholders could help the farmers to take measures/initiatives either individually or collectively to protect groundwater from NPS pollution.
- Demand for safe drinking water varies across the villages, based on the variations of socio-economic characteristics of the sample households and groundwater quality. However, with reference to farmers' willingness to protect groundwater quality, their willingness to support local government shows different results. For example, farmers from villages having higher concentration of groundwater nitrate, are willing to protect groundwater quality and reluctant to support local government. *However, adoption of demand driven approach for provision of drinking water may not be suitable specifically when the risk of consuming contaminated drinking water is not commonly perceived by the consumers, as the presence of nitrate does not change the taste, odour, colour or any other commonly perceivable quality/characteristics of drinking water.*
- Farmers' knowledge about impacts of agricultural practices on groundwater quality significantly influences their perceptions about groundwater quality and willingness to protect groundwater. Therefore, provision of agricultural information and education along with basic agricultural extension services could induce the farmers to protect groundwater from NPS Pollution.
- Both socio-economic characteristics of the households and the characteristics of the subject (groundwater or drinking water) significantly influence the farmers' perceptions. Knowledge of agricultural BMPs and their impacts on environment positively influences farmers' perceptions and willingness.
- Farmers' perceptions about groundwater quality influence their willingness to support local government to supply safe drinking water. Irrespective of sources of drinking water, farmers are willing to support local government
- Memberships in social participatory institutions and sources of agricultural information, significantly influences farmers perceptions and willingness.

The role of stakeholders and their voluntary participation in agro-environmental management in general and water resources conservation/management in particular is a new area of research, at least for a developing country like India. The study will be useful for policy since there are many areas in India and other developing countries which are facing similar groundwater pollution problems. The issue of groundwater pollution from nonpoint sources is a growing concern not only for a relatively water scarce country like India, but also for water abundant countries around the world.

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Introduce Market Mechanism into Urban Water Management Establish Public-Private Partnership

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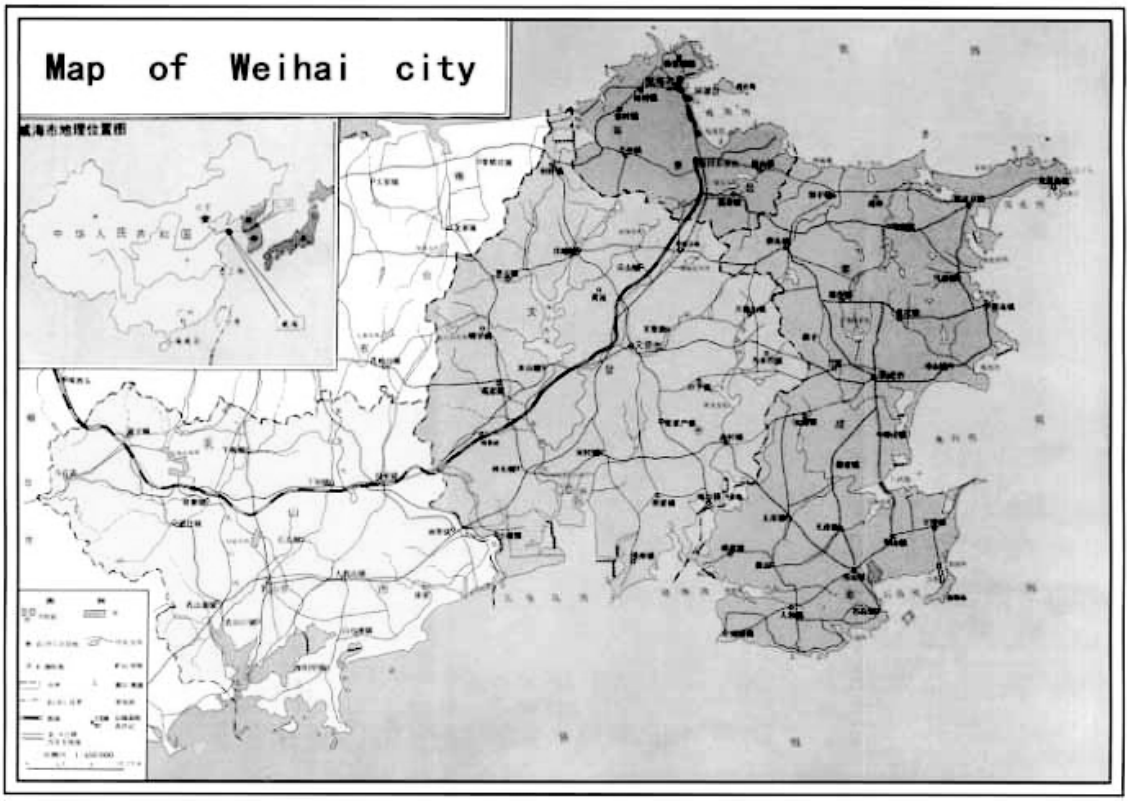
Abstract
Weihai as a coastal city in China enjoys the preferential policies and unique location, the urbanization and economy developed very fast, that also causes severe environmental pressure especially for the water. Weihai introduces market mechanism into the water management, using discharge fee, pricing, BOT, polluter pay principle, encourage the water saving, solved the fund shortage problem, established a public-private partnership, though the GDP, urban population and developed urban area grow very fast, but the water quality remains the same as before.

Keywords: market mechanism, water pricing, BOT, polluter pay principle, public-private partnership

Background
Weihai is located in the eastern tip of Shandong Peninsula of China, opposite to the Liaodong Peninsula, the Korean Peninsula and Japanese Islands across the sea. Weihai has a history of over 600 years. It had been a small frontier town till the 1980s with a population less than 70,000.



In 1987, Weihai was founded as a prefecture level city. Three lower level cities are under its jurisdiction; the total area is 5436 square kilometers, with a population of 2.47 million. Weihai has 986km coastline with attractive beaches, beautiful landscape, numerous historic sites and a pleasant climate. The GDP was only 3.4 billion yuan in 1987, mainly from fisheries and light industries, the environmental quality is one of the best in China, and these make Weihai a famous tourist city.

When China began to open up and move on to the current fast track to development, Weihai as a new developing coastal city，enjoys many preferential policies and a unique location，this lead to a rapid development for the city and economy. In 2007, compared with the foundation of Weihai city in 1987, the developed urban area grew from13.1 to 109.0 km^2; the urban population grew from 233,000 to 632,000; GDP grew from 3.42 billion yuan to 158.35 billion yuan. The GDP growth rate is 21 % annually. The rapid development also brings high pressures on the environment, especially the water quality.

Shandong peninsula is a water shortage area; the annual precipitation in Weihai is 770mm. Because Weihai is a hilly land, most of the rainwater runs into the sea immediately, and there is no river transfer water from inland to Weihai, the annual available water resource is only 548 m^3 per capita, just about 1/4 of the China's national average, which itself is only ¼ of the world average. This means that the water resource per capita in Weihai is only 1/16 of the world. But along with the rapid development of urban and industry, the water demand increases rapidly. In the central city, the supplied running water was 6.90 million tons in 1987, increased to63.30 million tons in 2007. Making the situation even worse, the scarce water resource face severe pollution because the increased wastewater discharges from human and industrial activities.

During 1999 and 2000, Weihai experienced a severe drought; the precipitation was 316 and 460 mm, only about 1/2 of the annual precipitation. The water level in the reservoir, the water resource of the city, dropped to the bottom, the whole city faced a severe water shortage problem. To ensure the residents' daily water supply, the government limited the water use of the factories; some big water consuming factories even were shut down. In the spring of 2001, before the rainy season came, the whole city especially the mayor was greatly alarmed. The rains finally came when the city had only 7 days of water left in the reservoir!

After this critical test, we thought about the water issue carefully. What are the problems? How can we solve them? The mayor held several meetings focused on the water issue. He directed the water resources, environmental protection, urban construction and industry administration departments to carry out investigation, present their suggestions and discuss these with each other. We found: yes, Weihai is a water shortage area; that is God gives us. We cannot change it. What we can do is increase the water use efficiency; protect the water environment, keep all the water clean enough for use; explore new water resources. To achieve this goal, introduce the market mechanism into the water environment management, establish public-private partnership is the key instrument.

Description of the initiative
The initiative focus on the follow area:

Collect pollutants discharge fee, force the industrial structure reform
In Weihai, 2/3 of the running water is consumed by industries and the same percent of wastewater discharged from industries accordingly. So reform of the industrial structure, establishing water saving industries in Weihai, is the key to solving the water shortage and water pollution problem.

In China, we have a policy, if the factories discharge pollutants into the air, water body or soil, they should pay the pollutants discharge fees to the government. The discharge fee calculated according the concentration and volume of the pollutants. But in practice, in most of the cases, because the local government leaders pay more attention on the economic development than the environmental protection, and the local environmental protection agency lack the technique and supervision force, this policy has not been carried out thoroughly. Before 2000, the situation is almost the same in Weihai. After the initiative, the mayor pay more attention on the environment; invested 8 million RMB, established a automatic-continuous air quality monitoring system, installed 30 on line water quality monitoring equipment on main wastewater discharge points; recruited 16 university graduated students, stressed the supervision force, that makes the environmental policy be carried out more thoroughly. In 1999, the collected pollutants fee was only 2.5 million; in 2007, it reaches 16.8 million, 6.7 times than 1999. The enforcement of the environmental protection law forces the factories to choose clean production, clean process, then improved the industrial structure.

In China, most of the town level cities have pulp & paper mills and ethanol factories. They use grain stems to produce paper and use sweet potatoes to produce alcohol. In some area they are the main contributors of the government revenue. But these industries consume a lot of water, discharge a lot of water pollutants, and create problems for water environment. Before 2000, Weihai has 4 pulp & paper mills and 4 ethanol factories; they cause a big pressure on the environment. We monitor their water discharge and collect discharge fee stringently, makes them no much profit, combine with the national and provincial industrial policies, these mills and factories were gradually be shut down. By 2000, only one pulp & paper mill was left. In 2001, we made the decision to shut down the last one. Now in Weihai only allow use recycled paper to produce paper. This decision can save 3 million ton water a year, reduce the same mount of wastewater discharge and improved the water environmental nearby very much.

These years, because the preferential policy and advantage environment, many investors came Weihai to open factories or do business. During the approval process, the relative departments of Weihai municipal government insisted on the principal of non-pollution and efficient water use, and refused to issue permits to polluting industry though it might make a big contribution to the local revenue. During the last 7 years, we rejected about 230 projects with total investment about 120 million USD.

Now the main industries in Weihai are electronics, garment, machinery manufacture, medicine, food processing and service. This kind of industrial structure consumes less energy and water resources, making the development more sustainable.

Using pricing mechanism, encourage water saving

Before 1978, China had a centrally planned economic system. After China open up to the outside of the world, it began to conduct economic reforms, gradually changing the centrally planned system to a market system. During the planned economic period, salaries were very low, but the residents enjoyed subsidies for most of their living cost. The government owned companies allocated apartments to their employees, charging only a very small rent. The government also subsidized food and water. All the investment for water supply came from the government revenue, the price charged for the residents covered only a small part of its real cost. In this case, there was no motivation for the residents to save the water in order to saving their money.

After the economic reform, China follows market principle, began let the beneficiaries pay the cost. In order to stimulate public saving water, we gradually raise the water price. In 1999, the water price for the residents was only 1.20 yuan per ton, now is 2.85 yuan that including 1.70 yuan for water supply, 0.8 yuan for sewage treatment and 0.35 yuan for water resources. We also use the progressive pricing mechanism that means the more water you consume, the higher of the water price is. For example, if a house uses more than 12 tons per mouth, the price of the water will be double than 12 tons below. This mechanism is designed to protect the poor and punish the waster. In 1999, the water price for factories was only 4.00 yuan per ton, now is 6.85 yuan that includes 5.00 yuan for water supply, 1.10 yuan for sewage treatment, 0.35 for water resources and 0.40 for other cost.

Now in Weihai, at the household level, most people use water saving equipment, change the screw tap to one action tap, use urinals with a volume of less than 6 L. Some householders even store the water after washing hands and vegetables then use it for flushing the urinal.

For industries, more factories use clear product process. The water is recycled, reused as much as possible. Some factories even take the sewage treatment plant as their water resource; use the treated wastewater as cooling water or for other purpose. From 2002 to 2005, the 3 heating & power stations in the central city invested 150 million RMB, changed the heating system from supplying steam to circulated hot water that can save 1.5 million ton water every year. Now the industrial water reuse rate is 93.14%.

The entire municipal infrastructure maintenance, like irrigation of grassland and trees, road wetting, use recycled water. In municipal engineering, most of them use rainwater from reservoirs and pools nearby. In down town of Weihai, along the coastline, there are several large parks with grass and trees. Here we constructed pipelines under the ground and connected the parks with a sewage treatment plant, use treated water to irrigate the grass and trees. With this project alone we saved 0.16 million tons fresh water in 2007.

Using BOT method, absorb private company invest in the sewage treatment plant

In the early 1980s, after a careful study from both the environmental and economic aspects, we found that compared with the individual sewage treatment system, the district sewage treatment system has many advantages. It costs less, has higher efficiency, is easier to administrate and the environmental quality is better. So Weihai government decided to use the district sewage treatment system. According the urban development, landscape, sewage discharge volume and water environment, we made a plan for sewage collection and treatment plants construction, let the municipal administration bureau to construct the sewage treatment plants accordingly. We do not demand the factories and hotels build their own

treatment facilities, except those factories, like electroplate plants, whose wastewater is not suitable for the biochemical treatment method.

The No1 sewage treatment plant began to operate in 1985; that was also the No1 in Shandong Province. At that time one could count on his fingers the total number sewage treatment plants in China. Its capacity is 15000 t/d, total investment is 12 million RMB. The No2 sewage treatment plant began to operate in 1995, with a capacity of 80,000 t/d, investment is 120 million RMB. The first phase of No3 sewage treatment plant began to operate in 2000 with a capacity 10,000 t/d, investment is 50 million RMB.

When we constructed the No1 sewage treatment plant in 1985, No2 sewage treatment plant in 1995 and the first phase of No3 sewage treatment plant in 2000, all the investment came from the government revenue. When we expanded the No2 and No3 sewage treatment plants in 2005 and 2006, we used the BOT (Build, Operation then Transfer) method, absorbing private investment in the city's infrastructure. The expansion of No2 sewage treatment plant invested by a company headquartered in Beijing. It takes care of all the design, construction and operation, the capacity is 40,000 ton per day; the total investment is 62 million RMB. The beneficiaries pay the sewage treatment fee, 0.91 yuan per ton. After 25 years of operation, the company will transfer the plant to the local government with zero payment. The expansion of No3 sewage treatment plant is done by a company headquartered in Qingdao. The capacity is 40,000 ton per day, total investment is 61 million. The beneficiaries pay 0.93 yuan per ton. Its operation period is 25 years. After that time, the plant also will be transfer to the local government with zero payment.

Using the BOT method, the government does not have to spend money, but solved the sewage treatment problem properly. In 1999, the sewage treatment rate in Weihai was 59.99 %, increased to 83.56 % in 2007.

Follow the polluter pay principle, collect sewage treatment fee

Before 2005, in most of the cities in China, the running cost of the sewage treatment plants was covered by the government; it was free of charge for both residents and factories that is a big burden for the local government. In some cities, the local government constructed the sewage treatment plant under pressure of environment with the assistance of central government, but can not afford the running cost, so they just lay the sewage treatment plant there, only operating when the investigation team came. In 2005, the central government of China issued a regulation, orders all the cities must collect the sewage treatment fee, gradually raises it, till covers the running cost and the property depletion.

Weihai is the pioneer of sewage treatment fee collection. In 2000, the Weihai government issued a regulation to collect a sewage treatment fee from beneficiaries, 0.40 yuan/t for enterprises, and 0.20 yuan/t for residents. In 2006, we raised the treatment fee to 0.8 yuan/t for resident, 1.1 yuan/t for factories. Now the sewage treatment cost in Weihai is about 0.9 yuan/t. In this case, the sewage treatment fee collected can almost balance the cost.

The collection rate of the sewage treatment fee is another problem. In some cities the residents and factories refuse to pay the sewage treatment fee, they argue the amount they discharged, because usually there is no meter for the sewage, and in most of the cities the responsibility of water supply and drainage are belong to different government departments, it is difficult for the drainage staff to prove it. In order to improve the water management efficiency, in August 2003, Weihai reformed water management system, established Weihai Water Affairs Group. Weihai municipal government gives all the responsibility and power for both the water supply and drainage to this group. Now the responsibility is clear and the work efficiency is higher. The Water Group collect wastewater treatment fee with the water supply fee together, if no special reason, from how much water consumed, they can calculate how much sewage have discharged. If somebody refuses to pay the sewage treatment fee, he cannot get the running water. So the sewage treatment fee collection rate is almost 100%.

Using market mechanism, encourage new water resource exploration

In Weihai urban area, the population and industry have developed very fast, and this trend will continue for some time. Water shortage is a strategic bottleneck for the development of Weihai. Water saving alone cannot solve the problem in long term. We must explore new water resources to meet the demand of development.

Before the initiative takes place, because the running water price was low, the other water alternative resources can not compete with it, so the factories have no motivation to explore new water resources. After the initiative, the running water price for industrial usage has been raised from 4.00 yuan to 6.85 yuan, that give the chance for water alternatives.

Weihai is a coastal city; we have 986 km of coastline, the longest of any city in China. Desalination is one of the alternatives. Before 1999, we only use seawater for industrial cooling. There were no desalination stations because the cost is higher. But during the 1999-2000 drought, the water means survival or death for some factories, and after the running water price raise and the desalination technology improvement, the cost of the desalination almost can compete with the running water, desalination stations began emerging.

The first desalination station in Weihai was constructed by Huaneng Weihai Power Station in 2001. This power station is the biggest water consumer in Weihai. During the drought season, it faces high pressure, which led them to find an alternative in constructing a desalination station. The capacity is 2500 tons per day, the investment was 18 million yuan RMB, and the running cost is about 7 yuan RMB per ton. The second desalination station was constructed in 2002; it was built by the Weihai Water Affaires Group. This station is constructed on an island, to solve the drinking water problem of the residents on the island. Its capacity is 500 tons per day; total investment is 8 million yuan RMB. The third desalination station was constructed in 2003 by a fishing company, to solve the water shortage problem for the nearby area. Its capacity is 5000 tons per day, total investment is 40 million RMB.

Another alternative is reuse treated wastewater. Now we have three sewage treatment plants in the central city. Most of the treated wastewater is discharged into sea directly. This is a waste. In 2003, the Weihai Water Affairs Group constructed a water purification plant, using a third treatment method, deeper treat the water discharged from the second treatment plant, makes it meets the standard for most of washing, irrigation, cooling and engineering. The capacity is 10,000 tons per day, and investment is 30 million RMB. They sale the treated

wastewater at 1.00 yuan per ton, that much cheap than the running water, so most tree and glass land irrigation use this water, some factories use it for cooling and washing, some office and residents buildings use it for toilet flushing.

In recent years, some cities try to store rainwater for industrial and municipal usage. That is a new idea for us. We began to do some investigation and feasibility study in this area.

Strength environment education

In order to stress the public participation in water management, we pay much attention on environmental education. We set up an environmental program on TV and radio; a column in the newspaper Weihai Daily; publishes environmental information, environmental law and good practices. We disclose the environmental information, established a website, www.whep.gov.cn, where the public can get the environmental regulations, standards, statistics and environmental qualities. We opened the mayor's mailbox, mayor's hotline 12345, and environmental hotline 12369, to answer questions and receive complaints about the environment. Whenever we want increase the water price, we held a public hearing, consult with the public, collect their opinions, after reach a general agreement, then make the decision.

Housewives are the important players in the water environment management. We encouraged local communities to organize housewives to participate in various environmental activities, to share their experience on water saving, visit the reservoir and sewage treatment plants and increase their awareness of the water environment.

Impact

Since the initiative of water environment management began, the effect is obvious. In 2007, compared with 1999, the supplied water increased from 43.67 million tons to 63.30 million tons; the industrial water reuse rate increase from 89.62% to 93.14%; the sewage treatment rate increased from 59.99% to 83.56 %. Though the urban population and GDP grew very rapidly as mentioned, but the water environment remains good quality. All the rivers, the sea water, the supply water resources can meet the national standard.

Weihai received the awards of 1st National Sanitary City, National Model Cities for Environmental Protection, National Garden City, and National Excellent Tourist City. Weihai has twice got the International Award as the Best Practice for Comprehensive Management of the Living Environment by UN-HABITAT in 1996 and 2000; got the UN-Habitat Scroll of Honor Award in 2003; got the name of Eco-City from the National Environmental Administration of China in 2006.

Replicability

Most of the cities in China face the same problems as Weihai, water shortage, environment pollution and lack funds. The initiative in Weihai is the pioneer in China, the experience in Weihai is a very good show case for other cities. After the No.3 Sewage Treatment Plant BOT project completed in October 2006, until now, there are 90 delegates, 300 visitors come from other cities visited the plant. Experts from UN ESCAP and IGES are also interested in

Weihai's experience, try to organize a study tour in Weihai, let other cities in Asia and Pacific region to share the experience in Weihai.

Lessons Learned

There are some issues that still need to be improved in the water environment management in Weihai, mainly are:

The pollutants discharge fee. China created the regulation for pollutants discharge fee collection in 1982, emended the regulation two times later, increased the fee rate and scope. The pollutants discharge fee is a good mechanism, that encourage the company to save the resources, decrease the pollution. But now the rate of the fee is a little bit low, in some cases can not cover the damage it caused; and the enforcement of the regulation is weak. So we need to increase the fee rate and scope again and stress the enforcement, let it has the punishment effection.

Public participation. Public participation in environmental protection in China is just beginning. Though the item has appeared in some environmental laws and regulations, only a few are in practice. Public participation in water environment management in Weihai still in a primary stage, they still lack the knowledge, the information, and especially organization.

Using the market mechanism. Several years ago, all the cost for the water environment management came from the government revenue, these years we introduced the market mechanism into this area, but we are still in the early stage and lack experience. BOT is a good option to cover the needed investment. But there is no law to follow until now in China. If there are some disputes, it will be difficult to solve them.

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3. Weihai Urban Construction Statistic, Weihai Construction Bureau

Designation of Water Quality Management Areas in the Philippines

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Abstract
The Philippine Clean Water Act (CWA) of 2004 specifies the designation of certain areas as Water Quality Management Areas (WQMA) using appropriate physiographic units such as watershed, river basins or water resources regions. The WQMA shall have similar hydrological, hydrogeological, meteorological or geographical conditions which affect the physico-chemical, biological and bacteriological reactions and diffusion of pollutants in the water bodies or otherwise share a common interest or such as similar development programs, prospects, or problems. Each WQMA will have a Governing Board, a Technical Secretariat and a Water Quality Multi-sectoral Group to carry out planning and implementation activities.

