Water Quality Monitoring and Water Quality Situation in Thailand

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Abstract
Based on geographical characteristics, Thailand can be divided into 25 river basins. From the monitoring programs of major rivers in 25 river basins, surface water quality varies widely in the different regions in Thailand. The results showed that about 19 % of sampling stations were good (Class2),35 % were fair(Class3),44 %were poor(Class4) and 2 % very poor(Class5) compared to the water quality standards. Highest contaminants were high fecal and total coliform bacteria (32 %), High solid (in term of turbidity and total solids,31%, total phosphorus 15%, dissolved oxygen depletion, DO(12 %),Ammonia-nitrogen (6%) and biochemical oxygen demand, BOD (2 %). There are two major sources of pollution; point and non-point sources of pollution. For the whole country, the main source of pollution comes from domestic wastewater. Wastewater pollution management mainly bases on command and control approach under the Enhancement and Conservation of National Environmental Quality Act, 1992. Under the act, the effluent standards from major point sources of pollution were established and enforced. Besides, ambient water quality was set up as a goal for water quality management based on various beneficial uses. Existing water environment policy is addressed under the National Economic and Social Development Plan for 2007-2011 and the National Environmental Quality Plan for 2007-2011 which aim at rehabilitation of water quality and increasing local and community participation. However, there is still lack of integration of water resources management. 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. The agencies on water environment and water quantity are different. Currently, basin management approach is being implemented in some river basins in the country such as Bang Pakong and Thachin River Basins in the central part of the country. This approach incorporates with water quality and quantity, aquatic resources and land development, also 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 and increasing in many river basins, such as Ping and Chaopraya rivers.

Keywords: water quality monitoring, basin management approach, Public Participation.

Introduction
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 366 station s in 49 river in the country. Water quality samples were taken 3- 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 . 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 . 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.

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 sewage work in Thailand is still under the stage of development for improvement of living standard and water pollution control in the public water bodies. According to the law, all buildings and houses should have a wastewater treatment system. The old houses and commercial building might use the septic tank. Modern houses and commercial building use the compact treatment tank, which is more convenient and of higher efficiency than the septic tank. Large buildings such as hotel, office building, and department store, should have their own wastewater treatment system, which such as biological treatment system. However there are illegal discharges such as untreated wastewater and sub- standard effluent from wastewater treatment systems that are operated improperly. There are a number of municipalities that have central wastewater treatment plant, operating as the publicly owned treatment works (POWTs).

Total Amount of Domestic Wastewater Generated

Wastewater is one of the most serious environmental problems in many industrialized and urbanized areas in Thailand. Approximately 14 millions m^3/day or 2.6 millions kg. of BOD/day of wastewater generated by the population around the country is discharged to receiving waters and the environment. This includes the 1,156 municipalities considerably generated approximately 2.5 millions m^3/day, Bangkok Metropolis and Pattaya city about 2.5 m^3/day and the areas of 6,624 Tambol Administration Organizations contributed about 9 millions m^3/day.

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 Thachin 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. Until now the Partnership Formulation were increasing on many parts of river basins, such as Ping river, Chao Pha Ya river and Banpakong river.

Conclusions and Recommendations

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.

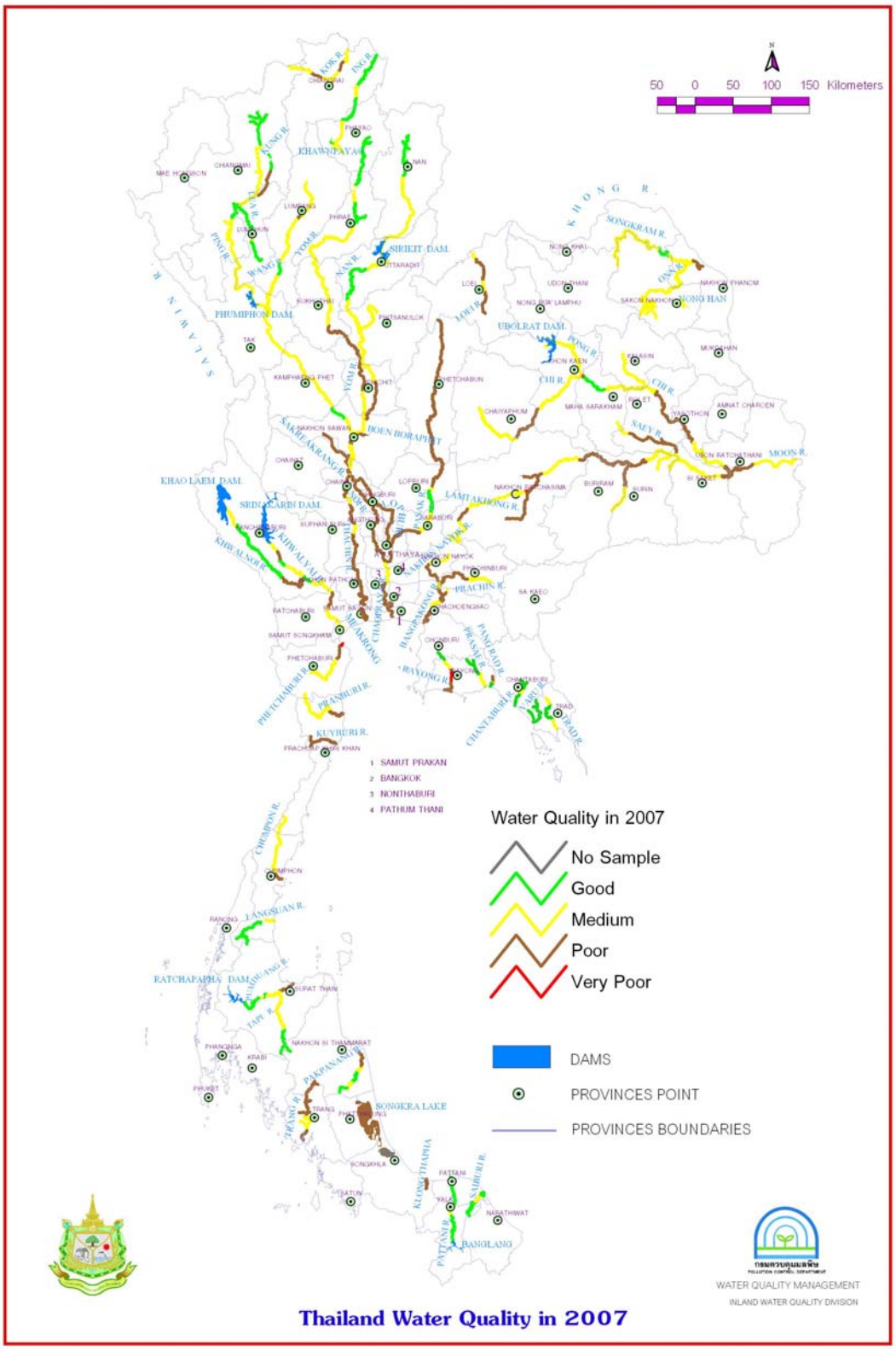
- Waste load allocation should be applied to management wastewater discharges from various sources of pollution. This depends on the assimilative capacity of the receiving water body and guidelines to attaining receiving water quality standards.