The designation of WQMA is one of the strategies identified to effectively enforce the CWA and improve the water quality of water bodies through focused interventions or actions that are designed to address specific water quality issues of the areas. Therefore, the designation of WQMA shall take into consideration water quality problems, its sources of pollution, and the beneficial use of the receiving water body; and shall determine what combination of control measures can effectively achieve water quality objectives or improvements.

To date, officially designated WQMA are the area within the jurisdiction of the Laguna Lake Development Authority, the Tigum-Aganan Watershed WQMA, and the Marilao-Meycauayan-Obando River System WQMA. Activities for the designation of Iloilo-Batiano River System WQMA in and Sarangani Bay WQMA are on-going.

Keywords: Water Quality Management Area, Governing Board, WQMA Action Plan, non-attainment areas, attainment areas

Introduction
Republic Act (RA) No. 9275 or the Philippine Clean Water Act (CWA) of 2004 is the basic law on water quality management in the Philippines. CWA was published on 21 April 2004 and subsequently took effect on 6 May 2004. The Implementing Rules and Regulations (IRR) of CWA was approved as Department of Environment and Natural Resources (DENR) Administrative Order No. 2005-10.

In Article 1, Section 2 of RA 9275, the policy of the CWA is stated as follows: "*The State shall pursue a policy of economic growth in a manner consistent with the protection, preservation and revival of fresh, brackish and marine waters*" using the framework of sustainable development. Section 3 of the CWA further states that water quality management shall primarily apply to the abatement and control of pollution from land-based sources.

The water quality management areas (WQMAs) are designated as part of the water quality management system as provided in the entire Chapter 2 of the CWA. Water Quality Management Areas are certain areas using appropriate physiographic unit, such as watersheds, river basins or water resource regions. These management areas shall have similar hydrological, hydrogeological, meteorological or geographical conditions which affect the physico-chemical, biological and bacteriological reactions and diffusion of pollutants in the water bodies or otherwise share a common interest or such as similar development programs, prospects, or problems. Each WQMA shall have a Governing Board (GB) which shall primarily serve as the planning, monitoring, and coordinating body of the said WQMA. The GB shall also review the WQMA Action Plan prepared by the DENR through the EMB. A Technical Secretariat and a Multi-sectoral Group for water quality monitoring and surveillance shall also be provided to the WQMA.

The designation of WQMA is one of the strategies identified to effectively enforce the CWA and improve the water quality of water bodies through focused interventions or actions that are designed to address specific water quality issues of the areas. Therefore, the designation of WQMA shall take into consideration water quality problems, its sources of pollution, and the beneficial use of the receiving water body; and shall determine what combination of control measures can effectively achieve water quality objectives or improvements.

Guidelines for the designation of water quality management areas

The policy of the DENR is to develop a holistic national program of water quality management through the designation of WQMA, the identification of non-attainment and attainment areas, and the preparation and implementation of WQMA Action Plans to improve water quality of water bodies. This should be achieved within the integrated water resource management (IWRM) framework and implemented through the proper delegation and effective coordination of functions and activities.

The Guidelines for the Designation of Water Quality Management Areas was developed with the following objectives:

1. To provide the process through which a WQMA is delineated and designated.
2. To provide useful information for use by the EMB, the Local Government Units (LGUs) and other stakeholders that would ensure that the process of designation of WQMAs is done uniformly.
3. To explain the technical requirements and participatory approaches to direct the users in effectively initiating/implementing the designation of WQMAs.

A WQMA will consist of surface waters, whether natural or man-made and include streams (rivers and creeks), lakes, and marine waters. Only the water bodies that have been classified by the DENR through the EMB based on its beneficial use will be included in considering WQMA designations. A WQMA will also cover the land that is within the hydrologic unit identified, including residential, industrial, commercial, agricultural, tourism, forest and protection areas.

A. Conditions in Designating a Water Quality Management Area

There are four major conditions that must be present when a WQMA is designated.

These are:

1) The WQMA shall utilize an appropriate physiographic unit, such as a watershed, river basin, or water resource region. However, the use of the lowest appropriate level (such as the sub-basin or micro-watershed) is deemed more suitable from the standpoint of ecological, financial, organizational and institutional considerations.
2) The WQMA shall have similar hydrological, hydrogeological, meteorological or geographic conditions which affect the physicochemical, biological and bacteriological reactions and diffusions of pollutants in the water bodies.
3) The WQMA shall share a defined common interest, such as, but not limited to, similar water quality-related development programs, prospects, or problems.
4) The water quality of specific water body/ies within the physiographic unit chosen may be:

i) A non-attainment area (NAA) that needs immediate water quality management interventions to improve the water quality. This a body of water in which the level of a criteria water pollutant is higher than the level allowed for its classification under the water quality guidelines.

ii) A combination of NAA and Attainment Area (AA). AA is a body of water that has acceptable levels of water pollutants and therefore meets the water quality guidelines. The designation of a WQMA with a NAA and an AA is applicable when there is a need to improve water quality and the management of the existing and potential pollution sources must be addressed through specific interventions.

iii) An AA, but water quality management interventions are needed to improve and/or preserve its condition.

Even if the WQMA without a NAA is justified given the above conditions, priority should be given to the areas where water quality has already exceeded the water quality guidelines to ensure that limited resources is efficiently used. The screening of a WQMA proposal therefore, may be made according to the intensity of the pollution problems and its impacts on public health and on the regional economy.

B. Process of Designation

There are two ways by which a WQMA may be initiated. The first way is through the DENR RO, as specified in Section 5 of the CWA, and Rule 5.1.1 states:
"Initiating the process of designation. The Regional Office of the Department shall initiate the process of designation by evaluating information using the criteria to be developed by the Department."

The second way is proposing the designation of a WQMA from other sources or proponents aside from the DENR RO through the EMB RO. Rule 5.1.1 states:
"***Initiating the process of designation.*** . . . However, any concerned government agency, including local government units, Protected Area Management Boards, watershed councils, Fisheries and Aquatic Resources Management Councils, government corporations with relevant concerns, or civil society, may propose the designation of WQMA in their area to the DENR and submit the relevant information. The concerned agency or organization shall follow the general procedure for designation outlined herein and coordinate with the Department throughout the process of consultations and data gathering."

In any case, whether or not the process to designate a WQMA is by the EMB or other proponents, the designation process will pass ten (10) main steps, as shown in Figure 1. *Procedure for Designation and Re-designation of WQMA*. These steps establish a consistent way to designate and re-designate WQMA, while still maintaining the flexibility to accommodate the distinctiveness of each WQMA. The EMB Regional Office (RO) shall be the lead agency for this activity.

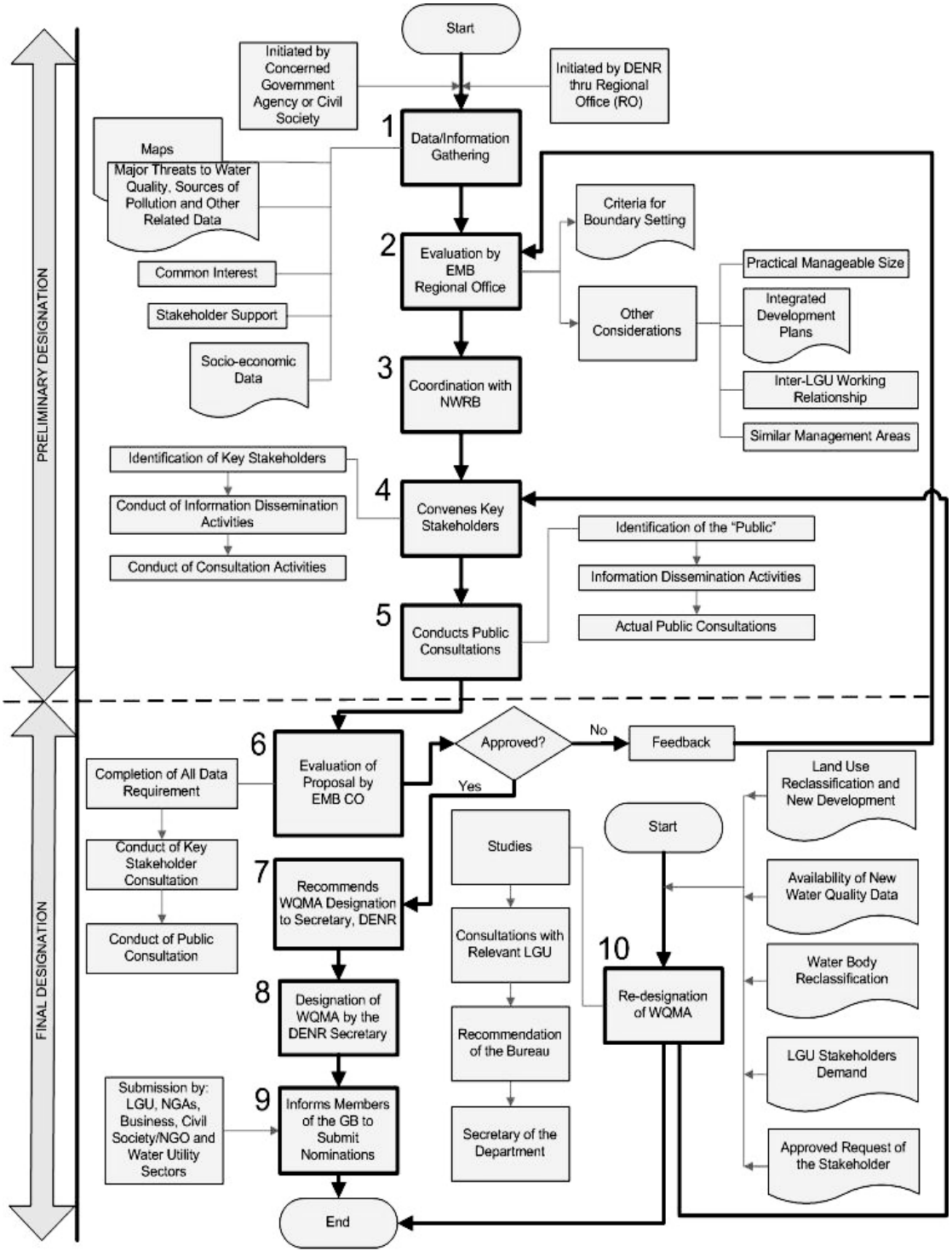

Figure 1. Procedure for Designation and Redesignation of WQMA

1. ***Gather Relevant Data/Information***
   Among the relevant data/information that should be collected include maps; major threats to water quality, sources of pollution and other related data; common interest such as water quality-related development programs and prospects in the areas to be covered by the proposed WQMA; stakeholders' Support; and socio-economic data.
2. ***Evaluate the Data and Information***
   The data and information gathered must be evaluated against a set of criteria to ensure that the data is adequate to designate a WQMA.
3. ***Coordinate with the National Water Resources Board***
   In designating a WQMA, the Department will coordinate with the National Water Resources Board (NWRB).
4. ***Convene Key Stakeholders***
   Key stakeholders will be identified afterwhich information dissemination and consultation activities will follow.
5. ***Conduct Public Consultations***
   Not only the key stakeholders are to be informed and consulted on the proposal to designate a WQMA, but also the general public. Public consultations provide an opportunity to inform, educate and communicate with an identified or targeted public.
6. ***Evaluate Proposal by the EMB Central Office***
   The proposal to designate a WQMA must pass evaluation by the EMB Central Office (CO), in particular, its Water Quality Management Section. If found to have fully complied with the law, then the proposal will be forwarded to the Office of the Department Secretary with the recommendation for WQMA designation, based on having met the prerequisites for designation such as the completion of all data requirements, and the conduct of key stakeholders and public consultations. However, if the proposal is found to have not fully complied with the requirements, then it shall be returned back to the EMB RO, with notations.
7. ***Recommend WQMA Designation and Composition of the GB to the Department Secretary***
   All final recommendations for WQMA designation and composition of the GB are addressed to the Department Secretary, and shall emanate only from the Director, EMB CO. This ensures that each proposal has passed strict evaluation for its compliance with all the requirements found in the CWA.
8. ***Designate WQMA by the DENR Secretary***
   Rule 5.1.7 of the CWA IRR states that the designation of the WQMA is made by the DENR Secretary upon the recommendation of the EMB. The designation, therefore, shall take the form of a Department Administrative Order (DAO).
9. ***Inform the LGUs, NGAs, Business, Civil Society/NGOs, GOCCs and Water Utility Sectors to Submit Nominations in the GB***
   The main provision on the designation of the WQMA GB is found in Section 5 of the CWA, which states:

   ". . . Said management area shall be governed by a governing board composed of representatives of mayors and governors of member LGUs, and representatives of relevant national government agencies, duly registered nongovernmental organization, water utility sector, and business sector. The Department representative shall chair the Governing Board. In the case of the LGUs with membership on more than one (1) management board, the LGU

shall designate only one (1) single representative for all the management areas where it is a member."

10. Submit Names of GB Membership to the DENR

The names of the permanent and alternate members of the GB shall be submitted to the Secretary of the DENR for approval.

11. Re-designate WQMA

The re-designation of a WQMA can be undertaken as stated in Rule 5.1.7 of the IRR CWA:

"Thereafter, these initial WQMA may be subject to review and consultations for re-adjustment of boundaries and representation in the Governing Board, if necessary."

Designation of water quality management areas and creation of the governing board

Per Section 5 of RA 9275, the area within the jurisdiction of the Laguna Lake Development Authority (LLDA) was designated as one WQMA under the administration of the LLDA. Aside from the Laguna Lake WQMA, there are two officially designated WQMA, namely, the Tigum-Aganan Watershed WQMA in Iloilo province (Region VI) and the Marilao-Meycauayan-Obando (MMO) River System WQMA in Bulacan province (Region III) through DENR Administrative Orders (DAO) Nos. 2006-18 and 2008-07, respectively. The DAO also created the Governing Board for the said WQMA. Activities for the designation of Iloilo-Batiano River System WQMA in Region VI and Sarangani Bay WQMA in Region XII are on-going.

The following section will focus on the designation of the Marilao-Meycauayan-Obando River System as a Water Quality Management Area.

The MMO River System WQMA is within the province of Bulacan in Region III and parts of the National Capital Region. The area is at the southern end of the Central Valley Basin where major rivers (including Pampanga, Angat, and MMO Rivers) flow from the north and east that eventually drain into Manila Bay.

The MMO River System was prioritized for the WQMA designation due to the following issues:

1. MMO River System is one of the priority rivers for rehabilitation by the EMB-DENR. There is an immediate need for water quality management interventions to revive the Marilao-Meycauayan-Obando River Systems. This is due to various sources of pollution such as domestic wastewater, industrial effluent, dumpsite leachate, agricultural run-off upstream, and nutrient build-up due to aquaculture downstream.
2. The MMO River Systems has an active group of NGOs fully supported by the LGUs, concerned NGAs, and the private sector.
3. Water quality monitoring data is available.

Among the activities undertaken leading to the designation of the Marilao-Meycauayan-Obando (MMO) River Systems WQMA are as follows:

1. Identification and evaluation of candidate sites
2. Identification of water quality problems and possible actions to address the problems
3. Verification of water classification and use of the proposed WQMA
4. Gathering of relevant primary and secondary data
5. Evaluation of data for boundary setting
6. Convening of the key stakeholders
7. Conduct of public consultations

The Governing Board (GB) for the MMO River System WQMA is being chaired and co-chaired by the Environmental Management Bureau Regional Directors of DENR Region III and NCR, respectively. Members include representatives from the LGUs in Bulacan, Valenzuela, and Caloocan; relevant national government agencies; Laguna Lake Development Authority; business/industry; water utility; non-governmental organizations; and the academe. The composition of the GB is in line with the policy of the Philippine Clean Water of 2004 which encourages the participation of an informed and active public in water quality management.

The "success" of the MMO River System WQMA lies in the preparation and implementation of the Water Quality Management Action Plan through multi-stakeholders participation.

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Application of IWRM/IRBM Principles for Tasik Putrajaya Catchment

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Abstract
Integrated Water Resource Management (IWRM) principles, where the need of holistic and systematic management approach is required, has been accepted by the Malaysian Government and these needs are already in the government policy statements such as in the RM8, RM9, OPP3 and the National Water Vission.

The Federal Government has encouraged all state governments to establish its own water management system i.e. in complying with the standard IWRM policies. The state of Kedah and Sabah has recently gazette their own water management act. The Selangor State Government has already established the Lembaga Urus Air Selangor (River Basin Management Authority) Enactment way back in 1999 to improve their river basins management.

One of the river basins in Selangor which need a serious and systematic approach of management is the Putrajaya Lake Catchment. The planning, approval, monitoring and enforcement jurisdiction over all land development and human activities in this catchment area will have a direct impact to the Putrajaya Lake. The Lake is an urban lake, created right in the middle of the newly developed Putrajaya, the Government Administrative City of Malaysia.

Putrajaya was planned to be developed into a "City in a Garden" with the 600 hectares Putrajaya Lake and Wetland as its focal point. The lake has to be always in acceptable urban setting condition with a high water quality level to cater its multi-functional uses such as for boating, fishing, recreational and water sport.

This paper discusses the Putrajaya Lake Catchment system and the various mechanisms that had been implemented for an effective and best result to ensure the high water quality level of the lake is continuously maintained. It also describes some problems in implementing an effective catchment management.

Keywords: Catchment management, Putrajaya lake and wetlands, management issues, implementation, enforcement, monitoring and funding.

Introduction
The Malaysian Government in its policy statements and other planning documents has included the Integrated Water Resource Management (IWRM) approach as part of its development programs. This holistic water management approach is already in the government policy statements such as in the RM8, RM9, OPP3 and the National Water Vision.

All the State Governments had been encouraged to establish their own water management system that complies with the standard IWRM policies. The states of Kedah and Sabah have gazetted their own water management act for this purpose. The Selangor State Government had gazetted the Lembaga Urus Air Selangor (River Basin Management Authority) Enactment in 1999 to improve its river basins management.

The Putrajaya Lake Catchment and LUAS

One of the river basins in Selangor which need a serious and systematic management approach and control is the Putrajaya Lake Catchment.

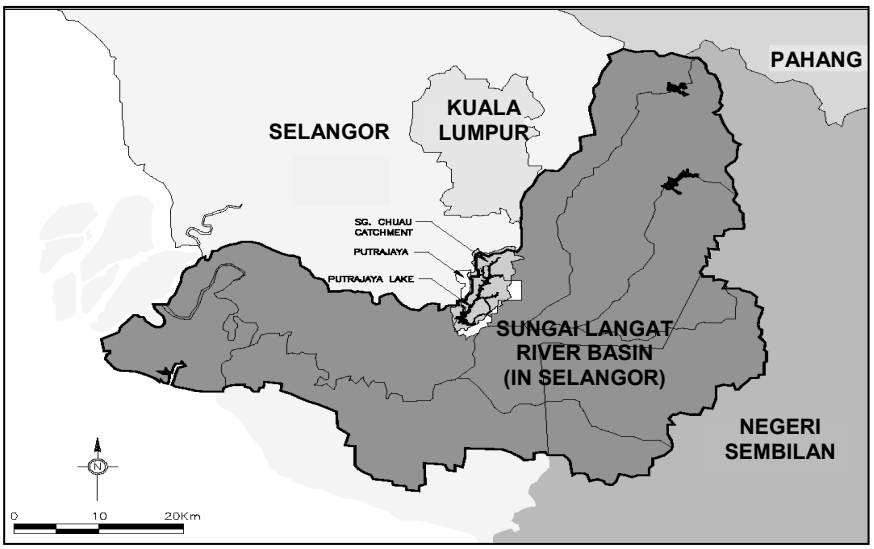

Figure 1. The Putrajaya Lake Catchment is only a small part of the bigger Sungai Langat River Basin.

The Putrajaya Lake Catchment is a small river catchment of about 52.4km^2 (square kilometers), located in the middle of Sungai Langat River Basin, 25 km south of Kuala Lumpur. It extends about 12 kilometers in the north to south direction and about 4.5 km in the east to west direction.

Figure 1 shows the location of this small catchment within the large Sungai Langat River Basin. In this small catchment area lies the Putrajaya City – the newly developed Government Administrative Center of Malaysia. The 600 hectares Putrajaya Lake is the focal point of this "City in a Garden". The lake is use for activities such as recreational, boating, fishing and water sport, in addition to enhancing the aesthetics of its waterfront characters.

Even though it is an urban lake in the middle of a city, the Putrajaya Lake has always to be in its acceptable good water quality conditions to cater for its multi-functional uses.

As an urban lake with active human activities around it, the planning, approval, monitoring and enforcement jurisdiction over all land development and human activities in its catchment will have a real and direct (normally negative) impact to the water quality and the lake characteristics.

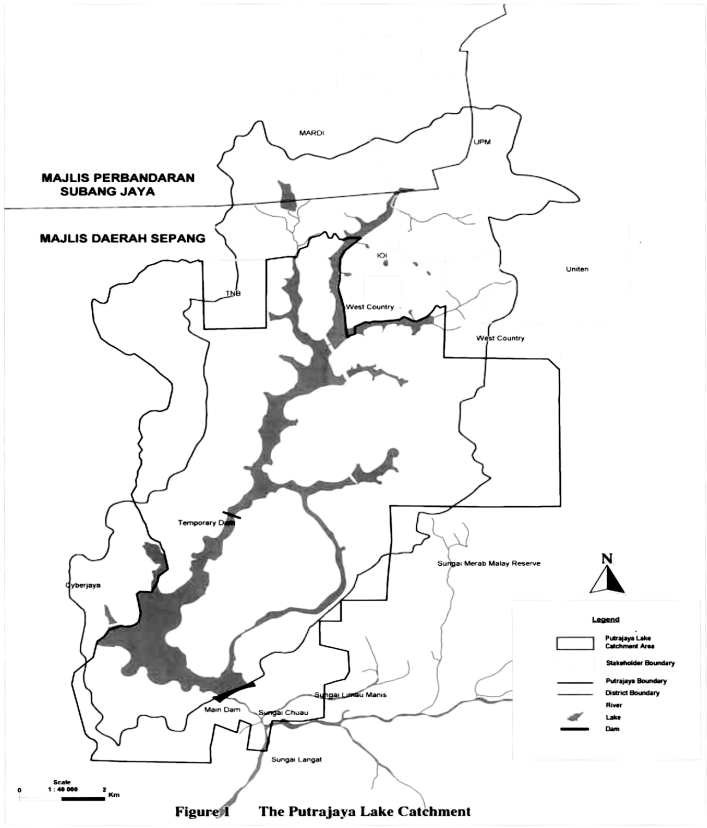

Figure 2. 30% of The Putrajaya Lake Catchment areas located in Selangor.

Development projects within Putrajaya boundary, which occupies about 60% of the Lake catchment area are complying to the Putrajaya Masterplan and stringent regulatory enforced by the Perbadanan Putrajaya (PPj).

However, the remaining 30% of the same catchment area but located in the upstream part outside the Putrajaya boundaries (in the state of Selangor as in Figure 2) belongs to various landowners and without coordinated control over its development and acitivities programs. This has become a serious concern to the Selangor State Government as well as to the Perbadanan Putrajaya.

The Putrajaya Lake integrated catchment management

Why is it important to manage the catchment?

Being a man-made lake in an urban setting, the Government recognizes that careful planning and management of the physical as well as the human issues within the catchment is necessary.

The task is to achieve and maintain The Putrajaya Lake Ambient Water Quality Standards (PLWQS) (which is of higher level than the DOE's Interim Water Quality Standards of Class IIB) and other objectives set for Putrajaya Lake and the allowable activities in it.

One of the major issues is the control of development activities in the catchment. There is a need to develop a pragmatic and implementable plan of action to ensure that the catchment area of Putrajaya Lake and the water resources within the catchment area are protected from pollution and the water quantity is maintained.

Furthermore, the design objectives of the artificial wetlands were only to improve the water quality of the surface runoffs flowing into the lake from the upstream areas. It was designed to treat only certain level of pollution loading i.e. the level of pollutant in the runoff should be limited to a certain acceptable level to enable the wetlands to function properly.

In the year 2000, Perbadanan Putrajaya has developed the Catchment Development and Management Plan (CDMP 2000) for Putrajaya Lake Catchment. This document is for easy reference to all stakeholders and it provides guidelines on the various methods/control to achieve and maintain the water quality level required for the Putrajaya Lake. The guidelines also define the land-use, drainage and sewerage master plans for the areas within the small but very important catchment.

Lembaga Urus Air Selangor (LUAS)

The CDMP 2000 has clearly defined the role of LUAS in implementing its power to manage, control and enforce the necessary rules to the landowners and stakeholders within the 30% of the Putrajaya Lake Catchment area in Selangor.

During the last eight (8) years of applying the CMDP 2000 guidelines, however, shows that the planning control for land use, drainage, environmental pollution control and coordination tasks empowered to LUAS is not easily applicable and implemented by the agency.

At the same time, realizing its role to ensure the success implementation of the IWRM and IRBM in the state, a strategic empowerment review of this organization is necessary to arrest various setbacks experience so far.

Thus, the challenges face by LUAS can be defined which includes the following:

- The problems are known;
- The causes are often complex and the problems cannot be solved overnight;
- The main task will include the decision on how to implement a successful coordination and programs agreeable by all stakeholders; and
- The Putrajaya Lake Catchment is the testing ground of its capabilities to apply the IWRM principles to all other areas in Selangor.

Catchment Management Plan Policy Statement

Recognizing the importance of careful planning and management control for the attainment of the city vision, Putrajaya Lake Catchment Management Plan need to be based upon the following policies:

i. Pollution control measure shall focus on the minimizations of pollutant generation at source;
ii. The drainage system shall base on vegetated landscape drainage corridors and conversion of flood detention and water quality enhancement ponds into mini-wetlands;
iii. The Putrajaya Wetland will be considered as an *additional (last stage)* water quality enhancement or "polishing" mechanism. It will integrate with the upstream water quality enhancement features, such as vegetated landscape riparian buffers, drainage corridors and upstream mini-wetlands cum flood detention ponds.
iv. Diversion or alteration of the natural drainage lines in the catchment shall not be allowed, however, improvement of its flow profile will be considered;
v. All development activities in the catchment shall be in accordance with an agreeable and approved Catchment Development Land-use Master Plan.
vi. All pertinent regulatory agencies shall coordinate (LUAS will play major role) their functions and enforcement effort to attain the catchment management objectives and targets;
vii. Active participation of the catchment stakeholders and communities in the management of Putrajaya Lake;
viii. Equitable sharing of the cost for the implementation of the catchment management programs including the maintenance cost shall be recovered based on the policy of *"the polluter pay"* and *"the direct beneficiaries pay"*.
ix. Realization of that, the cooperation and mutual agreement among all stakeholders in achieving the common goal of best water quality level of the surface runoff flowing through a catchment will be the best Integrated Water Resource Management outcome.

The successful implementation of ICDMP

There is a need to update the CDMP 2000 to incorporate eight (8) years of implementation experience and taking into consideration the latest policy, legal, current and future landuse plans of the catchment stakeholders. This will include the identification of the relevant clauses in the LUAS Enactment and develop the required institutional framework to enable LUAS to work with Perbadanan Putrajaya to protect Putrajaya Lake Catchment.

The Review Strategy

i. Development of institutional structure and identification of necessary legal provisions in LUAS Enactment to enable management of the 30% of the Putrajaya Lake Catchment, which is in Selangor, to be upgraded to the same level as that implemented by Perbadanan Putrajaya;
ii. Proposed institutional structure for managing the Putrajaya Lake Catchment, utilizing the provision in the LUAS Enactment (e.g. Clause 56 that is to enable the Putrajaya Lake Catchment to be a "Declared Catchment" with a management body involving all pertinent stakeholders);

iii. Legal guidelines to support LUAS and Perbadanan Putrajaya in implementing a transboundary catchment institutional framework, utilizing the existing provisions in the LUAS Enactment, and other related laws;
iv. Updating of CDMP 2000, so that an integrated lake catchment management and monitoring system can be implemented by the developed institutional structure especially by LUAS and its legal provisions; and
v. Info-sharing among catchment's stakeholders to support Integrated Catchment Management System (ICMS)
vi. Effective telemetry system to enable real-time, remote measurement and reporting of lake catchment monitoring information centre.

Aspects of Management and Planning
The CDMP 2000 review will cover the details for the integrated regulatory control for the areas outside Putrajaya especially on the following aspects:

a) Planning and Land-use Control;
b) Drainage Planning and Water Quantity Management;
c) Sewerage Planning;
d) Environmental Management and Water Quality;
e) The Lake and Wetlands;
f) The information System study; and
g) Legal and Coordination Between Regulatory Agencies

The management scopes and its recommendations for review on various aspects are as in Appendix A.

Organisation and coordination structure

Administrative Jurisdiction
The catchment lies within the administrative jurisdiction of the Majlis Daerah Sepang (MDS), Majlis Perbandaran Subang Jaya (MPSJ) and PPj. **Figure 3** shows the Northern area of Putrajaya Catchment boundaries. The stakeholders in the Putrajaya Lake Catchment are:

i. Universiti Putra Malaysia (UPM);
ii. Malaysian Agricultural Research Development Institute (MARDI);
iii. Industrial Oxygen Incorporated Bhd. (IOI);
iv. West Country Sdn. Bhd. (WEST);
v. Universiti Tenaga Nasional (UNITEN);
vi. Sungai Merab Malay Reserve (SMMR);
vii. Cyberjaya Flagship Zone - Phase 2B (CFZ), and
viii. Putrajaya.

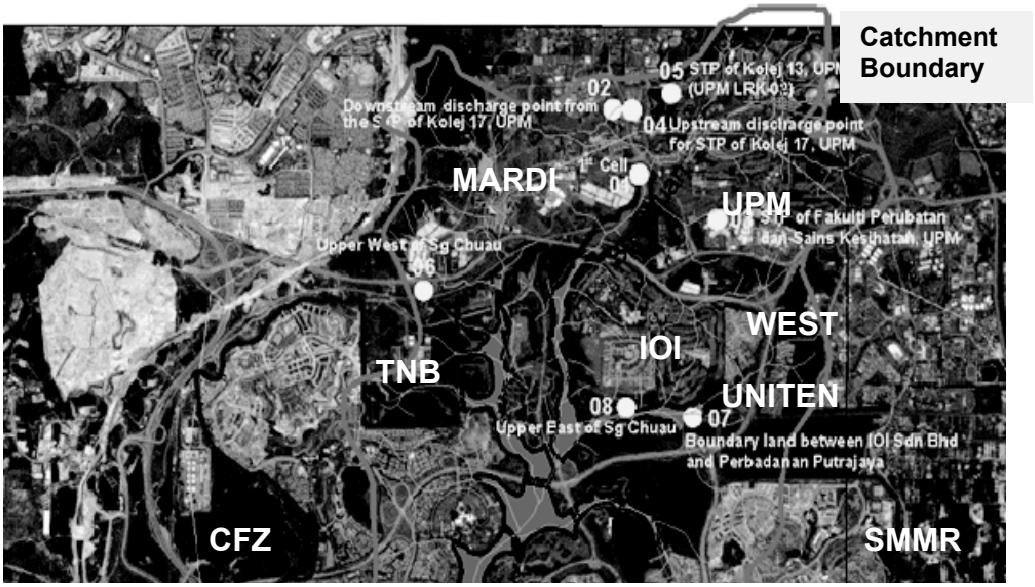

Figure 3. Upper Part of Putrajaya Lake Catchment (30% of the Lake's Catchment is not under the jurisdiction of Perbadanan Putrajaya)

Implementation requirements

i. Successful implementation requires co-ordination, co-operation and collaboration between existing planning authorities and between different interest groups and stakeholders.
ii. CDMP is more than a technical and engineering solution to catchment management, providing a platform for integration of various stakeholders' interest, besides establishing an overall guidance for consistent implementation of policies.
iii. Legislative and institutional framework has to be put in place first to establish the discipline and direction.
iv. It is necessary to establish a mechanism that can merge co-ordination and seek co-operation not only across sectors, but also political and administrative borders.

The Catchment Development and Management Committee

In keeping up with the catchment development on-going progresses, cooperation and coordination amongst the stakeholders together with the implementation of various regulations and control of land development and human activities, A Federal and State inter-government committee consisting of officers from different government agencies, local authorities and stakeholders will need to be established.

Known as the Putrajaya Lake Catchment Management Committee (PLCMC) as recommended by the CDMP 2000, the formation of this committee will be in accordance to the Selangor Waters Management Authority Enactment (SWMAE, 1999).

The earlier recommended committee chaired by the State Secretary of Selangor (as listed in Appendix B) with Lembaga Urus Air Selangor (LUAS) and Bahagian Tasik Perbadanan Putrajaya as the joint-secretariat, however, has no legal powers. Thus, to facilitate the monitoring and implementation of legislative enforcement of the catchment area, a legally constituted Management Committee is to be formed under the SWMAE (1999).

To expedite the legal process in implementing, monitoring and enforcement of the SWMAE (1999) Act, Perbadanan Putrajaya and the Selangor State Government through LUAS is preparing the formulation of the "Study on Operationalisation of LUAS's 1999 Enactment for Institutional Development and Integrated Catchment Management for Putrajaya, 2008"

Conclusion

The success of the implementation of an Integrated Catchment Management especially for an urban catchment depends largely on the cooperation and coordination between the stakeholders (landowners), government agencies and the local authorities involved.

Although through the cooperation of LUAS, MPSJ, MDS and Perbadanan Putrajaya, the existing by-laws and guidelines can be executed within the CMDP, the real challenge is whether the authorities can work together with all the landowners and stakeholders for a command goals of achieving a predetermined water quality of a lake.

The success, however, will be seen more effectively whereby the by-laws and guidelines is carried out by all the stakeholders of the lake catchment voluntarily for the benefit of everybody within the catchment.

The practical application of this arrangement will also be a showcase of our legislative frameworks and the much-awaited effective solutions for the use of all the other water basins management for the whole of Malaysia.

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Appemdix A: Catchment Management Scope Review and Recommendations

SCOPE	DESCRIPTION	RECOMMENDATION
Water Quality Management	The current water quality in the lake is within the permissible values of Putrajaya Lake Water Quality. It is recognized that the most effective way to attain the desired water quality objective is to minimize the generation of pollutants at their source. Also, it is recognized that erosion and transport of sediment during the land clearing, earthworks and construction phase pose a very serious threat to lake water quality.	To manage pollutants at source. The drainage system should be based on vegetated landscape riparian buffers, drainage corridors and mini-wetlands water quality enhancement ponds. To prevent the entry of rubbish Gross pollutant/sediment trap (GPT) structures are to be installed at the ends of all concrete drains flowing into the vegetated landscape drainage corridors. To ensure effective control of erosion and sediment during earthworks. It is recommended that a new "Erosion And Sediment Control By Law" be enacted by Putrajaya Corporation and Majlis Daerah Sepang. The recommended By- Law should be supported by a new "Standards For Erosion And Sediment Control" Manual.
Water Quantity Management	It is important that all possible runoff arising from lake catchment should enter into the Lake system. Also, there should be proper control over the amount of water drawn for irrigation or other purposes and no diversion or alteration of the natural drainage lines in the catchment is to be allowed.	Compensation flow equal to 10% of the Annual Average Flow may be allowed during the in-filling of the main dam. A well field of 6 groundwater wells can be developed, downstream of the main dam, to supply 0.013 m3/s (10,000 g/hr) of groundwater to meet any water demand. A separate irrigation masterplan study on the impact of the proposed rainwater harvesting within the catchment on the water quantity in the lake
Drainage Planning	The drainage Masterplan comprises of Drainage Planning and Design Guidelines.	Drainage planning and Design Guidelines based on the vegetated drainage corridor concepts. Specific recommendations for upgrading the drainage systems in UPM, MARDI, IOI, West Country and Cyberjaya
Pollutant Sources Management	The sewage effluent discharge from outside have been identified as the major point source pollutant. They are controlled in the sewerage masterplan. Accident associated with the oil tankers moving along the road passing through the wetlands can be a major point source pollutant. Thus, the pertinent authorities (JKR, Putrajaya Corporation) has to ensure that Emergency. Response Plans and Procedure are prepared and implemented to handle such potential emergencies. **THE ISSUES** In-stream discharges from UPM and MARDI located north of Putrajaya Lake Catchment Area (sewerage discharges, treatment plant, septic tank system) Discharges from point and non-point sources of various types of pollutants from agriculture, institutions, commercial areas, golf course, residential areas, power station, health facility and parks The wetland cells (point and non-point pollutant source) Existing and future landuse type and pollution potentials The main lakes and outlets	Non-point pollutant sources from road runoffs are to be controlled through the implementation of the drainage system based on vegetated drainage corridor. Those from fertiliser and pesticide input from MARDI, UPM, IOI, and Cyberjaya are to be controlled by regulatory measures using the prepared MP guidelines on the use of fertilizer and pesticides. To improve the quality of water entering into Putrajaya Lake To ensure Putrajaya Lake and water resource areas are protected from pollution To streamline and improve on the efficiency of monitoring, observation and enforcement of water quality in the Putrajaya Lake Basin To enhance the overall environment

SCOPE	DESCRIPTION	RECOMMENDATION
Land-use Planning	To ensure that the development in the above areas are in line with the objectives for the catchment a land-use masterplan has been prepared. Detailed review of any changes or deviations between current landuse and landuse in the CDMPPL, 2000 An evaluation of the committed projects that have come into effect since the publication of the CDMPPL (Perbadanan Putrajaya, 2000) Updated GIS generated maps showing the current landuse scenario	**Landuse Issues** Sustainability of the landuse landuse positions of major stakeholders (shares of the Putrajaya Lake catchment) identify and evaluate sensitive issues of physical development **Landuse Policies and Guidelines** Structure and Local Plans used:- Selangor Structure Plan; Putrajaya Structure Plan Sepang Local Plan; and Subang Jaya Local Plan. Putrajaya Landuse Masterplan Putrajaya Urban Design Guidelines (UDG) Multimedia Super Corridor (MSC) - The plan should be incorporated in MSC areas Local Plan that is currently being prepared by JPBD.
Planning and Land-use Control	Planning and land use control of areas within the catchment represents one of the most important mechanisms for the protection of the water quality in the lake. The mechanism and set-up for control and management of planning in Majlis Daerah Sepang (MDS) and Majlis Perbandaran Subang Jaya(MPSJ) is not as well organized as in Piutrajaya. The major land parcels in the catchment areas outside Putrajaya are UPM, MARDI, IOI, TNB, West Country, UNITEN, Cyberjaya and the Sg. Merab Malay Reserve.	To develop and gazette local plans for the land parcels outside Putrajaya. This will be carried out by JPBD as part of local plan for MSC Area. To implement similar planning submission and approval process requirement similar planning submission and approval process requirement as those in Putrajaya Corporation, for all proposed development projects in the catchment areas of Majlis Daerah Sepang (MDS).
Sewerage Planning	The sewerage masterplan comprises of Sewerage Planning and Design Guidelines:	Specific recommendations for the management of the sewage effluent discharge from MARDI,UPM, IOI and Cyberjaya.
Drainage Management and Control	There is no integrated approach to this issue since the responsibilities for drainage lies with JPS, local authorities and other agencies such as JKR and other developers.	To require all development projects, including utilities and transportation projects to comply with the recommended drainage concept and design guidelines for the Putrajaya Lake catchment. To assign an additional Civil Engineer and Technical Assistant to MDS so that they can give special attention to drainage and earthworks for developments in the Putrajaya Lake catchment areas.

Appendix B: The Putrajaya Lake Catchment Management Committee (PLCMC) as recommended by the CDMP 2000

The designations of the committee are as follows:

Chairman: Selangor State Secretary

Secretariat: LUAS/The Lake Unit, Perbadanan Putrajaya;

Members:

i. Selangor Waters Management Authority (LUAS),
ii. Jabatan Pengairan dan Saliran (JPS),
iii. Jabatan Alam Sekitar (JAS),
iv. Jabatan Perancangan Bandar dan Desa (JPBD),
v. Jabatan Kerja Raya (JKR),
vi. Jabatan Perkhidmatan Pembentungan (JPP),
vii. Majlis Perbandaran Subang Jaya (MPSJ),
viii. Majlis Daerah Sepang (MDS),
ix. Perbadanan Putrajaya (PPj),
x. Representative of Stakeholder's Consultative Committee

The Evolution of Community-Based Water Environmental Governance in Surabaya, Indonesia: From Solid Waste into Clean Water Management

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Abstract
Promoting local initiatives in participatory environmental governance to improve water quality would ensure more effective success and sustainable. The problem within local initiative in Indonesia, however, is that poor who should become active actors in their development are often beyond easy reach. Within the Indonesian decentralization policy with such ambiguities, the participatory process has descended into an arena for predatory politics. It is about the credibility of elites and governments with such temptation to weaken, de-legitimize, incorporate or indeed repress social movements. If that so, the papers will take advantage of the possibility for a critical perspective afforded by some community development programs at helping communities to attain the right to clean water as poverty reduction strategies in the shaping of specific developmental intervention by donor. In particular, a primary role is played by processes of "collective learning" which result in a "socialized" growth of knowledge and embedded not only in the internal culture of local community but, particularly, for the private sectors. Pilot testing the use of a participatory assessment in Surabaya is designed to promote specific measures of design and implementation that take better account of participation, community demand, gender, and poverty perspectives.

Keywords: participatory environment governance, water quality, collective learning

Introduction
The best way for development agency to facilitate local initiative is just not to focus on capturing, codifying, and documenting knowledge of individuals, but rather to concentrate on ways, through which knowledge can be shared, discussed and innovated (Smith 2003; Mittendorff, 2006). It needs to generate a shared repertoire of ideas, commitments, and memories which in line with developing of various resources such as tools, documents, routines, vocabulary and symbols. Along with social network, a development agency will also contribute to attune their values with their stakeholders, clarify their social responsibilities, develop new local knowledge and innovative solution to overcome problems, enhance mutual understanding and built the trust and commitment necessary for collaborative action (Svendsen and Laberge, 2005). However, Bebbington (2006) raised question to the credibility of elites and governments with such temptation to weaken, de-legitimize, incorporate or indeed repress social movements. For external actors, i.e. community or non-government organization, such governments can become the object of policy which the process can be

fraught with tensions both within government as well as in its relationships with other sectors of society.

Following the Indonesian decentralization policy, local initiative has been emerging as a central issue for adaptive co-management, particularly in order to fulfill the basic right on clean water. Many programs for community water, such as irrigation management reform program, water resources and irrigation sector management program or green and clean competition emphasize a participatory approach to the management in a decentralized administrative and fiscal framework. Through Act no 25/2004, it is a mandate to both national and local government to conduct development planning which aims to maximize citizen participation". For the biggest archipelago country with 50% of 215 million populations living within $2 per day income per capita, the task of involving poor people in the planning and implementation of development efforts has to deal with contests between competing interest. Involving community in developing program seems to be threats for those who have been having privilege on local resource. Some others view participation with deep skepticism and argue that communities prefer to do simply argue within development to get some more financial support rather than focus on the long term goal. With some legal contradictions and ambiguities, the participatory process has descended into an arena for predatory politics. If that so, the question comes up to what the best way to motivate all community members to share repertoire of ideas and build commitments.

The papers would like to share the best practices about community development program for the types of water issues we encounter in Surabaya inner-city environments. It generates the question on what type of learning result on how the program responds to particular water issues in the urban context and what the particular challenges faced in translating community development into social-ecological change within today's urban setting. To investigate these questions, we describe a recent participatory assessment in some local initiatives in City of Surabaya Indonesia which concern on improving water quality. The research leads to some lessons for practitioners, such as the need to build "constant" elements into community development projects.

The Legacy of Local Initiative

Basically, the local initiative to environment improvement has been a common activity for all communities in Indonesia, particularly as part of activity to celebrate the independent day. Started at early August, the citizens conduct a communal work of cleaning the vicinity of their house and environment. This spontaneous work is called "kerja bakti". Kerja means work, whereas bakti means devotion. They do it in a "gotong royong" way, which means work hand in hand with each other to dress up their kampong, clean up the disposal of waste water, and for rapid run-off of rainwater. During the economic downturns in 1998, the activity on doing garbage collector has also become local economy activities in Surabaya in which more poor people took a job to waste picking as a survival strategy. One of the most popular jobs is metal waste picker, which common to Madurese ethnic who living in northern part of Surabaya City. While poor and inaccessible areas are plagued by pollution from uncollected wastes, many inhabitants of these areas depend upon waste recovery and recycling to meet some of their basic needs for shelter, food and employment.

Responding to the economic crisis in 1997, a community development program began in Kampong Rungkut Lor in 1999 initiated by PUSDAKOTA. At the early stage, the

development organization would like to address the source of poverty, particularly unemployment through job creation for communities who lost their jobs during the crisis. Instead of adopting high class professor, the program was involving some young social workers who easily live up with community within poverty condition. The community development workers were envisaged as a "helper", "encourager" and "facilitator". Focusing on capturing, codifying, and documenting knowledge of individuals for two years, the organization came up with conclusion that the main problem in Rungkut Lor was not economic issue but environment, such as flood, sanitation, health, and waste due to poor water quality. What need to be done was not offering the community with such bulk of financial resources and making them hope the financial support. If that so the program initiated with strong effort on doing informally integrated between communities and the social worker to generate a shared repertoire of ideas, commitments, and memories which in line with developing of various resources such as tools, documents, routines, vocabulary and symbols. As González et al, 2007 pointed out, there is a growing consensus that the best way to improve community learning is not to (simply) focus on capturing, codifying and documenting knowledge of individuals, but rather to concentrate on ways through which knowledge can be shared, discussed and innovated.