- 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.



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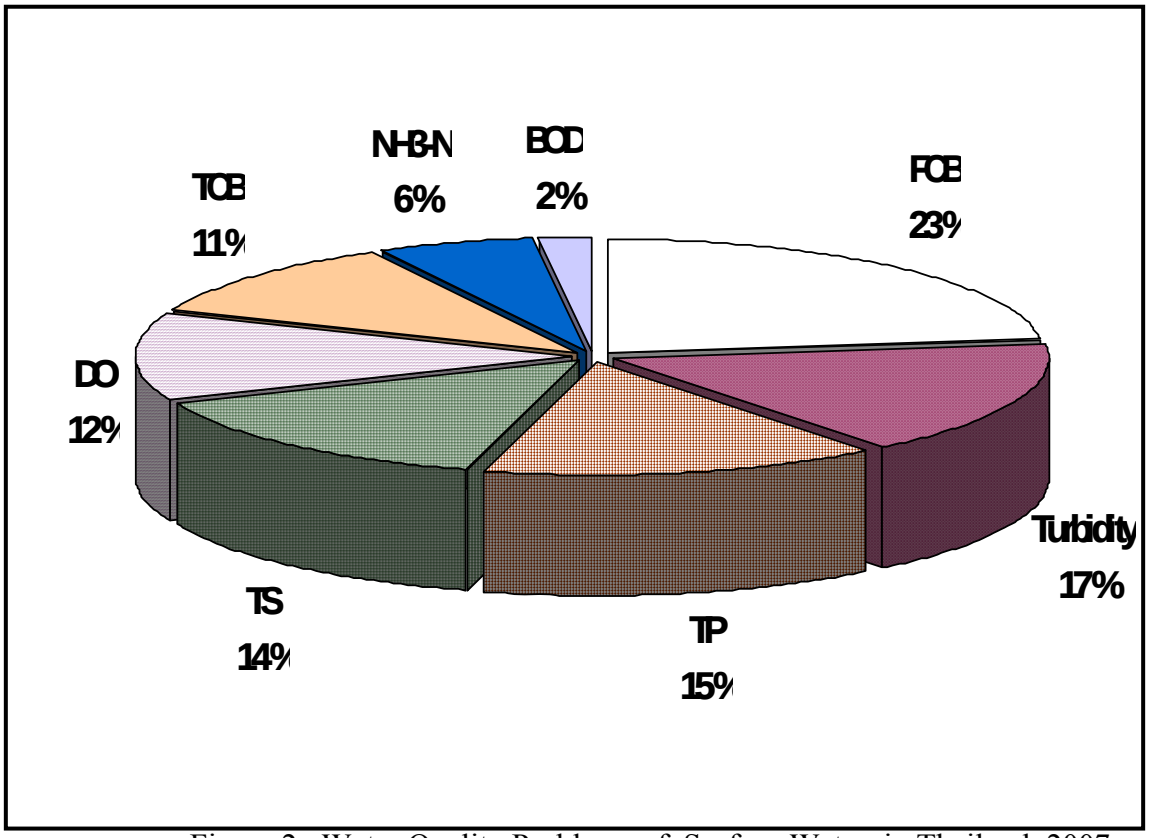

Figure 2 Water Quality Problems of Surface Water in Thailand, 2007

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			n	5000	20000	-	-
- Total Coliform	MPN/100	P80	n	1000	4000	-	-
- Faecal Coliform	ml	P80	n		5.0		
7. NO - N	”	Max.allowa	n		0.5		
8. NH -N	mg/l	nce	n		0.005		
9. Phenols	”	”	n		0.1		
10. Cu	”	”	n		0.1		
11. Ni	”	”	n		1.0		
12. Mn	”	”	n		1.0		
13. Zn	”	”	n		0.005*,0.05**		
14. Cd	”	”	n		0.05		
15. Cr (hexavalent)	”	”	n		0.05		
16. Pb	”	”	n		0.002		
17. Hg (total)	”	”	n		0.01		
18. As	”	”			0.005		
19. CN^-	”	”	n		0.1		
20. Radioactivity	”	”	n		1.0		
- Gross α		”	n		0.05		
- Gross β	Becqurel/l	”					
	”	”					

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)