Started at the end of 2001, Pusdakota organized a community in Kampong Rungkut Lor to separate the communities' household waste. Struggling with local commitment building, they were request to separate between organic and inorganic waste from their own houses. These projects have come to incorporate source segregation of wet and dry wastes and thus reduce waste picking. In the years of 2004, the community collaborated with Kitakyusu International Technology Association (KITA) Japan to improve technology on waste management that resulted in the Takakura Home Method (THM). The milestone on environment governance was designed in a simple way to process the organic waste resulted from the household activities to reduce the volume of organic waste at family level. Made from a basket, skin of rice as a filter, carpet, and organic bacteria and finally, it was patented by PUSDAKOTA for social purposes. About 4000 THM has been distributed to families in Surabaya and other cities in Indonesia. KITA further developed the technology that is able to compost domestic waste in seven day cycles generated from the largest market in Jawa Timur.

Transforming the slum teeming with unorganized residents into the green, healthy and hygiene-conscious community is basically success of the social workers to encourage urban worker conducted the former work activities in rural area, as a farmer. As a pilot project, the composting communities in Rungkut Lor have been actively proliferating places with organic vegetables and herbal plants in the spaces of their house. For the plants they use compost, as the organic fertilizer, that resulted from the household composting process. One approach favored by Pusdakota is the encouragement of partnership of waste collectors, which commonly informal workers. Involving group of women, the movement expanded into other communities such as Kampong Wonokromo and Gadel. The communities develop plantation in their limited yard spaces to their waste management and effective communal work schedule. In Kampong Gadel, another slump area, the community is chopping up the mounds of waste vegetables and fruit that pile up around them from making sure that the waste is whittled down to just the right size to fit into the “Bambookura”, a specially designed bamboo basket. The waste processed activities have made compost ready to sell for Rp.500 per kilogram.

Another driving force to the eco-management is coming from the women movement of the Family Empowerment and Welfare Coordinating Team (Tim Penggerak PKK) City of

Surabaya which all of the leaders are wives of local government leaders. The head of the organization which is the wife of the Surabaya Major enthusiasm enact local initiative to promote local movement on waste management. She manages the distribution of the national subsidy programs, such as food subsidy program, health assistance for older people who are economically disadvantaged and baby health program for children from economically disadvantaged families. Now, it is a mandate for the women organization which spread for every kampong in Surabaya to incorporate source separation of wet and dry wastes and thus reduce waste picking.

Moving into Domestic Water Treatment

The water treatment model was initiated with community-based approach. However, at an initial stage, the ceaseless outpouring of development agency's initiatives were affecting the local initiative and the overbearing burden of monitoring that development agency any statutory funding program demonstrate a profound lack of trust and indeed respect for third sector organizations. Secondly was some indication that the term originated in the voluntary sector itself which now most keen to clarify the difference between volunteering and mandated activity. Unfortunately, the former donor policy made 'easy money' for the communities. Everyone who involved the activities initiated by donor will get allowance. That made the traditional voluntary system was damaged. It has been raising question on sustainability of the 'change'.

One of the key actors for improving water quality came is women communities. Dealing with household daily activity, they are very sensitive with water quality. Wells were used to provide water for non-drinking needs due to poor quality. They were relying supplies of drinking water from street vendors on a daily basis. It made them keep asking for some water quality improvement programs. They has also raised some issues on the need of public toilets and washing facilities. Conversely, male who spent most of their time for working at office or factory preferred to improve road facilities. While a group of women and men were asked about their role in social-ecological policy, they stated that they were capable of participating on issues of domestic responsibility could be easily resolved with simple implementation, such as domestic waste management. However, they stand in a different relationship to their environment, in particular that women group are more responsive to their household activities related impacted the water. The group of men more concern on financial income and their work activities rather than their household environment.

Responding to those different interests, the community development program preferred to the vulnerable group, the women and children. Instead of conducting activities with children, the program arranged community movement for participatory water management. Starting from set up a model of water embankment to reduce the annual flood in 2002, the program was gradually moving into dealing with sanitation and water treatment. There were many optional technologies to improve quality drinking water, such as chlorination, filtration (biosand and ceramic), solar disinfection, combined filtration/ chlorination, and combined flocculation or chlorination. However, based on the urgent issue which risen by the community, the program set up water embankment for three kampongs, locally called "rukun warga". With pressure from the local leaders, they believed that it would benefit community organization if they were involved as they were often the people with hands on responsibility for resolving individual and community issues. Without doubt, the leadership role of the women who experienced as group leaders and consolidation the communities have been fundamental in

solving their housing problems and in successfully moving from an individual to a collective vision.

To attain a sense of ownership of local communities which is very important for sustainability and better management, the setting up of independent institution in communities is one of the core important aspects of it. The best practice of solid waste management has opened up new avenues for communities and confidence on them that they can do for clean water. What has been done by social workers were just about listening the communities, raising their idea, and encouraging the communities to get the right to water. In those women organizations we observed, there were informal hierarchical social networking. When critical decisions were to be made, individuals often enlisted support above the level of their immediate superior. This is an informal network system for making decisions, particularly when the communities determined the priorities issue. Moreover, the local leader pays more and more attention on monitoring effort. As a consequence, the social worker reduces their monitoring effort. It can be beneficial for the local social worker to volunteer to be the group leader. The model was expected to encourage other kampong to adopt the best practices.

Competition with Local Government's Initiative

Most of activities belong to government and private company rather than social enterprises which should consider as blending the fields of entrepreneurship, social change, social responsibility and venture philanthropy (Srivastva, 2004). With support from some private enterprise and non government organization, the City Government of Surabaya also promoted some local initiative to engage environment program. Emphasizing on basic physical infrastructure, Surabaya City engaged Kampong Improvement Program in 1990s which also provided alongside the footpaths for the disposal of waste water and for rapid run-off of rainwater. It facilitated each house to have its own septic tank which is emptied regularly. Public toilets and washing facilities were also provided. A water supply network with stand-pipes was provided throughout the Kampung, with each stand-pipe serving 25-35 families. Supplies of drinking water were also purchased from street vendors on a daily basis. Wells were used to provide water for non-drinking needs and the quality of this water continues to be improved. During the years 1984-1990, 70 km of access roads and 150 km of footpaths were improved, 93 km of drains and culverts were constructed and 56,000 m of water pipe was set up. Eighty-six public bathing, washing and toilet facilities were built (Silas, 1992). Currently, the high-profile activity to promote Green and Clean Kampong has raising competition to each kampong to dress up kampong. Conducting at the time to celebrate the Independent Day in August, the City Government conducts annual competition to chosen the cleanest kampong. Some innovations have been coming up from local communities. Since making green need more water, some kampongs have initiative to set up water treatment from their home to ensure that their three get enough water supplies.

Along with support of some multinational corporations, the competition provide cash award about Rp25 million or $3000 for each kampong. Those even organizers then acknowledgement that the best kampong was their communities. There has been much dispute over the acknowledgement of the actors behind the success of the best kampong. Some local leaders disappointed that the ones who provided award to the competition (i.e. government and companies) admitted that the success to transforming their kampong belongs to their corporate social responsibility. Rp 25 million was nothing compare to the community effort for many years. However, other cities follow to hold the annual Green and Clean Competition. Since being held in Surabaya, Jakarta is the second city which held the similar competition,

following by the city of Jogjakarta. In 2008, it will also be held for the first time in Makassar, South Sulawesi. It remained us with the hypothesis of Bebbington (2006). It is about the credibility of elites and governments with such temptation to weaken, de-legitimize, incorporate or indeed repress social movements. For community or development agency, such governments can become the object of policy which the process can be fraught with tensions both within government as well as in its relationships with other sectors of society.

Conclusion

In the case of Surabaya City, the most prominent characters in the pattern of promoting local initiative takes the form of contribution and help in certain specific situation (short-run program) than of maintenance on a more regular basis which has to deal with the complex local paternalistic relationship. For becoming or sustaining a learning community, local leader is the one who has the important role to make the best possible use of the knowledge of the workers in the community. Involving within communities as a leader, development agencies would invest on the human capital that holds the most valuable potential for community learning. Unless integration community, implicit learning results in tacit knowledge, which is context-specific, personal and difficult to communicate. Moreover, the sustainability of community learning on dealing with clean water needs to be examined to the next challenge on getting right to drinking water.

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The Development of Gedung - An Information and Data Sharing Repository Platform For Hydraulic Research in Malaysia

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Introduction

The National Hydraulic Research Institute of Malaysia (NAHRIM) is a government institute (under the Ministry Of Natural Resources and Environment). NAHRIM engaged itself in research and specialist consultancy in all aspects of water hydraulics and water environment.

As with most research organisation, NAHRIM aspires to become the premier water research institute in Malaysia and also within Southeast Asia and to assume the role as an expert referral centre in the same field. As part of this effort objective, NAHRIM is in the process of establishing a "National Water Information Repository Centre".

It is a known fact that much of the researcher's time is spent on finding information. Hence, the project aims to assist researchers in this tedious process by providing a point of access for water related information. The Information Repository is currently being populated and when fully developed, it can then not only serve the staff and management of NAHRIM, but also the various government departments and agencies, academicians, consultants, students and the public.

These users can have access to the information available in the repository to serve their needs which can varies from research, design, planning and implementation, coordination, environmental management, policies and decision support, socioeconomic activities and others.

Background

The basis for any information repository system has to be robust, easily expandable and easily accessible to the many communities requiring the information. The vast availability of ICT networks in Malaysia provides the passage and opportunity to allow for the smooth flow of vast information and data and NAHRIM has taken advantage of the current advancement in ICT to develop the system.

In hydraulic and water environment related researches, many types and format of information are prepared, collected and analyzed. These collections of information will not be fully utilised if it is not manage properly. Many valuable information lay idle and a lot of time can be wasted in searching, collating and integrating of data needed for research where it may already have been gathered by other researchers. There are instances whereby the same information was collected over repeated number, at the expenses of public funds.

In order to avoid this duplication of efforts, an Information Repository centre was developed where all water related information are grouped, categorized and digitized, to assist in all water related research and development (R&D) activities.

One of the most significant aspects of this Water Information Repository is to provide NAHRIM with a single water related information platform. It brings together experimental data from many research projects into one consolidated searchable database. As more research works are being done in NAHRIM, this repository will continue to grow and subsequently become an increasingly significant asset to the country and the international research communities.

Objective and Methodology

The objectives of the project were multiple including the creation of an Information Repository that contains all the water related information available in NAHRIM. Here information are digitize according to the respective R&D activities. The Information Repository will act as an electronic support system within NAHRIM and can serve as the Information Repository for other decision support systems.

The system that was developed also allows archiving of information that may otherwise be scattered or even lost. The system has been designed to provide sufficiently comprehensive and granular information so that they are informative and at the same time easily reused or processed for presentation in various formats to meet the user's requirements which finally will be used to generate a consolidated reports of various resource types.

During its first stage, that is the first six months of the project had been focusing around NAHRIM research activities. However, in the second stage, new methods and tools will be developed to make the information compatible with emerging standards, hence making it easier to be linked and cross analysed with related information from other sources.

Currently, the focus of work covers the collection, compilation and development of the Information Repository for the following divisions in NAHRIM:

a. Research Center for River Management,
b. Research Center for Coastal Management,
c. Research Center for Water Resources Management,
d. Research Center for Water Quality and Environment, and
e. Hydraulic and Instrumentation Laboratory

From then, the information as translated into several main subjects including collecting, compiling and developing databases for the following repository:-

1. Coastal Engineering Information Repository
2. River Engineering Information Repository
3. Water Resources Information Repository,
4. Lake inventory,
5. Coastal Resources Risk Index,
6. Laboratory and Instrumentation,
7. Registry of Experts,

8. Waterpedia,
9. Waternews, and
10. NAHRIM Water Information Repository Portal

The next step that was carried out is to provide an information management framework that can be customised to suit the needs of the Information Repository. The framework must include facilities to manage the following types of information:

a. Documents in proprietary format,
b. Pictures, images, maps, charts and diagrams,
c. Records of reports, surveys, modelling outputs, field data, assessments etc.
d. Unstructured and semi-structured information in HTML and XML format.

The final step is then to store only inputs to and outputs information from modelling and analysis applications for easy reference. It will not include facilities to process unprocessed information as they will require custom built applications for their handling. For example hydraulic engineering applications will include specialised methodology in their processing, analysis and presentation of the outputs.

What has been stored?

There are 9 repositories were developed to realize the need of researchers. The information stored from various resources was mapped and group according to issue that related to NAHRIM core R&D activities.

Information has been stored in each repositories specifically can help researchers in planning and strategies their R&D. These are the information that are collated and stored in the respected areas:

i) Coastal Engineering Information Repository

Research Center for Coastal Management will own and manage Coastal Engineering Information Repository. The types of information that are stored includes Project Information, Environmental Data, Physical Data, Engineering Data,Structure Data, Coastal Development, Management Data, Biological Information, Socio-Economics,Findings and Recommendations

ii) River Engineering Information Repository

For River Management information currently partly handled will include Project Information, Physical Data, Biological Data, Human Activities,Key Issues and Option and Integrated River Basin Management

iii) Water Resources Information Repository

Within the Water Resources Information Repository, the following feature were incorporated which includes Project Information, Environment, Socio-Economics, Water Availability and Environment, Water Use, Simulation, Water Resources Development and Water Resources Management

iv) Lake inventory

Lake Inventory module is to be owned by the Research Center for Water Quality and Environment. This module will store information about lakes in Malaysia. Types of information stored include Physiographic Data, Lake Water Quality, Socio Economic Data, Lake Utilization, Deterioration of Lakes Environments and Hazards, Developments, Legislative and Institutional Measures for Upgrading Lake Environment and Monitoring Stations

v) Coastal Resources Risk Index

Besides Lake Inventory, Research Center for Water Quality and Environment will also manage Coastal Resources Risk Index. Information stored in this module which include information such as Project Information,Coastal Classification Schemes, Coastal Vulnerability, Methodology, Water Quality, Biological Resources, Fisheries Socio Economics, Recommendations, Guidelines and Proposal

vi) Laboratory and Instrumentation

Objective of Laboratory and Instrument Information Repository is as follows:

(a) Inventory Listing for various equipments and instruments managed by the division.
(b) The inventory list of the instruments in the custody of the other division can also be managed if required.
(c) Specifications and usage records of the Physical Modeling Facilities available in the Laboratory such as Tidal River basin facility, 2D flume, Coastal Wave Basin Facility, Tilting Flume and Port and Harbor Deep Basin Facility.
(d) Physical Modeling Report
(e) Research Project Information

Type of information available in this module is about Equipment available at NAHRIM. This module is manage by Hydraulic and Instrumentation Laboratory

vii) Registry of Experts

As for Registry of Experts, this module will store information about experts in water related. The objectives of this module are:

(a) To maintain a repository water related experts in Malaysia. These experts may be from NAHRIM or other organizations.
(b) To facilitate the process of identifying the right experts through profile searching facility.
(c) To provide a resume bank of staff in NAHRIM.

Types of information stored in this module are List Resources Persons, Themes and Sections, GWP IWRM Tools, Field of Study, Country o Study, Age Groups and Current Status

viii) Waterpedia

Waterpedia module is a module that can be called as water dictionary or water encyclopedia where it store general information about water. The objectives of Waterpedia Information Repository are as follows:

(a) To maintain a glossary of water related terminology, facilities, instruments and equipments, software, organizations, people, law and information about major projects in the Malaysian context.
(b) To provide Gazetteer facility for users to search for geographics names or places and associates them with geographics locations and other descriptive information. This includes the register of rivers, the river basin management unit and shore reaches.
(c) To provide facilities for the administrator to add, edit and delete all various static and dynamic resources.
(d) To provide a suggestion form to add new subject matters and technical terms.

Types of information available under this module include:

- Technical Terms, Acronyms and Abbreviations, Gazetteer
- Facilities, Instruments and Equipments, Software and Databases
- Organizations and Distinguish Personalities
- Legislation
- Major Projects
- Water Bodies
- Publications, Journals, Guidelines and Technical Specification

ix) Waternews

Waternews is a repository of news related to water issues in Malaysia and the region. It is a compilation of news items from various news sources. Similar news is grouped together into customizable news categories, events and issues which are of interest to water community.

The objectives of Waternews Information Repository are as follows:

(d) To provide a repository news resources related to water in Malaysia and the region. The news item will be grouped into customizable news categories. The news can be further grouped into secondary groups such as issues, locations, organizations and personalities.
(e) To provide facilities for the administrator to add, edit, delete and organize news.
(f) To display current news at the front page with the facility to expire the news item after specified time frame.

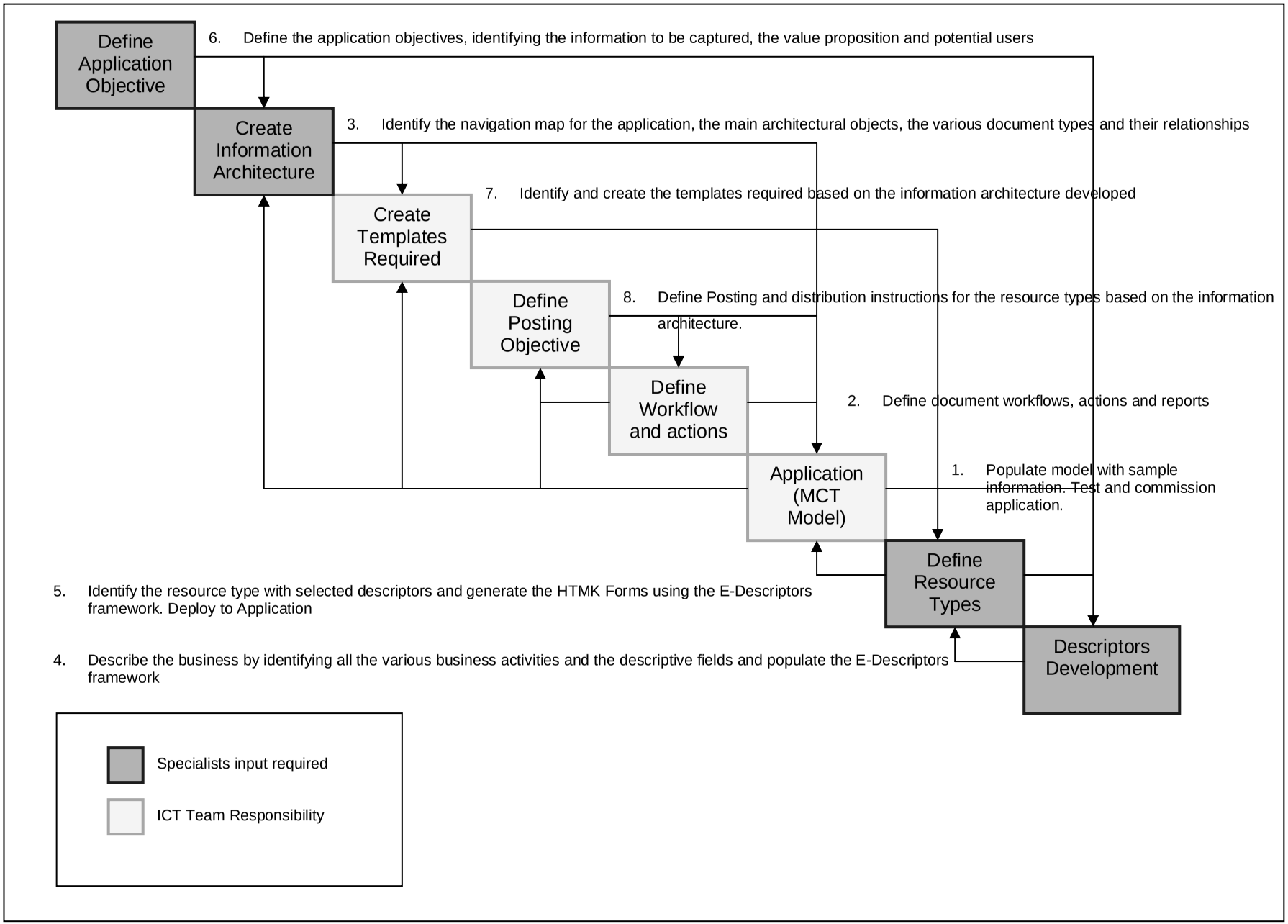
(g) To enable users to search for archived news with various options.
(h) To complement the news clipping related activities in NAHRIM.

Types of news collected are :

- Climate Change, Environment, River Engineering, Water Policy, Water Quality, Flash Flood and Natural Disasters

x) NAHRIM Water Information Repository Portal

This portal will act as the gateway to the Repository and the sub-repositories. The applications for the various divisions are designed as the work space for the divisions. The portal will allow users to view and search the information across divisional boundaries.



Application Development Methodology

Special Features of the repository

NAHRIM Water Information Repository Centre shall be based on an information management framework. The final framework when ready shall have the following features:

i) Document management

The information source for the repository is most likely to be in the form of documents in various formats. It is therefore crucial for the repository to be able to store and manage these documents in their native format. Users should be able to browse and search for the documents available using metadata. It should also provide support for hyperlinks and the definitions of these links in the other documents in the repository. The repository should also be able to maintain different filing structure of each division as it depends on their needs and current practices.

ii) Information architecture and structure management

The application to be developed for the various divisions in NAHRIM will require customised information architectures to suit their diverse needs. Information architecture is defined as the structural design of shared information environments. It is the practice of structuring information for a purpose.

In the Information Repository, the information architecture will be used as the navigation structure for users to browse, explore, group and filter the repository. It will also be used as a place holder for the resources to be captured.

iii) Document-centric computing

All information stored in the Information Repository will be in the form of documents. The information type identified will be entered using HTML forms where these HTML forms will have to be designed to meet the requirements of the different resource types over their business processes. These forms may require to be revised from time to time to meet new requirements.

To ensure productivity and reduce errors in the information capture, these HTML forms must incorporate various constraints and validation rules; provide pick-lists based on the information captured in the Information Repository. Information from existing documents may also need to be transferred to the forms during data entry to reduce inputs and typing errors.

iv) Water related descriptors

A key to the success of the Water Information Repository is for similar information to be described in a similar manner. This will help reduce redundancies and ensure that the collected information can be easily compared or consolidated. This requires the use of water related descriptors.

Descriptors are not to be confused with the term *specification* that engineers and researchers are more familiar with. *Specification* specifies what is required whereas *descriptors* describe what is already there. The *descriptors* list shall contain the descriptive fields for all the technical information handled by the division. The *descriptors* shall be arranged into sections in line with the current practices of the division.

Where the *descriptors* are for quantitative information, a description of how the quantitative information is to be determined must be provided together with the recommended units of measurement.

Some descriptive fields may require a controlled vocabulary or qualitative scales and these must be provided by the specialists together with descriptions of the vocabulary used.

The highly discriminative *descriptors* must be identified so that when the *descriptors* are used, they are mandatory.

v) Ease and efficiency in populating the Information Repository

The Information Repository is generally found to be easy to be populated either using a desktop application or a web browser. The desktop application provides native access to all the information in the Information Repository with extensive searching, navigating, filtering, export and import capabilities which may not be available on the web-based applications.

vi) Flexible querying and reporting abilities

The Water Information Repository collects all related information throughout NAHRIM. It organises the information for study and make it completely flexible for intensive reporting and analysis. In order to do so, a searching facility needs to be provided for the user, for example searching information by full text or by common sets search.

The information can also be grouped under multiple categories and can be related to any other information based on its relationship. This can be use to

describe, summarise and compare data, hence providing a more meaningful report generation.

vii) Spaces and Security Policies

Each division in NAHRIM is given the privilege customized application for their business processes and needs. Some work-in-progress information may also be stored to serve the division needs and should not be exposed to users outside the division. In other words, the divisions would like to work in their own spaces.

Management, on the other hand is more interested in the final information and the status of the projects in progress. They need to look at the information across all the divisions. Typically the information may need to be grouped into geographical units, resource types and time frame. Management may also require consolidated reports across the various divisions. As such, the management space is different from the division spaces. Collaborators and other users will also require their own space.

The information stored in the data repository will require information in different subject areas to be stored in different models. The security policies will need to be defined at model, folders, document types and resource type's levels. Security policies can also be defined for the various actions that can be used for work-flow and documents updates.

Challenges

Among the issues and challenges faced in developing Information Repository are:

(a) Content development must be based on industry practice and usage. This includes descriptors categories in each information repositories.
(b) Active participation from various divisions to process the reports and to populate the repository and to take the ownership of the repository.
(c) To ensure desk officers and support staffs are familiar with the information architecture of their respective application and the various functionalities provided.
(d) Acquiring more reports and information in digital format to be used for populating the repository.
(e) Creating a critical mass of information in the repository so that it will become the primary reference for water related technical information by the researchers.
(f) Enforcing quality control measures to ensure the accuracy of the information in the repository. This will determine the success of this project where the success is measure through quality, usefulness and also quantity of information available in the information repository.

Development Progress

To date the development progress of the system is 80% completed and over 12,344 reports and document have been processed. The system is currently available for the use of researchers in NAHRIM.

For Waterpedia and WaterNews repository, these 2 modules are ready to be used. However, from time to time refinement will be done to enhance repository.

Conclusion

Capacity building can be in varied form and one of them is through the provide access to information. NAHRIM repository is aimed at that objective and hopefully will reduce the amount of time taken to produce research findings. Once fully populated it is hope to be a useful referral platform not only to NAHRIM officers but to those who are involved in all aspects of water related research.

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Urban Water Management, Lahore Pakistan

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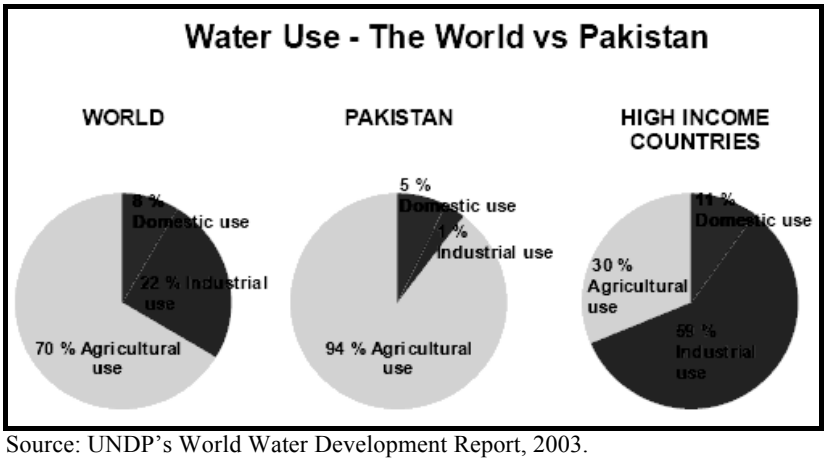
Abstract
With the rapid urbanization the provision of a safe and reliable water supply has become the biggest challenge for urban areas of Pakistan. As compare to whole of the Asia, Pakistan has the lowest water tariffs but still its collection is low due to people's reluctance to pay for unsatisfactory service. Water and Sanitation Agencies (WASAs) which cover 44% of urban population in Pakistan is responsible for Water and Sanitation activities in the urban areas of the major cities. WASA is able to recover only 50 to 60% of annual O&M costs at best. This is an unsustainable situation considering these figure do not include any debt servicing or capital cost repayments. This paper will examine how the current situation may be improved through introduction of public sector reforms, involving private sector, provision of technical assistance, and improvements in service deliveries by capacity building and institutional strengthening of WASA Lahore.

Keywords: urban water, public sector reforms, private sector involvement

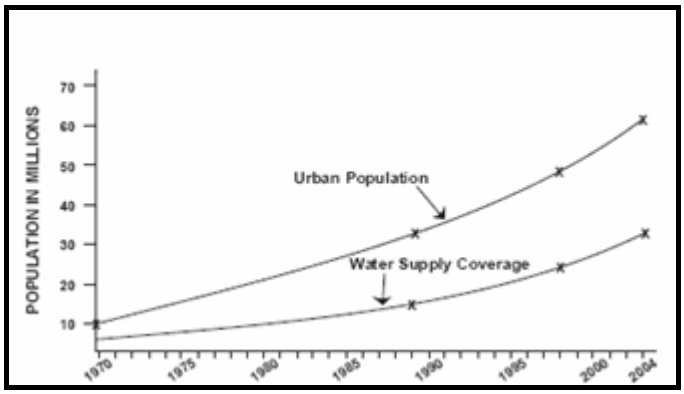
Background
Pakistan's population estimated at 135 million in 1999 is growing at about 2.3 percent annually. Its water supply and sanitation infrastructure has already become inadequate to cope with this rapid growth though compared to the rest of the world and in particular the developed nations, water consumption has very low figures in Pakistan (see Figure 1). This has forced the government to put potable water and sanitation at the top of the national agenda and it is strongly reflected in Pakistan Water Sector Strategy (PWSS) (MOWP 2002) and the National Environmental Policy (NWP) (MOE 2005).



Source: UNDP's World Water Development Report, 2003.

Figure 1. Water Use – Pakistan in comparison with the World

The Government's overall target was to provide safe drinking water to 68 percent and sanitation facilities to 44 percent of the total population by 2004 but it failed to meet this target due to numerous reasons. However, it is always blamed on limited financial resources. Figure 2 shows the increasing gap between water demand and urban population over a 30 year period.

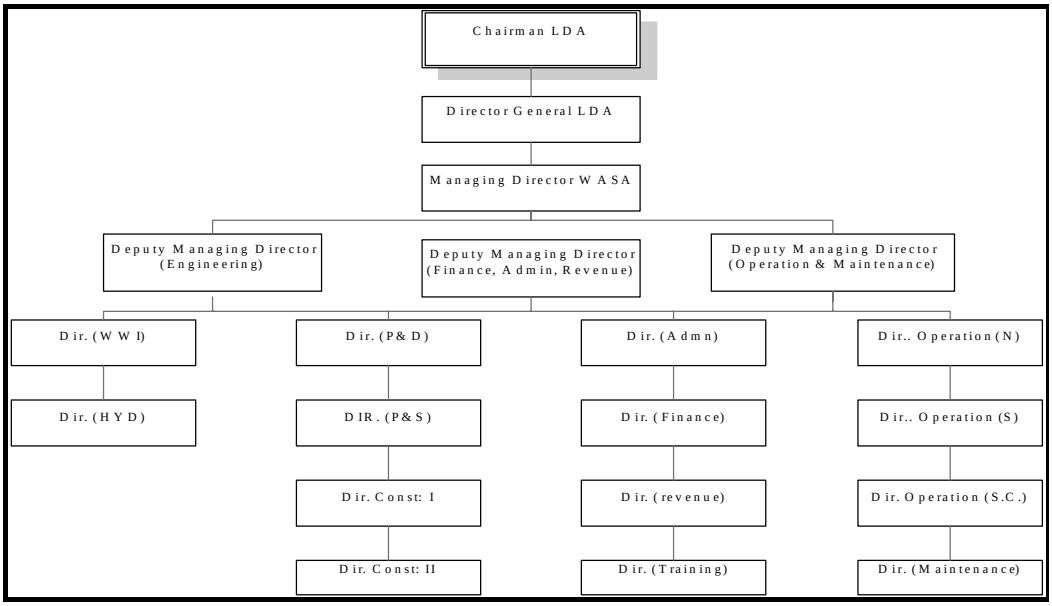


Source: (Shahid 2005)

Figure 2. Growth in Urban Population with corresponding coverage

Further, despite very low tariffs, collection efficiencies remain low pointing to the fact that people are not satisfied with the quality of service provided and hence avoid paying. In none of the cities in Pakistan there is a 24 hour 7 days a week water supply.

Water And Sanitation Agency (WASA)- Lahore
WASA was created in 1976 as subsidiary agency of Lahore Development Authority (LDA) to take care of water supply, sewerage and drainage requirements in Lahore.



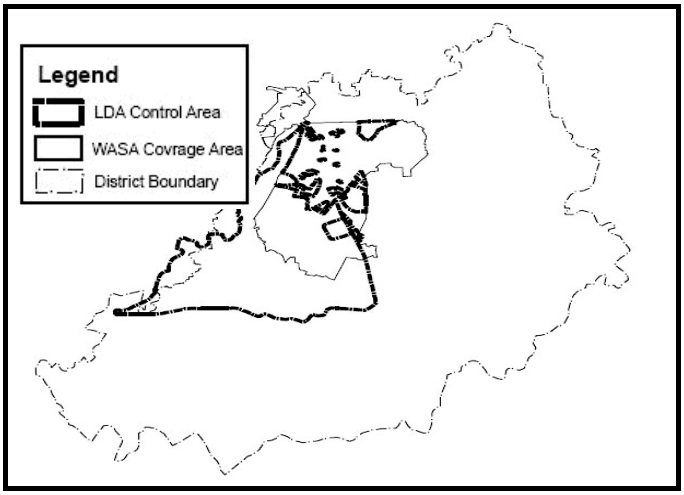
Source: (WASA 2008)

Figure 3. WASA Organization Structure

WASA is divided into various sections in accordance to specific functions and each section is headed by a Senior Officer as shown in the above Figure 3.

Following are the main functions of WASA:
Forecasting of demand for services of Water Supply, Sewerage and Drainage, preparation of plans and design for their extension, rehabilitation and replacement.
Construction, Improvement, Maintenance and Operation of Water Works, Sewerage Works and Main Storm Water Drainage Channels, and Pumping Stations.
Billing and collection of all rates, fees and charges, for the services so provided to the consumers.

The coverage area and statistics of WASA for Lahore are shown in the Figure 4 and Table 1 and Table 2. It is interesting to observe a clear lack of coordination between WASA and LDA development plans (Figure 4) though WASA is a subsidiary of LDA.



Source: GIS Section, The Urban Unit

Figure 4. WASA Served Area in Lahore District

Table 1. WASA Water Supply Statistics. Lahore

DESCRIPTION	
Number of tubewells	316
Pipe lines length (3"-20" dia in Km)	3,200
Population served (million)	4.11
Per capita per day (gallons)	80
Water production (mgd)	329
Water connections (thousands)	426
Population coverage	90%

Source: (WASA 2008)

Table 2. WASA Field Staff Statistics. Lahore

DESCRIPTION	
Sub engineers	98
Sewer man	1540
Recovery inspectors	215

Source: (WASA 2008)

WASA's failure as an institution to manage urban water supply remains at the heart of the crisis and much of problem can be attributed to the quality of human resource and the structure of incentives that govern the operation. The potential factor considered responsible for the downfall and poor services are:

Absence of legal and regulatory frame work.
Lack of alignment between the interests of WASA's owner (LDA) and its primary financier (Provincial Government)
Institutional constraints (Overlapping of activities between different departments such as WASA, the Public Health Engineering Department (PHED) and municipal committees/ corporations).
Inability to recover costs and finance services locally which is further aggravated by pervasive misallocation between capital and recurrent expenditures
Limited autonomy of WASA as financial support is coming from Provincial government which is also interfering departmental human resource management and field operations in the absence of human resource and career management mechanism.
Unrealistic development plans and inappropriate pricing of resources and services based on outdated data
Insufficient personnel strength and capacity of the individuals in current organizational set up.
Limited role and discouraging attitude towards local community and private sector involvement
Poor working conditions, work acknowledgement and salaries of the staff.

Unfortunately till now every effort has been directed towards tariff increase and no real attempt has been made in understanding the reasons of poor collection. In order to address the key determinants, following three approaches are worth consideration:

Improvement in WASA's performance without institutional reforms/realignment
Outsourcing / Privatization of selected activities of WASA
Introduction of Institutional reforms/realignment

Improvement in WASA's performance without institutional reforms/realignment is seeked through introduction of performance criteria and implementation of short term strategic and improvement plans. The core values of this concept are:

Visionary leadership
Customer-driven excellence
Organizational and personal learning and capacity building
Valuing employees and partners
Innovative management
Informed management using geographical information system (GIS).
Social responsibility and environmental responsibility

For the visionary leadership, WASA has already hired professional Managing Directors (MD) at competitive market rates to act as the champion for this cause. Further, the Urban Unit (Urban Sector Policy and Management Unit), formed under Planning and Development Department, Government of Punjab is helping WASA towards development of a geographical information system (GIS). It has already developed a geodatabase for the WASA major

infrastructure for up-to-date and informed decision making. New customer complains centres whose complaints database can be directly accessed by the MD are under development. It is hoped this will assist in implementing some kind of monitoring mechanism and will also help in restoring customer's confidence to pay WASA for its utility services.

In Pakistan both the National Water Policy (GOP 2008) as well as Pakistan Water Sector Strategy (MOWP 2002) highlights the importance and the need for *Private Sector Participation (PSP)* for the following reasons:

Financial/Budgetary constricts of Public Sector Organizations
Expansion of existing infrastructure and introduction of new technologies
Assumption that Private sector works more efficiently than the public sector

However suggestion of *outsourcing / privatization of selected activities* of WASA have raised many eyebrows due to misapprehension and misunderstanding about PSP in the provision of urban water supply and sanitation services. Actually the concept of PSP in the municipal water industry is still relatively new and it should be tailored to suit particular needs of a community bearing in mind constraints and limitations which are bound to exist in any situation.Although there is little doubt that without PSP the future needs of a growing urban population can never be met. But it is important to understand that private sector runs the business solely for profit while water supply and sewerage are low tariff public utility services usually taken for granted.

The foremost requirement for PSP to succeed is that of a strong *regulatory framework*. The need for PSP is greatest where governments are weak and have failed to meet water needs of people. Unfortunately, the risks of PSP failing are also where governments are weak and are unable to provide proper regulation and oversight to protect public interests (Bundschuh and Fuertes 2001). It is up to the governments to define and enforce laws and regulations.

Equally important is a *legal framework* under which PSP contracts are negotiated and awarded. The legislation should be clear and unambiguous allowing all stakeholders to enter into a contract which is fair to both and at the same time protects public interest. This requires provisions ensuring the quality of service and a regulatory regime that is transparent, accessible, and accountable to public. Because contracts are usually much easier to enforce when signed with private parties, PSP should be encouraged, primarily for improving the quality and the efficiency of the Water Supply & Sewerage (WSS) service. PSP in WSS can take many forms (ADB 2006) such as:

Simple short term "Service contracts" for commercial (meter reading, billing, collection), maintenance (plants or networks), or non revenue water (NRW) reduction activities;
Medium term "Management contracts" with part of the remuneration of the Provider linked to its technical and/or commercial performance;
Medium term "Lease" and "Affermage" contracts for which revenues from collections are shared between the Owner and the Provider; and
Long term "Concession contracts" (with existing WSS assets transferred to the Concession for its duration but still remaining owned by the WSS Utility)

"BOOT: Build, Own, Operate and Transfer" for new plants and/or networks which both transfer most risks, including that of financing extension of WSS assets, to the Operator and Joint ventures

Earlier on, an attempt to introduce PSP in Lahore failed due to ill conceived notions and the process adopted. In 1998, a multinational British company was invited to carry out due diligence and put forward proposals to privatize Lahore WASA. Negotiations took place behind closed doors and a deal was almost finalized when nuclear testing resulted in international embargoes against investments in Pakistan. In 1999 LDA again entered into negotiations with a private company, this time a German utility to privatize WASA but again this failed due to lack of transparency and an absence of legal framework. Further PSP approach is still unable to gain any in house support from the WASA operational field staff.

To be successful, PSP in WSS requires significant preparation. The recently published toolkit on "Approaches to Private Participation in Water Services" (World Bank/Public-Private Infrastructure Advisory Facility (WB 2008) explains in great detail the main steps to be followed for implementing a "acceptable" PSP arrangement.

Introduction of Institutional reforms/realignment envision transforming the existing WASAs, currently working under the Development Authorities, into autonomous, efficient, accountable, customer oriented and financially viable WSS corporatised utilities through following interrelated priority steps:

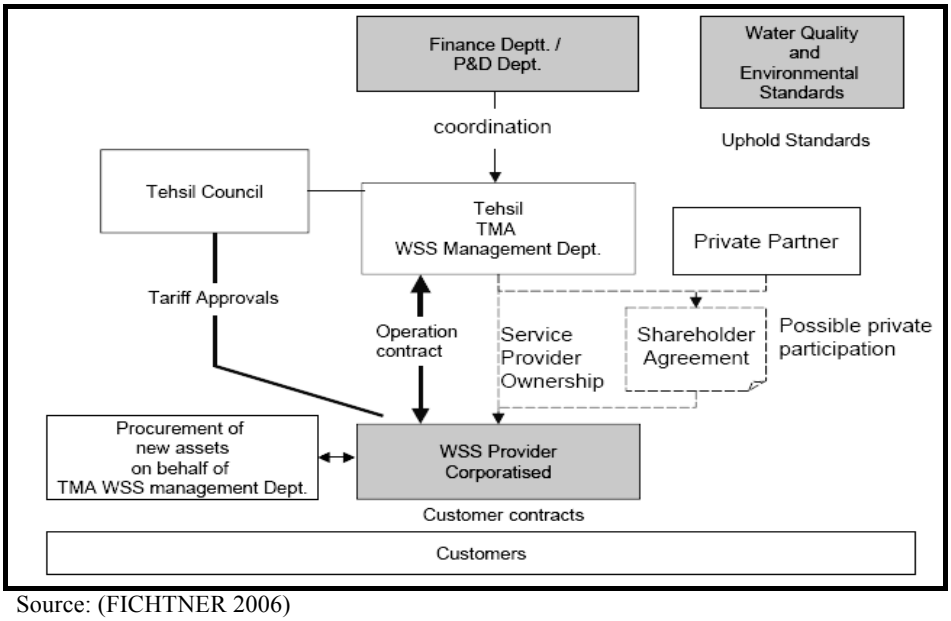
Transforming WASA into an autonomous entity, and establishing a renewed corresponding institutional framework of accountability
Strengthening the new WASA, into a responsive well managed institution able to deliver world class services in its jurisdiction
Preparing a business plan for the services including the strengthening and capacity building programme, and
Designing and carrying out a integrated water and sewerage investment program

Preparatory and design activities required within the reformed sector structure are identified as (FICHTNER 2006) :

Sector objectives, goals and targets in such detail to be used as the basis for planning WSS
Legislate drinking water quality standards and monitoring responsibilities
Appoint independent technical auditors to monitor performance
Appoint financial auditors
Define detailed rules for tariff determination and make their implementation mandatory
Revise and clarify the appraisal criteria for investment funding and performance standards
Facilitate transfer of WSS assets and responsibilities for investment to local governments
Develop draft service agreements to be used by service providers to outsource O&M and other services

Given the time needed to establish new institutions and build their capacity, it is necessary to consider transitional arrangements, particularly to deal with the planning and management of new investments in WSS assets. The final organizational arrangement following transition is shown on Figure 5. It refers to a future condition in which the WSS providers are no longer

mainly dependent upon Provincial government grants for infrastructure development (> 10 years in the future).



Source: (FICHTNER 2006)

Figure 5. Final Institutional Arrangements

At this point the Local Government authorities would have to take over the function of performance monitoring in connection with tariff approvals. Each Tehsil Municipal Administration (local government administrative unit) will establish a new WSS management department with the following functions:

To have representation on the Supervisory Board of the WSS corporatised utility and thus be involved in all governance issues
To prepare the statutes for the corporatised WSS utility
To recruit and engage the General Manager (GM) of the corporatised utility (paying at market rates) and to establish performance contract
To review business plans inline with the Master Planning (co-ordination with urban planning)
To review tariff change proposals prior to approval by the relevant authority
To lobby for investment support to state institutions on behalf of the corporatised utility.

In order to ensure the success of the reform programme, the Government of Punjab will need to co-operate with the local government bodies and the service providers to prepare short-term WSS projects for each city participating till the complete implementation of reforms.

Conclusion

As Pakistan's population grows and economy develops, unconventional initiatives are needed to meet challenges of rapid urbanization and water scarcity. It is the right time to understand that without strengthening the institutions and defining a definite role for them, it will be impossible to run the system in an efficient manner. It is significant to understand that introduction of any change or reforms in the institutions in the absence of regulatory & legal frame work as well as proper political backing will not deliver the desired results.

It is also imperative to recognize that the urban water service problems are not the result of some inherent properties of the services but are products of urban governance, the availability of human and economic capital, the political will and the strategic preferences. By identifying the strengths and weaknesses of existing system this paper presented a framework for promoting institutional complementarity through a cohesive governance system where superiority of one form of governance takes shape depending on the issue in place.

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The Impact of Climate Change and Human Activity on Mongolian Water Resources

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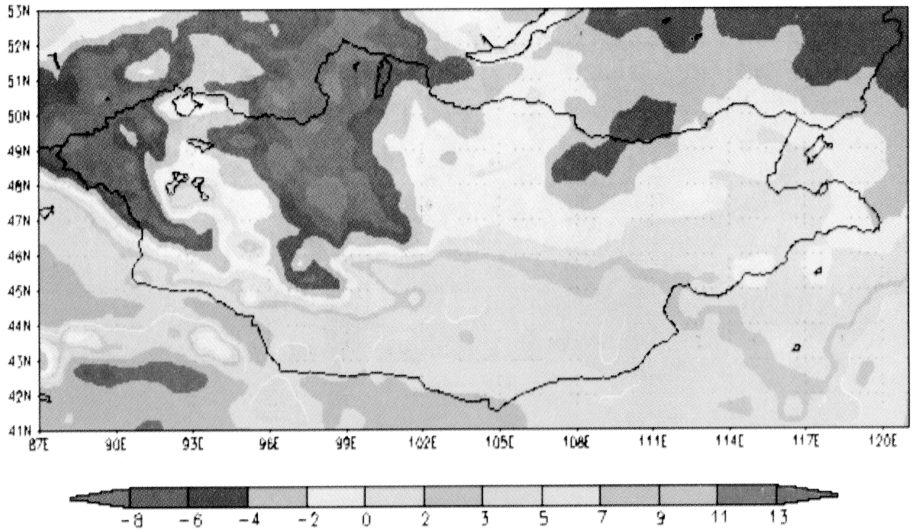
Abstract
Problems of water resources are becoming important factors restricting social and economic development of our country. Water resources of Mongolia are dramatically sensitive to climate change that a small alternation in the precipitation might bring about severe water shortage. In the recent 50 years, it is obviously warmer in southern of Mongolia than before. The particularly obvious warming in winter had not only resulted in a greater evaporation and reduction of runoff volume, but also intensified the conflicting of water supply and demand. The impacts of climate change on water resources are displayed in every sector of water system. In this paper, we will pay attention to develop integrated water recourse management plan.

Keywords: water, water supply, climate change, evaporation, precipitation, wastewater.

Climate
The Mongolian climate is extremely continental with a short, hot summer and a long, cold winter, high temperature fluctuation (both daily and seasonal) and a relatively high number of cloudless days. The average annual temperature is between -7.8°C and +8.5°C (Figure 1, Table 1)



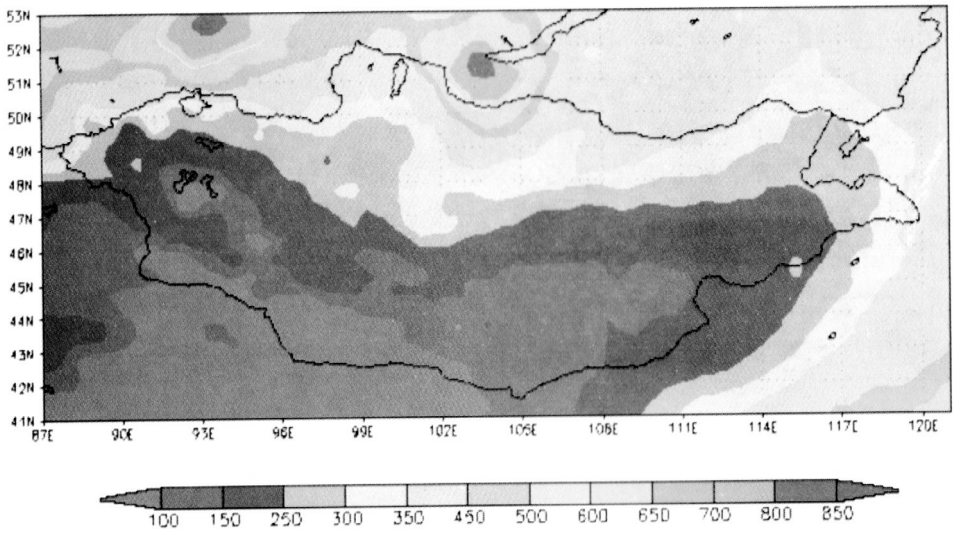
Source: "Assessment of the water sector in Mongolia" Report, 2007

Figure 1. The geographical distribution of average temperature, °C

Table 1. Average air temperature for different regions

Region	Average air temperature of coldest month (January) (°C)	Region	Average air temperature of warmest month (July) (°C)
Valleys between mountain ranges Altai, Khangai, Khentii and Khuvsgul	-30 to -34	Great lake valley, Orkhon and Selenge basin and region between Altai, Khangai, Khentii, and Khuvsgul mountain ranges	+15 to +20
High mountains	-25 to -30	Altai, Khangai, Khentii and Khuvsgul mountain ranges	+15
Steppe	-20 to -25,	Dornod steppe and other steppe zones	+20 to +25
Gobi Desert	-15 to -20	Southern part of Dornod steppe and Gobi Desert	+25 to +30

The annual average precipitation is low in Mongolia; it is about 300-350 mm in Khangai, Khentii, and Khuvsgul mountain ranges; 250-300 mm in Mongol Altai and forested areas; and 50-150 mm in Gobi Desert area (Figure 2).



Source: "Assessment of the water sector in Mongolia" Report, 2007

Figure 2. Geographical distribution of annual precipitation, mm

Mongolia is situated in more sensible region with climate change than in many other regions in the world. The main cause for this fact is that the country is located in a narrow inland

transition zone between the great Siberian taiga and the Central Asian desert, highly elevated above sea level.

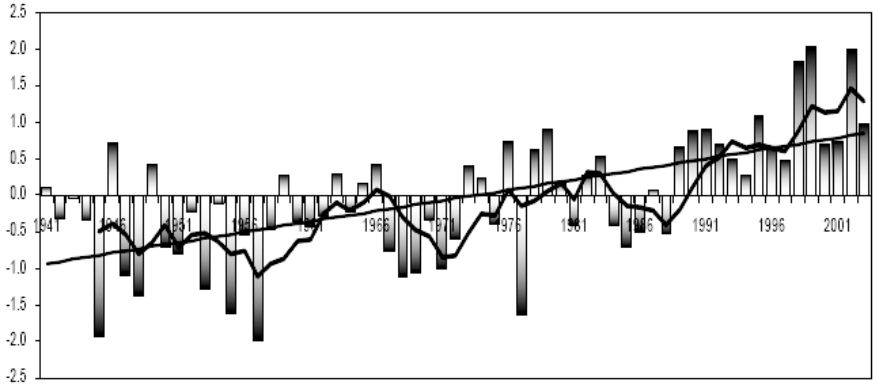
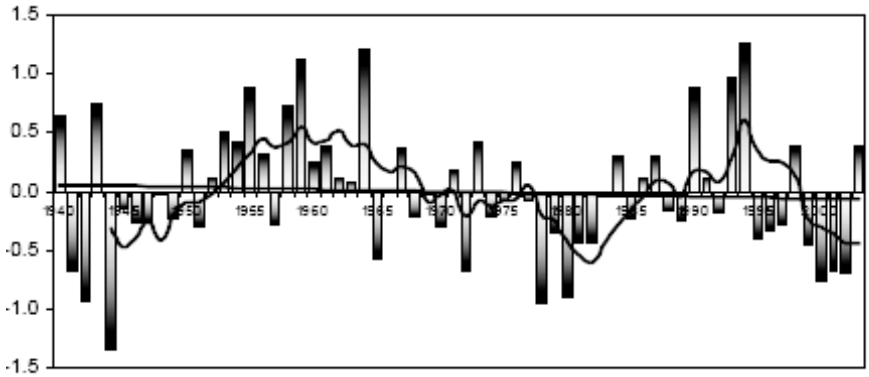


Figure 3. Spatial average of normalized annual temperature over Mongolia

In the past 60 years, the annual average temperature has increased by 1.9 °C; more specifically, for the winter period by 3.6°C, the spring and fall period by 1.3-1.8 °C, and in summer time by 0.5°C (Figure 3). During this time, the annual average precipitation has decreased by 10% within the country (Figure 4).

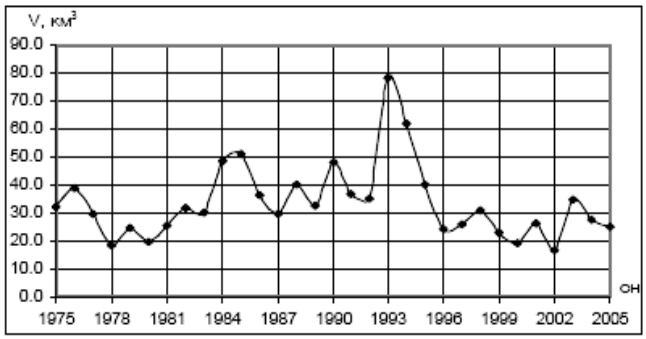


Source: L. Natsagdorj, 2006

Figure 4. Spatial average of normalized annual precipitation over Mongolia

Surface water resources

Surface water resources of Mongolia are composed of rivers (34.6 km^3), lakes (500 km^3) and glaciers (62.9 km^3). The 36.5 % of the total lakes are distributed in the Gobi region and 410 km^3 of total lake water resource 500 km^3, is fresh water. The 75.2% of the total glaciers are the mountainside glaciers, the 21% are valley glaciers and the 3.8% are denudation surface glaciers. The 50-70 percent of annual runoff of rivers in Altai mountain area forms from snow and glaciers contribution, while 5-10 percent from rainfall. In case of rivers originating from Khuvsugul, Khangai and Khentei mountain ranges, the 56-76 percent of annual runoff forms from rainfall. Highest runoff is observed at Selenge-Sukhbaatar site. The variation of rivers water resources is presented in Figure 5.

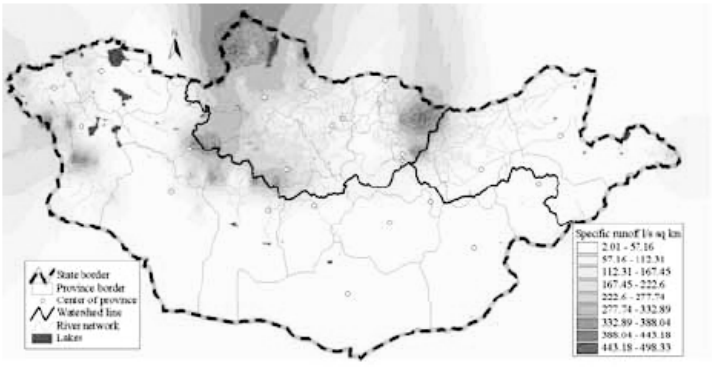


Source: MNE, State of Environment 2006 report

Figure 5. Long-term variation of surface water resources of Mongolia, km^3/year

The main elements of surface water balance, such as the total inflow, evaporation from water surface and total evaporation, are varied due to climate condition, soil and vegetation cover and land surface of the country. The main elements of the surface water balance of Mongolia are presented in the Figures 9, 10, 11.

It is very important to determine climate impacts on the river regime and balance, and tendency according to the time and the space.



Source: "Assessment of the water sector in Mongolia" Report, 2007

Figure 6. Average run-off of the rivers, l/s km^2 * 100

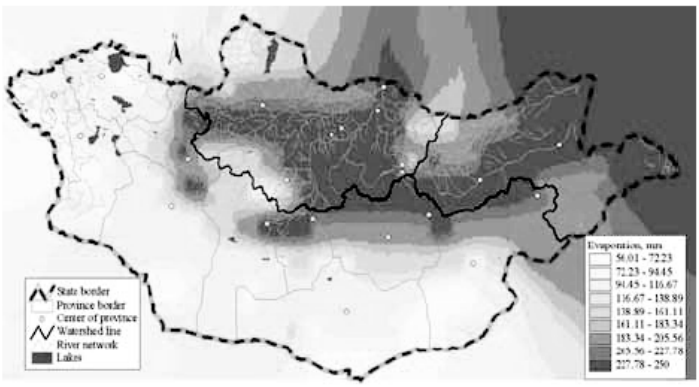
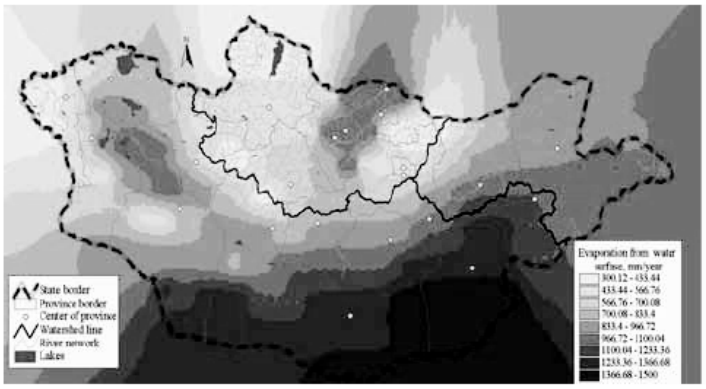


Figure 7. Total evaporation, mm/year



Source: "Assessment of the water sector in Mongolia" Report, 2007

Figure 8. Evaporation from water surface, mm/year

Climate change impact on surface water volume

Scenarios generated by the Hadley model (England) show that by 2040-2070 runoff will increase in the Pacific Ocean basin and to a less extent in the Arctic Ocean basin. For the Central Asian Closed basin it is expected that until 2040 runoff will increase a little and then by 2070 runoff will decrease.

In 2004, meteorologist L. Natsagdorj determined that potential evaporation had been increased by 3.2-10.3 % in steppe and Gobi region in last 60 years and 10.2-15.0 % in mountain and forest-steppe regions and in the first half of 21st century the total evaporation will increase by 6-10 times than precipitation based on summarizing the total surface evaporation studies estimated by other researchers.

Groundwater resources

The groundwater resources are formed differently depending on geological formation, climate, geomorphologic and hydrological conditions. In 1958, groundwater resources was estimated for the first time in Mongolia by the Russian scientist A.T. Ivanov and later, the Institute of Water Exploratory Research (IWER) in 1973, Russian scientist N.A. Marinov (1977), scientists G. Davaa, M. Myagmarjav (1999) and scientists Sh. Jadambaa, G. Tserenjav (2003) estimated the groundwater resources using different methods. These estimations are summarized in the following table.

In 2003, Dr. N. Jadambaa and G. Tserenjav estimated the groundwater resources that could be used for economic use of pastureland, shown in the table 2. Their estimation was based on a proposed distance between four water points in the whole territory of the country and it took into consideration different types of water bearing rock formations and possible rates of discharge when calculating the groundwater resources.

Table 2. Potential groundwater resources per unit area (1 km^2) and whole territory of Mongolia

Classification of exploitation resource per unit area		Water for unit area	Area of distribution		Groundwater resources
		10^3 m^3/year	êm^2	10^6 m^3/year	%
1	Area with small resources	< 3	770225	1032.9	9.6
2	Area with from small to moderate resources	3- 10	571780	3032.7	28.1
3	Area with moderate resources	10-30	139825	2182.8	20.2
4	Area with large resources	> 30	65790	4538.0	42.1
Total		**1547620**		**10786.4**	**100**

Source: N. Jadambaa and G. Tserenjav's estimation in 2003

Potential groundwater resources for pasture by Mongolian economic regions is 2548.39x10^6 m^3/year (80.90 m^3/s) in Dornod region (including Hentii, Dornod and Sukhbaatar provinces), 2600.0 x10^6 m^3/year (82.5 m^3/s) in Central region (including Selenge, Tuv, Darkhan-Uul, Dundgobi, Dornogobi, Gobisumber and Umnugobi provinces), 3005.1 x10^6 m^3/year (95.4 m^3/s) in Khangai region (including Khuvsgul, Bulgan, Orkhon, Arkhangai, Uvurkhangai and Bayankhongor provinces) and 2633.7 x10^6 m^3/year (83.6 m^3/s) in west region (including Gobi Altai, Zavkhan, Khovd, Uvs and Bayan-Ulgii province.

Water quality

Surface water quality per basin

In terms of the assessment of surface water quality per basin, the surface water in the mountainous region of Mongolia is fresh and soft, and it is included in the hydrocarbon calcium classification. In the *Arctic Ocean Basin* which occupies 19.5 % of the territory of Mongolia, the Selenge River and its tributaries, the Sishged and Huremtei Rivers` mineralization is at maximum 320.0 mg/l in winter. In summer, when it is fed by spring snow melting and rainfall floods, the mineralization becomes at minimum 53.3 mg/l, pH =7.40-8.30 (low alkali) and average hardness is 2.30 mg-ekv/l. At the all sample sites along Selenge river, water is fresh (mineralization is 200-320 mg/l), soft (hardness is 2.30 mg-ekv/l), with pH=7.40-8.30 (low alkali), and belongs to 1-2nd types of Hydrocarbon Calcium classification. Near to upstream of Orkhon river, Ulaan, Tsagaan rivers and Tsenkher, Tsetserleg, North Tamir, South Tamir, Khoshigt, Jargalant and Mogoi tributaries are very clear, soft and not affected by human influences. The mineralization of Eroo river which is the biggest tributary of Orkhon river is not more than 70 mg/l and the hardness is 0.30 mg-ekv/l. Therefore, this river is very clear, soft and its chemical composition resembles with rain water. The Kharaa river belonging to 2nd type of Hydrocarbon sodium and calcium classification is clear and soft. All tributaries near to upstream of Tuul, are mountain clear, soft and not affected by human influences.

In the *Pacific Ocean Basin*, the average mineralization for the Onon, Ulz, Kherlen and Khalkh rivers is at maximum 120-300 mg/l and the average hardness is 2.0 mg-ekv/l. They have considerable fresh and soft water.

In the *Central Asian Internal Drainage Basin,* the average concentration level of mineralization of the Bulgan, Uyench, Bodonch, Buyant, Khovd, Tsenkher, Tsagaan, Sagsai, and Sogoot rivers with their tributaries which are Bokhmoron, Turgen, Ongi, Taats, Tui and Baidrag etc. is about 60-450 mg/l, which is very fresh. Their hardness is 0.80-3.80 mg-ekv/l. By research materials of surface water chemical composition, mineralization of most rivers is mainly determined as 300-500 mg/l so that it is almost suitable for any economic sectors uses. On the other hand, mineralization of the main lakes is different from each other. For example, mineralization of Uvs, Khyargas, Khar, Boontsagaan, Sangiin dalai, Khukh and Oigon Lakes is 2'000-15'000 mg/l, but mineralization of Khar Us, Khuvsgul, Buir, Tolbo, Terkhiin tsagaan and Khoton Lakes is 50-300 mg/l.

Groundwater quality

Mongolian ground water quality and chemical composition can be defined by 4 physical-geographical zones.

The *Khangai- Khenti mountainous region* involves most of the forest steppe area (30% of Mongolia) and covers the northern part of the country. The mineralization of the samples taken from this region range between 100-800 mg/l, with rare exceptions of having >1000 mg/l. Average mineralization equals to 450 mg/l. Hardness of water in the region equals to 4.5 mg-eqv/l.

The *Altai mountainous region* involves Mongol Altai, Siilhem, Kharhiraa, Turgen and Gobi-Altai mountains of western Mongolia. Average mineralization for the region is 640 mg/l and hardness is 4.8 mg-eqv/l which is higher than the previous region. The water for the region is salty and fluorinated.

The *Mongolian Dornod steppe region's* average mineralization is 950 mg/l, average hardness is 5.6 mg-eqv/l and it is characterized by a high concentration of iron.

The average mineralization for the *Gobi region* is 1120 mg/l and hardness is 5.4 mg-eqv/l which exceeds the standard for drinking water. Water quality in more than 100 soums does not meet the drinking water quality standard since 60% of the soums have water rich in mineralization, 40% have high hardness and over 80% of them have a high magnesium-hardness degree.

The groundwater mineralization and chemical composition of the Mongolian territory are changed from north to south by principle that the chemical composition is altering from hydrocarbon into sulphate, then chloride but cation altering from calcium into magnesium and sodium.

Water pollution

The regime and quality of water resources become more and more affected by human influences, global climate warming and changing soil and vegetation cover to. A state inventory for surface water conducted in 2003 showed that although most of the rivers still contain mountain fresh water, for at least 28 rivers in 8 provinces riverbeds have changed and/or are polluted due to mining activities. For example, the large Orkhon, Tuul, Kharaa and Eroo rivers in the Selenge river basin have been polluted from the impacts of gold mining industries, urbanization and industrial activities within the basin.

As impacts of mining activities, the aquatic ecosystem with insect and fish populations have been changing. Fresh water fishes cannot survive in heavily polluted blurry rivers and the amount of fishes which get infected by diseases is increasing. Groundwater sources which are close to Ulaanbaatar city and other bigger cities are polluted by urban waste and garbage since the regulations for protected zones are not obeyed.

Water resource scarcity

In recent years, water resource scarcity is appearing in some regions from reason of climate change and human impacts.

A state inventory for surface water conducted in 2003 shows that the total number of rivers in Mongolia is 5565 and from them 683 dried out in the last few years. Also 1484 springs of total 9600 springs and 760 lakes of total 4193 lakes dried out.

According to the LANDSAT7 satellite information of the glacier study in Kharkhiraa, Turgen, Tsambagarav and Tavanbodg mountains, the glacier area decreased by 30% from 1940 to 2002

A state inventory for surface water was conducted again in 2007. As the preliminary result, the abovementioned situation has become worse that the total number of rivers in Mongolia is 4290 and from them 887 dried out. Also 2096 springs of total 7244 springs and 1164 lakes of total of 2569 lakes have dried out. These results show that the water resources are rapidly becoming scarce. Water resource scarcity raises trouble for state, public and water user and needs to be well concerned on account of life base. A comparison of the state inventories for surface water conducted in 2003 and in 2007 is presented in the following figure.

Conclusions

Because of its geographical location and rugged topography, Mongolia is highly vulnerable to anticipated impacts of climate change on water resources. Due to the cross cutting nature of water resources, increased mean temperature, recurrent drought and floods, retreating glaciers and permafrost, and more intense and infrequent rainfall patterns will have a wide ranging set of impacts on water resources.

Water is most likely source of conflict, with different sectors for resources that will in many places become scarcer. These increased vulnerabilities to climate hazards will compound current water governance problems in Mongolia. Therefore, governance structures and water use practices will need to adapt to climate change. Good examples of Integrated Water Basin Management should be developed.

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Legislative Approach to Water Quality Management in Malaysia – Success and Challenges

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Introduction

Water resources in Malaysia come in the forms of rivers, lakes and groundwater. As long as we can remember, rivers have served as the sole source of water supply for our consumption in almost all parts of the country. Since achieving independence, the country has developed itself in leaps and bound from an agriculture-based society to an urbanised and industrialised nation. Both this shift and a rapidly growing population have threatened rivers as a vital source of water supply. In addition, the river water quality has deteriorated making its availability for consumption much more difficult than in the past. The continual pollution of rivers will deplete this water resource even further and will have serious repercussions on the national agenda to become a fully developed nation by the year 2020 if essential steps are not taken to improve our river water quality. This paper describes the legislative approach to water quality management in the country, and its success and challenges.

National Policy

The National Policy on Environment states that the nation shall implement environmentally sound and sustainable development for the continuous economic, social and cultural progress and enhancement of the quality of life of Malaysians. It is based on eight inter-related and mutually supporting principles and where water is concerned will include the sustainable use of water resources, conservation of a river's vitality and diversity, and the continuous improvement of its water quality. The policy outlines the strategies and measures to be taken towards an effective management of water resources, pollution control and prevention of environmental degradation. A holistic approach is required to manage our river water quality.

Water quality management

Legislation

Laws are used as a form of management response to environmental problems in Malaysia. Amongst the laws relevant to water quality management include the 1929 Mining Enactment, the 1930 Waters Enactment, the 1954 Drainage Works Ordinance and the 1974 Street, Drainage and Building Act. These laws are largely sectoral in character and focused on specific areas of activity. The increasingly complex environmental problems faced by Malaysia required a comprehensive piece of legislation which came in the form of the 1974 Environmental Quality Act. The Act came into force on 1 April 1974 for the abatement and control of pollution and enhancement of the environment. Three pieces of subsidiary legislation were formed as an initial legislative approach to water quality management. These were:

(i). Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations 1977;

(ii). Environmental Quality (Prescribed Premises) (Raw Natural Rubber) Regulations 1978; and

(iii). Environmental Quality (Sewage and Industrial Effluents) Regulations 1979.

Sources of pollution that threatened our water environment have been subjected to these regulations since the 1970s. It is essentially a command and control approach utilising effluent discharge standards. For pollution sources upstream of public water supply intakes, the effluent discharge standard was made much stricter than those downstream of such intakes.

In addition to making use of these laws to control pollution, additional legislation is also in place to effect prevention of pollution into a river or water body. A third mechanism involves a continuous assessment or monitoring of all the rivers in the country to ascertain the improvement or otherwise of our river water quality.

Prevention

The legislative approach in water quality management effected by the 1974 Environmental Quality Act makes use of Section 34A where a report on impact on the environment resulting from prescribed activities (EIA requirement) is mandatory. Among the prescribed activities or projects that can cause water pollution include airport, housing, industry, mining, petroleum, power generation, resort and recreational development, and waste treatment and disposal facilities.

For non-prescribed activities, site suitability evaluation would also be carried out so as to assess the capacity of the area to receive additional pollution load and the requirement for waste disposal.

The Environmental Quality (Sewage and Industrial Effluents) Regulations 1979 also require that written permission be obtained before the construction of any building or carrying out any work that may result in a new source of effluent or discharge.

Water Pollution Sources and Control

Malaysian rivers are degraded by both point and non-point sources of pollution. The major point sources of pollution are sewage treatment plants, agro-based industries, manufacturing industries, sullage or grey-water from commercial and residential premises, and pig farms. Non-point source (or diffuse) pollution is largely due to storm runoff after a downpour. Earthworks and land clearance activities contribute to siltation of rivers and can be both point and non-point sources of pollution.

<u>Agro-based industries</u>

The earlier post-independence years saw a proliferation of agro-based industries such as raw natural rubber factories and palm oil mills which polluted our rivers. The control of pollution from these sources involved a combination of both economic and command-control instruments which has proven to be very successful. These industries did not only invest in pollution control research and development but also made great efforts to comply as rapidly as possible with the stipulated effluent-discharge or land-disposal standards. They were induced to install effective wastewater treatment systems instead of paying the prohibitive

effluent-related or pollution fees imposed under the licensing requirements that came into force since 1977. The organic pollutant load dumped into rivers has been greatly reduced by more than 90 percent of the total load generated.

Manufacturing industries

A new set of environmental problems emerged as the nation progressed in its industrial development. In addition to organic pollutants, manufacturing industries generate inorganic pollutants, toxic wastes and persistent organic pollutants. All manufacturing industries are required to install wastewater treatment systems to arrest their water pollutants before being dumped into rivers. The achievement in controlling effluent discharges from these manufacturing industries varies from industry to industry. The small and medium scale industries have difficulties in complying with discharge standards. Constraints cited include financial problems and lack of space for the construction of wastewater treatment facilities.

The manufacturing industries are encouraged to implement alternative options such as cleaner production, waste minimisation and waste re-utilisation in order to reduce water pollution further. Such options could also enhance production efficiency, reduce waste generation and thereby its final disposal cost. They are also encouraged to adopt the approach of self-regulation and strive for ISO 14001 Certification not only to ensure compliance with discharge standards but also to attain competitiveness in the global arena.

Efforts are also being stepped up to eliminate indiscriminate disposal of toxic wastes and uncontrolled release of persistent organic pollutants. The management of toxic wastes is based on the cradle-to-grave concept. There are laws in place to control their generation, storage, transportation, treatment and disposal. An integrated state-of-the-art treatment and disposal facility has been set up and is in full operation since August 1998 to assist the manufacturing industries in the proper management of their toxic wastes.

Sewage Disposal and Sewerage Works

Sewage is a major polluter of our rivers. This is a problem of the past centuries that continues to plague the nation as it enter the 21st century. Initial efforts to control sewage are very much focused on protecting public health but there is now a gradual shift to protect water resources and the natural environment. A private company has been tasked to manage sewerage works and sewage disposal in the country since 1994 but currently it is only responsible for 86 out of 144 local authority areas. The management of sewerage in these 86 areas is far from holistic since there are sources that do not come under the private company such as private sewage treatment plants, individual septic tanks, sewage from primitive systems and discharges of raw sewage from squatters. There are still a lot of efforts required and measures needed to reduce the sewage pollutant loads so that river water quality can be improved.

Sullage (Grey-Water)

An important source of point pollution is sullage or grey-water which originates from residential and commercial premises but is often overlooked. The wastewaters can come from places such as kitchen sinks, bathrooms, washing machines, restaurants, wet markets and car washing centres. As rivers pass through urban areas and populated places the sullage will become a major contributor of water pollution. Usually a stream in an urban area does not have enough assimilative capacity to absorb pollutant loads and will contribute organic pollutants, ammoniacal nitrogen and nutrients to a river nearby. At present, sullage is not

treated and poses a problem to improving river water quality.

Pig Farming

Pig farming cannot continue to be a backyard industry if it is to flourish in the country. This industry has a high demand for water and discharges large quantities of wastewater into rivers with a high organic content. Designated pig farming areas are required not only to ensure a proper control of its wastewater discharges but also for disease control.

Non-Point Pollution and its Control

Non-point pollution is pollution that comes from many diffuse sources and is associated with rainfall moving over and through the ground. As it moves, the runoff picks up and carries away natural and man-made pollutants, and deposits them into lakes, rivers and even ground water. This runoff pollution can come from many different land uses over large areas and is far more difficult to control than pollution from point sources. One of the best ways to control this pollution is to implement best management practices.

There are at least three types of runoff pollution in the country. Firstly, agricultural runoff that carries pollutants that originate from activities such as pesticide spraying, fertilizing, planting, harvesting, feedlots, cropland, grazing, plowing and irrigation. The runoff will deposit manure, fertilisers, ammonia, pesticides, livestock waste, oil, toxins, soil and sediment. Good agricultural practices are required to manage these activities so that runoff pollutants are minimized.

Secondly, forestry runoff associated with activities such as timber harvesting, removal of streamside vegetation, road construction and use in forested areas, and mechanical preparation for tree planting Good forestry practices are required to minimize soil erosion and siltation, destabilisation of stream banks and disruption of river habitats.

Thirdly, urban runoff that will deposit many and high amount of pollutants into rivers and other water bodies. Some of the measures that can be implemented include installing storm water filter to treat drainage and runoff, construction of gross pollutant traps at appropriate places, maintaining vegetation as filters along contours, and constructing wetlands wherever feasible as a good revegetation practice to improve river water quality.

The control of non-point pollution is far from satisfactory but the problem is not unique to this country. Its control is also a major challenge in other parts of the world including the US and countries in Europe.

Erosion and Siltation Control

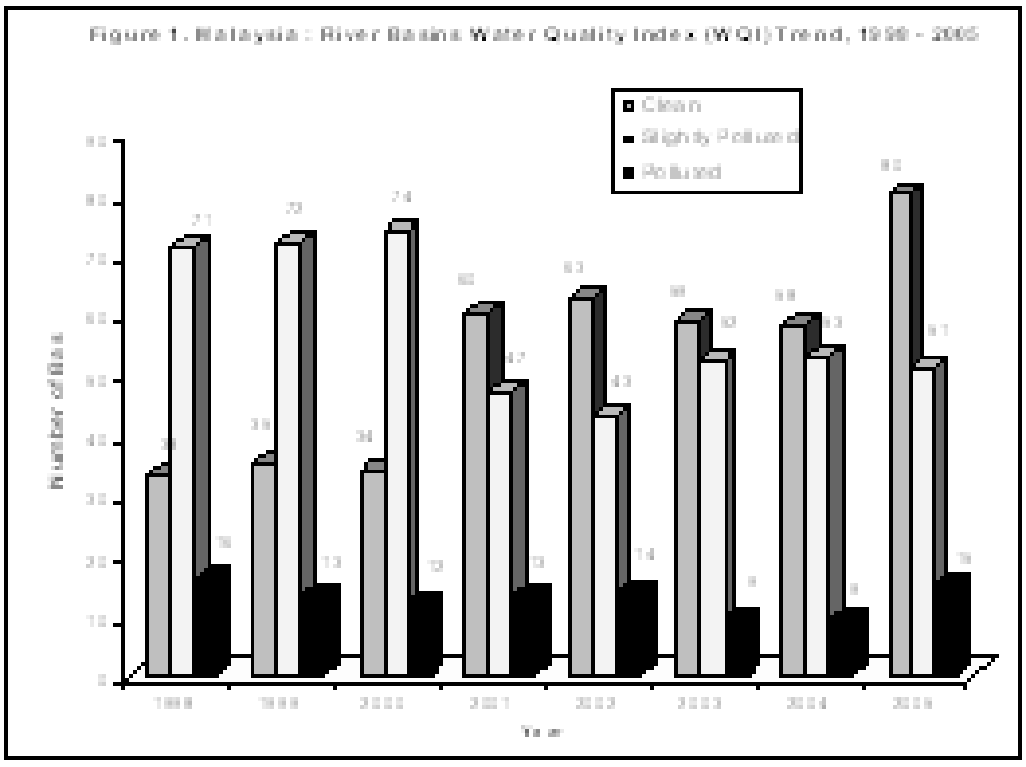
In the pursuit of national development, the country has embarked on rigorous land clearance activities and many earthworks for constructions purposes. These have resulted in soil erosion and the dumping of sediments into rivers. Significant negative impacts on the rivers are occurring not only in the form of siltation but also losses of river habitats. Control measures are necessary to be imposed on developers to comply with the "Erosion of Soil and Control Plan" made by the Drainage and Irrigation Department and also the "Guidelines for Prevention and Control of Soil Erosion and Siltation" issued by the Department of Environment (DOE).

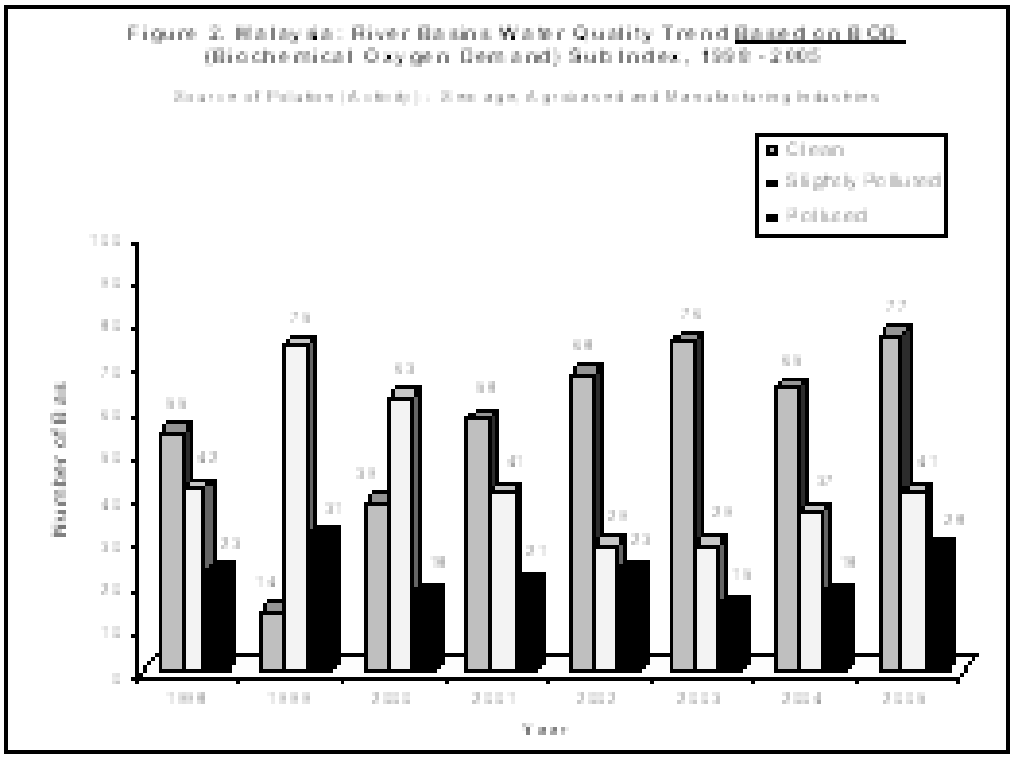
River quality monitoring

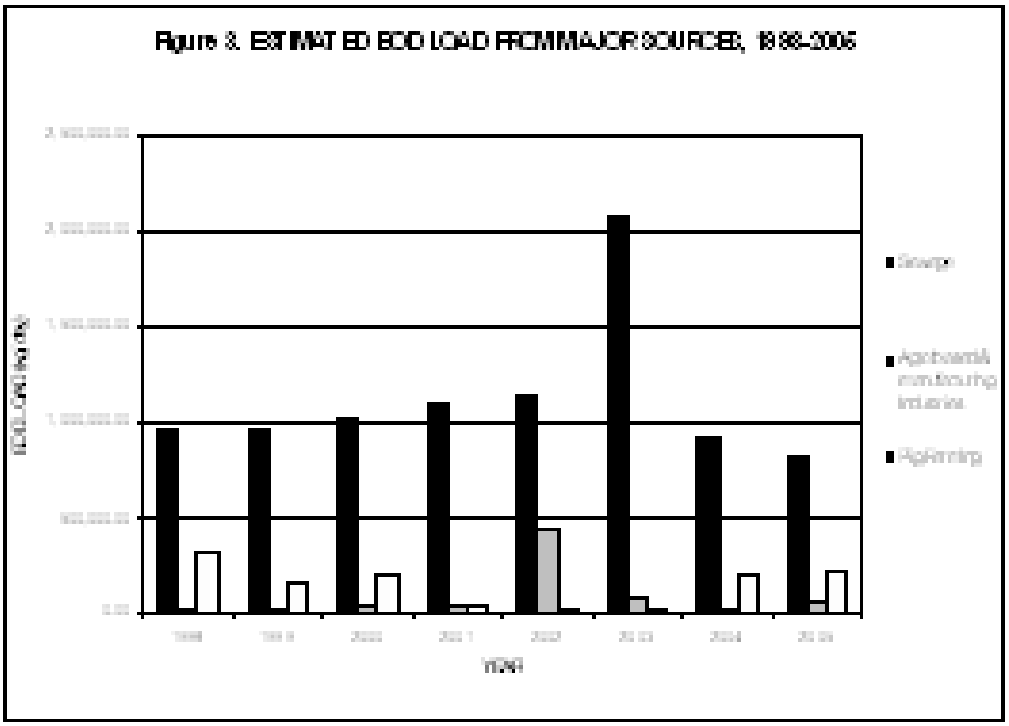
The DOE has established a river monitoring network since 1978 to establish the status of river

water quality, to detect changes in the water quality and wherever possible to identify pollution sources of rivers. It also serves to support environmental management and planning in the country. There are 1085 water quality monitoring stations sited within 140 river basins throughout the nation. The monitoring programme includes both the *in-situ* measurements and laboratory analyses of as many as 30 physico-chemical and biological parameters. In addition, 15 automatic water quality monitoring stations are installed to detect changes in river water quality on a continuous basis at strategic locations on major rivers basins. Water quality levels for specific parameters can be transmitted real-time to the DOE.

Between the years 1998 to 2005, the numbers of clean rivers have risen from 33 to 80 while polluted rivers remained between 9 and 15 (see Figure 1). Over the some period the number of polluted rivers, as measured in terms of biochemical oxygen demand (BOD, ranged between 14 and 31 rivers (see Figure 2). This organic pollutant originated from agro-based industries, manufacturing industries, sullage, pig farms and sewage. The estimated BOD loads from agro-based industries, manufacturing industries and pig farms were dwarfed by the BOD loads from sewage (see Figure 3). This suggests that while industries and pig farms are major polluters nevertheless sewage remains as a significant major polluter whose loading need to be reduced drastically.




Clean
Slightly Polluted
Polluted
Year


Sewage
Agro-based manufacturing industries
Agro-mining
Year

Challenges

In addition to challenges outlined earlier there are a number of other challenges that need to be given consideration. The uniform discharge standard is applicable throughout the country and does not take into account the assimilative capacity of a river or water body. For better protection, there is a need to develop river or stream standards and for effluent discharge standards to be set accordingly in order to comply with these river or stream standards.

A number of sources are not able to comply with existing discharge standards and there is a necessity to review these standards to be in line with current acceptable international standards and availabity of treatment technology.

Some State governments are requiring palm oil mills to comply with much stricter discharge standards than those imposed by the Federal Government.

Conclusions

The legislative approach in water quality management using the 1974 Environmental Quality Act has been successful in reducing pollution to a certain extent. It has involved pollution control, prevention of pollution and continuous assessment (monitoring) of the river environment. There are still many challenges that need to be addressed to achieve a holistic water quality management. Much of the past and present efforts are very much directed against controlling pollution from point sources while non-point pollution probably continued unabated. The necessary technical, institutional and legal arrangements are also necessary to treat sullage (grey-water) adequately before it is discharged into rivers. The nation will continue to use the water from its rivers for many years to come and it is imperative for the authorities to reduce pollutant loads and improve river water quality on a sustainable basis

Acknowledgements

The author would like to express his gratitude to Mohd Rosiskada, Noor Azme and Rosmiza for their assistance in the preparation of this paper. Views expressed are not necessarily those of the Department of Environment-

Urban River Rehabilitation:
A Case Study in Marikina City, Philippines

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Abstract
Urban rivers are vulnerable to different processes and activities that pollute and degrade the water ecosystem. Restoring their health poses a huge challenge to governments and other actors. This paper examines a 'success' case of a LGU-initiated river rehabilitation program in the Philippines in two sequential phases; the first phase which targeted physical restoration of the riverbanks and solid waste clean-up of the river (1992-1996) and the second whose main task is mitigating liquid discharges and improving river water quality (currently ongoing).

Despite noteworthy achievements at the local level, effectively addressing two no less difficult tasks of trans-boundary nature of the water quality problem and the integrated and adaptive management required for maintaining healthy rivers seems to lie beyond the overall capacity and mandate of the local government in a decentralized system of government in a developing country such as the Philippines.

Keywords: Urban River Rehabilitation, River Governance, Philippines

Introduction
Urban rivers are vulnerable to different urban processes and activities that cause pollution and degradation of the water ecosystem. Restoring the health of rivers poses a huge challenge to governments and other actors in the public domain. While the rehabilitation and/or restoration of urban rivers in developed countries offer measures and pathways to follow for developing countries, the differences in circumstances between the developed and developing countries including the various local conditions do not warrant simple replication and immediately transferable fixes.

Developed countries are able to effectively clean up their rivers backed up by adequate resources, strong public sector capacity and public institutions whereas developing countries struggle to rehabilitate theirs in the context of limited capacity and resource base and, often in the absence of appropriate public institutions, legal framework and strong regulatory enforcement capacity. This is particularly so in many local government units (World Bank, 2007). The Philippines is no exception. Decentralization resulting from the Philippine Local Government Code of 1991 had local governments grappling without the necessary power, authority, resources and training to manage a plethora of urban resources, facilities and activities (UNESCAP, 2006).

The Manila Times (2006) reports that water quality throughout the country has been deteriorating owing to high population growth, rapid urbanization and industrialization. As early as 1996, monitoring of the country's rivers showed that only 51% of the classified rivers still met the standards for their most beneficial use. The rest were already polluted from

domestic, industrial and agricultural sources (EMB, 2007). The major source of water pollution is domestic wastewater, accounting for 48% of the total pollution sources. While domestic wastewater is pinpointed to be the principal cause of organic pollution of water bodies, only 3% of investments in water supply and sanitation were going to sanitation and sewage treatment (EMB, 2007). More than 90% of sewage is not treated and disposed of in an environmentally sound manner. Residents rely on private solutions such as open drains and poorly constructed septic tanks to dispose of human and liquid wastes thereby polluting and degrading the surrounding urban areas and water bodies (Manila Times, 2006). It is no surprise that the Department of Environment and Natural Resources-Environmental Management Bureau (DENR-EMB) lists the rehabilitation of rivers as one of the key challenges faced by the country. The bureau initiated a *Sagip Ilog Program* (Save Rivers Program) and selected 19 priority rivers, including Marikina River for monitoring.

The River Rehabilitation Program

Marikina River is the town's main waterway and is a major tributary to Pasig River. It stretches from Rodriguez, Rizal to Pasig City. During its heyday, it was the picnic ground of the town folks who held *fiestas* in the vicinity of the river. But some four decades ago, the river was all filth and stench due to uncontrolled encroachment and indiscriminate disposal of both domestic and industrial wastes causing the deterioration of its water quality (Fernando, 1994). Borje *et.al*. (2004c) writes that the river merely served as a dumping area and no one ever dared to go near it.

The 'Save the Marikina River' Program was then conceptualized and implemented to revive by rehabilitation the Marikina River and its environs and, develop it as the city's biggest recreational and sports area. The program was implemented during the incumbency of former Mayor Bayani Fernando[1] (1992-2001) as stipulated in his Program of Government. The former Mayor even promoted a program's principle;

> *The people have to touch and smell the water. It is hoped that this experience and exposure will galvanize them to muster enough political pressure for the government and the rest to act and conserve the river* (Fernando 1994, p. 1).

The Mayor intended to showcase river rehabilitation not simply as one of those government programs on environmental preservation, but to communicate to his constituents that the local government is seriously working on such a program and that it is its business to entice them to clean up, follow what the laws say about sanitation, encroachment, among many others (Borje *et.al*., 2004c).

Marikina City started river rehabilitation work since the early part of 1993, without any completion date. After more than a decade of development, the landscape was transformed from being much polluted, flood-prone and adorned with informal settlements to one with free-flowing water, less flooded areas and with river park amenities such as an 11-km jogging/biking lane, skating rink (reportedly the biggest in the country), tree planting pockets, picnic and play grounds, sports amenities like baseball field and basketball court, a Youth Camp, a Chinese Pagoda, a Roman Garden, a gazebo, a riverboat, floating stages,

[1] Now Chairman of Metro Manila Development Authority (MMDA), Bayani Fernando served three consecutive terms (equivalent to nine years), as Mayor of Marikina

amphitheater and a Senior Citizens' Lifestyle Center (Borje *et.al*., 2004c). The task of rehabilitating was by no means simple. It involved relocating riverbank communities, addressing flooding problems and conducting dredging operations before the river had to be developed into a recreational park. These interrelated issues were dealt with strategically from the top while specific projects and activities were assigned to particular Departments and/or Offices within the city. The then Mayor oversaw the general plan and had the direct and final word on many aspects of it, a case illustrative of a top-down management style.
The events leading to the creation of the Marikina River Park generated mixed responses from the relocated communities, national government agencies and international organizations. Some of the informal settlers in the river were receptive while others were indignant. But more than a decade after the relocation, the affected communities are generally more satisfied with their present conditions having more secure lands and houses with improved access to infrastructure, community facilities and services. These present circumstances seem to 'justify' the non-consultative and compelling nature of the demolitions in the past.

The City's rehabilitation program received various citations and awards as well as further support for related supplementary projects. But even if the river had been cleaned of its squatter settlements, which were believed to be major sources of pollution in the past, water quality remains to be a big problem and domestic sources account for much of the pollution loading according to an article in Manila Water (2007) so then the city turns toward abating water pollution and improving the river's water quality via the introduction of Wastewater Treatment Plants (WTP). The latter project not only advocates for the construction of WTPs all over the city, but also calls for the appropriate construction of septic tanks in order to prevent groundwater contamination.

The Clean Water Act of 2004 provided, in part, the impetus for Marikina and Manila Water to coordinate efforts at treating wastewater, the latter being the agency mandated to provide water and wastewater services in the city. Further partnerships were also entered into by the city giving birth to the 'Clean Water, Clean River' project with USAID's ECO-Asia as the primary funding institution. These collaborations thereby created a different management structure for the city's water quality improvement project, now including the private sector and the donor agency, both of which have their own upheld organizational norms and principles. While Marikina may not be obligated to Manila Water, it is compelled to respect and follow the working principles of USAID, having signed a memorandum with it as the donor. This meant a compromise from the top-down, local government-centered planning and implementation of the first phase to a more collaborative approach on planning with the participation of stakeholders as espoused by the donor agency.

Interestingly, the policy instruments used by the local government have also been greatly influenced by its donor, with particular focus on information and education campaign or 'social marketing' in the second phase. These have not only informed people but have also involved representatives in the planning process at their respective level and area. A regulation on septage management is underway also but there is very little mention of incentives for treating wastewater. On the contrary, individuals who avail of the wastewater service may be asked to pay for the service thereby complicating the problem for a service that is new and an (environmental) aim which has been sought after by Marikina City alone.

Marikina River Rehabilitation vis-à-vis Comprehensive River Management

Marikina was successful in removing and relocating previous riverbank communities into in-city resettlement sites. It also provided those resettlement sites improved access to basic services, infrastructure and communal facilities such as basketball courts, playgrounds and community halls (MSO, 2007). The local government also boasts of an effective solid waste management system, with a garbage collection efficiency rate of 98% (WMO, 2007). The system had been established with the aim of preventing direct or indirect dumping of solid wastes on waterways. Another component which the local government was also able to address is the problem on flooding. The LGU improved the river being the city's principal drainage system through massive dredging operations and bank improvements. Flooding was reduced significantly from that which used to cover an area of about 27.52% (6.4 km^2) of the entire city in 1992 to 19.04% or 4.4km^2 in 2004 (Borje *et.al*., 2004a). Floodwaters also recede faster due to the decreased build up of sludge at the riverbed. Finally, the city developed the whole stretch of the river into a recreational park. Trees were planted on the banks to prevent erosion and communities field their own patrols to stop those who dump garbage (Gallego, 2004). Mini plazas were created and these provided venues for programs and games thereby bringing back a sense of community seldom seen in the harried world (Ramos, 1994). In fact, the World Bank and National Disaster Coordinating Council (2004) reports that the developments in Marikina River indirectly benefited the LGU in terms of higher property tax revenues resulting from a 10-fold rise in property values.

Despite these improvements, the river ecosystem particularly in terms of its water quality and the species that thrive in it are two major challenges which the local government is struggling with. Water quality remains to be worst than class D according to the Laguna Lake Development Authority (2005) and the river is suffering from Pterygoplichthys pardalis[2] infestation. Although these do not pose any direct threat to humans and other fishes, they multiply rapidly, eat voraciously, compete with other fish for food and further eat the eggs of other fish species thereby causing the latter's depletion. They also bore holes on the soft, muddy banks to create breeding nests, damaging the river's plant life and causing the river's sides to erode (ADB, 2006).

Furthermore, while the rehabilitation of Marikina River has been well-recognized by local, national as well as international organizations, the efforts remain confined and concentrated to Marikina alone. There is no steering committee, no legal and institutional framework in managing the entire river basin, over and above local administrative boundaries. As well, the fact that the river and its rehabilitation brought fame not only to the city but also to its leader may have affected other politicians who would like to build their own legacies and therefore choose to have different priorities and programs. In any case, the program was exclusively done by the city with very limited interaction and collaboration with those outside of the city's sphere of influence.

Although the exclusivity in the first phase offered ease of control for the LGU to direct its resources in solving its riverbank squatting issues, flooding as well as solid waste

[2] The rise of Pterygoplichthys pardalis, more commonly known as janitor fish posed greater problems not just in Marikina but also in neighboring Pasig River and Laguna Lake. This affected fishers who now report reduction of fish catch and loss of livelihoods and incomes. The DENR and other agencies are still experimenting ways to curb Pterygoplichthys pardalis infestation in these water bodies.

management problems, the second phase needed to address the trans-boundary nature of the water and therefore its vulnerability to pollution from different sources. Even with the passing and implementation of the Clean Water Act four years ago (2004), there is still no institutional framework or river basin plan established mainly for the management of Marikina River. Marikina City, *per se*, lacks the financial capability, technical expertise and appropriate technology as well as local knowledge and awareness on sanitation and the environment (ECO-Asia, 2006). The lack of funds compels the city to seek and maximize external sources of funding for its programs. It had since then partnered with Manila Water and USAID's ECO-Asia, the former for the provision of WTPs in strategic areas in the city while the latter for capacity-building, social marketing and a pilot project on decentralized WTP. The city resorts to incremental and decentralized approaches to wastewater treatment instead of the more expensive centralized WTPs. These approaches, in turn, require significant levels of community mobilization and stakeholder cooperation in the operation and maintenance of the systems.

Conclusion

River rehabilitation is a complex environmental management program so that its planning and management need to adapt to the change in circumstances. This is the challenge in the second phase, with river water quality improvement heavily dependent on community support and external donor provision due to the lack of public funds. The question on why the rehabilitation of Singapore River only took ten years to conclude its success can partly be answered by the availability of resources and the enhanced capability of the nation-state to address its problems (UNEP, 1997). On the other hand, developing country cities such as Marikina lack the necessary capacity in terms of expertise and funding required to fully undertake infrastructure projects so that it must rely on other means of ensuring sustainability, of balancing economic development with resource conservation and environmental resources management (UNESCAP, 2006). While developed countries have already looked into adaptive, integrative and river basin management frameworks that cross local administrative jurisdictions, urban rivers in developing countries have yet to establish institutional frameworks that effectively operate over and beyond the political boundaries of local governments. Marikina illustrates a local initiative that is neither shared by any other city nor municipality in the entire River Basin despite the fame of the river's transformation. Although the nature of the water quality problem in the river is trans-boundary, there was not and there is no river basin commission created to govern the river so that the efforts of Marikina are weighed down by continued pollution coming from elsewhere. Public participation in water resources management processes has also been limited and only very recently initiated by the local government, which according to Lorenzo (2007) is still bureaucratic.

The case proves the claim of the World Bank (2007) on the limited capacity of LGUs in governing environmental and natural resources. As posited by UNESCAP (2006), local governments need to be trained in managing urban resources, facilities and activities they are mandated and authorized to govern. Aside from this, it must be noted that while there had been widespread decentralization since the 1980's, nature does not follow political and administrative boundaries set by governments. As such, local initiatives will remain insufficient no matter how participatory and inclusive the planning had evolved to include communities and various stakeholders. Unless and until the entire resource is managed holistically, the problem on pollution and mismanagement remains. The Marikina River Rehabilitation Program indeed demonstrated how small initiatives can generate noteworthy

improvements and enthusiasm from various groups. At the same time, it also highlighted the limitations of these local initiatives in improving the overall condition of a publicly shared resource. Environmental management, water resources and river management, in particular, need to be integrative, adaptive and, more importantly, to cross political boundaries. These management modalities tend to go against the principles of decentralization with its (fragmented) management of resources based on territorial jurisdictions.

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Overcoming Pollution in Japan and the Lessons Learned

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Abstract
In the 1950s and 1960s, Japan experienced unprecedented environmental pollution and accompanying health damages, or so-called pollution diseases. The four major ones in Japan are Minamata Disease, Niigata-Minamata Disease, Itai-Itai Disease and Yokkaichi Asthma. Other Asian countries are now experiencing, or are going to experience, environmental degradation including pollution as their economies develop, but the distress caused by pollution in Japan should not be repeated by its neighbors. This paper describes the severe water pollution Japan experienced, how Japan overcame it, and the efforts being made by governments and enterprises to alert other countries not to make the same mistakes as Japan made.

Keywords: environmental pollution in Japan, pollution diseases, anti-pollution measures, conflict between prevention of pollution and economic growth, Clean Asia Initiative

Introduction
Pollution problems in Japan occurred as early as the Meiji era (in the late 19th century). The Ashio Copper Mine mineral poison case is recognized as the original pollution problem in Japan. The Ashio Copper Mine opened in 1610 and after its control was transferred to a man named Furukawa in 1877, the extraction of copper increased after the discovery of new veins and the modernization of production technology. It eventually grew into the largest copper mine in Japan. On the other hand, slag flowed into the Watarase River (especially during floods) from around 1890, destroying fish populations and causing damage to crops. The aggrieved farmers made petitions to the prefectural government, submitted written inquiries to the Diet, and resorted to other tactics. As a result, the Ashio Copper Mine mineral poison case was addressed by Japan's Diet in 1891. Even so, the company failed to take any substantial steps to prevent further pollution. It was not until 1974 that the Furukawa mining plant consented to pay ¥1.5 billion in compensation.

Severe pollution Japan has experienced

Background
In 1955, Japan's economy experienced unprecedented growth. In the late 1950s and early 1960s, 8.8 % and 9.3 % annual economic growth figures were attained respectively. Heavy industries and chemical industries grew at high rates due to increased investment in facilities and exports from the private sector, as well as active public investment. Heavy and chemical industries emitted more potential pollutants per unit than other enterprises in general. Processing in Japan of the products to be exported causes emissions of more pollutants in the

country than those commensurate to the end consumption of the products in the country. Also, investment for pollution control measures was less, in contrast to the high speed of growth. The enterprises' investment for anti-pollution was rather small, i.e. only 3% (about ¥30 billion) in 1965, which is the first year for which relevant data is available. This is one of the factors that caused severe industrial pollution in Japan.

Progression of water pollution

As the Japanese economy rapidly grew, water contamination became more serious at a high speed. The Sumida River, for example, had clean water in which many kinds of fish lived in the late 1940s through the 1950s. The river also served as a place of rest and recreation for people and provided a livelihood for fishermen. Since around 1955, however, the river it has become a sewage laden canal in which fish could not live any more and emitted a malodorous stench.

In those days, water pollution became serious mainly because of the effluents discharged from factories and business establishments. The effluents discharged by Honshu Paper Co.'s Edogawa plant without any pre-processing caused severe damage to the fishing industry in the Urayasu area in suburban Tokyo in 1958. The aggrieved fishermen entered into negotiations with the company and petitioned the relevant governmental agencies yet failed to attain any resolution. Later, an event occurred where about 700 fishermen broke into the factory and scuffled with police.

Severe damages from pollution

Minamata Disease, Niigata-Minamata Disease, Itai-Itai Disease, and Yokkaichi Asthma are called as the four major diseases caused by pollution in Japan. Yokkaichi Asthma is caused by air pollution, so it will not be referred to in the following pages.

(1) Minamata disease

Nippon Carbide Firm, one of the predecessors of Chisso Corporation, built its Minamata plant in 1908. Soon after, the plant began to discharge effluents into the sea nearby. In the early 1950s, massive fish populations were killed in the Minamata Bay while cats and pigs on land died in madness inducing disorders.

In 1956, a report was made to the Minamata Healthcare Center in Kumamoto Prefecture that a hospital took in a patient who was suffering from a brain disease whose cause was unknown. This was the first identified case of Minamata Disease. Minamata Disease is a toxic disease which affects the nervous system and is caused by methyl mercury. The Chisso Minamata plant was using non-organic mercury as a catalyst in the acetaldehyde manufacturing process. The catalyst generated a slight amount of methyl mercury which was discharged into the sea. It accumulated in fish through biological concentration. Heavy consumption of these fish caused Minamata Disease in humans.

Similar symptoms were discovered in patients near the Agano River in Niigata Prefecture in 1960. This disease was called Niigata-Minamata Disease. In this case, the cause of the disease was the methyl mercury disposed of by the Kanose plant of Showa Denko K.K. located upstream on the Agano River.

There were around 3,000 legally-certified victims of both Minamata and Niigata-Minamata Diseases in total and the damages (to the health of the victims due to contamination of bottom sediment, and to fisheries) are estimated to amount to ¥378.9 billion in total.

The Supreme Court decided that such diseases and damages were the responsibility of the national and Kumamoto Prefectural governments because they neglected to enforce regulation (Minamata Kansai lawsuit case, 2003). Today, five damage suits are pending (filed by about 1,500 plaintiffs) demanding the relief of about 20,000 victims.

(2) Itai-Itai Disease

Itai-Itai Disease is a pollution disease that frequently occured in the watershed of the Jintsugawa River in Toyama Prefecture. It became noticeable in the mid-1950s. The name "Itai-Itai" (Ouch! It hurts!) comes from the fact that patients of this disease suffer severe bone pain and always cry "Itai, itai!" It was found that this disease was caused by ingesting rice or water contaminated by cadmium over an extended period of time. Kamioka mining plant owned by Mitsui Mining & Smelting Co., Ltd. upstream on the Jintsugawa River had been discharging, without pre-processing, effluents containing cadmium after refining zinc, causing the contamination of water and soil.

The Law Concerning Pollution-Related Health Damage Compensation and Other Measures specified Itai-Itai Disease as one of the designated diseases to be awarded compensation for medical treatment expenses, etc., to certified patients. The legally-certified victims amount to 195, and they are still increasing as of 2008. The damages, including those to health and agriculture, are estimated to amount to ¥50.7 billion.

How pollution diseases were addressed

The conflict between fishermen and the paper plant over the fishery damages caused by effluents from the plant in 1958, as mentioned above, led to enactment of the Water Quality Control Low and the Factory Effluent Control Law, which are called the "former two water quality control laws") in the same year.

These laws ordered the national government to establish water quality standards for public waters designated by it and to impose regulation on factories' effluent.

However, these laws were enforced in such a way that further problems occurred. First problem is that the water area was designated after polluted. Second problem is that the laws had another purpose: to harmonize the health of citizens and preserve the living environment with industrial development, securing water quality to the point where the benefits of victimizing and victimized industries were in harmony. Accordingly, they were not sufficient from the point of view of pollution regulation.

As a result, degradation of quality in public waters became observed in other cities in various districts as industrial development even after the former two water quality laws were enacted.

Growing momentum of citizens' movements

Frequent occurrence of environmental problems attracted wide attention from common people, leading to citizen movements.

In 1960, there were widespread protest movements, including citizen rallies and signature campaigns against a petrochemical complex planned for the Numazu area of Mishima City, eventually forcing the plan to be cancelled in 1964.

Efforts in overcoming pollution

Conflict between prevention of pollution and economic growth

When promoting anti-pollution measures, it is important to solve the burden of costs required for mitigating/preventing pollution. In principle, such costs should be paid by the enterprises that generate contaminants. However, it was often stressed that the cost of anti-pollution facilities did not directly contribute to production and would also be a burden to industries. Therefore, anti-pollution measures were believed as a factor obstructing industrial development in Japan where small and medium-scale enterprises accounted for the majority of all enterprises. As a result, the Japan Pollution Control Corporation was established in 1965 as an agency specializing in aiding the cost for prevention of pollution.

Also in 1967, the Basic Law for Environmental Pollution Control was enacted under the concept that individual and first-aid-type regulations as intended under the former two water quality control laws were insufficient, and that it was important to declare the basic principles of anti-pollution measures and to promote such measures comprehensively and uniformly. The Law declared that the prevention of pollution was very important for securing the healthy and cultural life of citizens, establishing the "polluter-pays" principle and the environmental standards which served as administrative targets. The Law was superseded by the Basic Environment Law enacted in 1993, which took over almost all of the contents of the former Law.

"Pollution session of the Diet" and establishment of Environment Agency

The national government made active efforts in taking measures against pollution since the Basic Pollution Control Law was enacted. Given the fact that the sections in charge of taking the measures covered many ministries, the government established Pollution Control Office headed by the prime minister in July, 1970, to enforce the laws more powerfully. Under the leadership of the Office, new efforts were started in order to develop a legal system for pollution prevention.

In an extraordinary Diet session in 1970, pollution problems were front and center in response to the then public demand for anti-pollution measures and high public interest in the problems. This session of the Diet was called the "Pollution session of the Diet." The national government submitted fourteen bills, including an amendment to the Basic Pollution Control Law and the Water Pollution Control Law, all of which were approved and enacted by the Diet. Those bills featured: (1) Deletion of a clause providing for harmonization with the economy. This clause was deleted to cast aside the public's skepticism that the former laws might have put priority on the economic development over pollution control measures; (2) Introduction of national-wide regulations instead of regulations only in designated areas and also strengthening regulations by adding to the number of substances. This was applied to Air pollution and water pollution control; (3) Strengthening the power and authority to local governments. Substantially, all authority over business operators was delegated to local

municipalities, and the provisions for additional regulations were made to reinforce the authority of the local municipalities.

In addition, the Pollution Control Office was resolved developmentally, with the Environment Agency established in July, 1971.

New system of pollution control measures

The Water Pollution Control Law was enacted superseding the former two water quality laws, after they were reflected upon. The Law may be summarized briefly as follows: (1) The Law aimed to prevent contamination of public waters, thus protecting citizens' health and preserving their life environment, by regulating the effluents discharged by factories and business establishments into public waters; (2) The regulation covered the effluents discharged by the factories or business establishments having specific facilities, which might be specified not only in the manufacturing industries but also in any other industries; (3) The standards for effluent regulation covered all the public waters from the viewpoint of the prevention of water contamination in advance, and, if the standards were considered to be insufficient for any public waters, a prefecture might issue an ordinance adding stricter standards; (4) To ensure compliance with regulation, the Law provided requirements for the reporting of the installation, etc., of the specified facilities, the issuance of orders to change the plan reported, the issuance of orders to improve the waste water treatment processing method, and so on. In addition, the Law provided a direct penalty system in which any violation of the effluent standards would result in immediate punishment; (5) The Law provided that a governor of a prefecture could order a factory or business establishment to reduce the volume of effluents discharged into the public waters or to take other measures if contamination increased due to exceptional drought or other reasons; (6) The Law obligated the governors of prefectures to vigilantly monitor the levels of contamination in public waters and to make this information available to the public.

To enhance the anti-pollution system, the staff of municipalities in charge of pollution prevention were increased (from about 300 in 1961 to about 12,000 in 1975, (a 40 fold increase) and the budget for pollution prevention was also increased. (¥73.3 billion of the national budget in 1970 to ¥333.1 billion in 1975, that is about five fold increase). In 1972, 1,426 orders for improvement and 6,554 administrative directives were given to persons who violated the Law or regulations. But the direct penalty was imposed on only 13 violators, which was a rather small number. This shows that the administrative measures such as orders and directives, were adopted as final measures to enforce the anti-pollution regulations.

Efforts made by pollution generating enterprises

(1) Anti-pollution managerial system

Many of the factories obligated to comply with effluent regulations had no satisfactory system to prevent pollution. Accordingly, the Law Concerning the Improvement of Pollution Prevention Systems in Specific Factories was enacted in 1971, obligating those factories to establish a committee with experts in prevention of pollution.

(2) Pollution Control Agreement

These days, more and more enterprises, municipalities and citizens' organizations are entering into Pollution Control Agreements, which provide stricter regulation standards than the

government's, on-the-spot investigation, liability without fault, etc. The conclusion of such agreements is encouraged partly by the fact that an enterprise experiences difficulty in operating its factory without getting consent from the community as to location, and it can avoid unwanted protests by entering into such agreements.

(3) Increase in investment for anti-pollution measures

The enterprises' investment for anti-pollution measures increased substantially between 1967 and 1975 due to the long-term and low-interest fund that was made available by the Pollution Control Corporation or other related institutions, and that favorable tax policies were put into practice, including reduction of the fixed asset tax on anti-pollution facilities, reduction of the depreciation period, etc. (Table 1).

Table 1 Amount and ratio of investment for anti-pollution measures by the private sector (on an actual payment basis)

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Investment amount (in ¥100 million)	297	268	462	624	1067	1833	3057	3311	5147	9238
Investment ratio (in %)	3.1	2.9	3.5	3.7	5.0	5.8	7.6	8.6	10.6	15.7

	1975	1976	1977	1978	1979	1980
Investment amount (in ¥100 million)	11783	9368	6277	4171	2960	3169
Investment ratio (in %)	18.6	15.3	9.1	6.1	4.7	3.9

Among the investments in facilities made by enterprises, the revision of production processes and reuse of industrial water to reduce effluent, made radically substantial contributions to cleaner water, more so than the contribution made by improved effluent processing technology at the so-called "end of the pipe."

Both anti-pollution investment and the ratio have declined since 1976. The reasons may include the fact that the measures taken by enterprises to comply with anti-pollution regulations have advanced, reaching a plateau. This fact shows that anti-pollution investment is not necessarily required infinitely.

Environmental restoration

The Sumida River flowing through central Tokyo had 60 ppm of BOD at one time because of increased effluents from factories and houses as mentioned earlier. It was said that the recovery of the original state of the river before the contamination might be impossible. Yet today, the river has been returned to life and became the "Face of Tokyo" by means of the regulation on effluents from factories, improved sewage systems, dredging of bottom sediment, and the introduction of cleaning water. In other districts as well, water quality has been improved substantially, achieving environmental standards at high achievement rates with the exception of some lakes, swamps and closed sea waters.

Conclusion

One of the lessons Japan has learned is that the earlier the anti-pollution measures are taken, the better the result (Table 2). Once damages are incurred, they require costs for compensation, etc. Taking preventive measures is much more economical as shown in the table below.

Table 2 Comparison of damages from pollution and costs for anti-pollution measures

Pollution cases	Damages (yearly)	Cost of measures (yearly)
Minamata Disease	About ¥12.6 billion	About ¥100 million
Itai-Itai Disease	About ¥2.5 billion	About ¥600 million
Yokkaichi Asthma	About ¥1.3 billion * About ¥21 billion if assumed that no measures were taken with damages increased.	About ¥14.7 billion

* The yearly figures shown above were calculated by the actual amounts of damages and costs of measures equalized (redemption in 15 – 30 years assumed) in 1989 yen.

Today, Asian countries are achieving noticeable economical growth. It is desired that they may not go through the same experience as Japan has, but overcome the problem of environmental degradation, and take measures against global warming, a new issue as well. For that purpose, Japan has set up the "Clean Asia Initiative," and also will continue to promote the WEPA which is included in the initiative.

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Secretariat : Institute for Global Environmental Strategies (IGES)