

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 m³ 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	<u>Gasses</u> : DO <u>Dissolved salts</u> : Ca, Mg, Na, K, Cl, SO ₄ <u>Nutrients</u> : (NO ₂ & NO ₃), NH ₄ , PO ₄ , TP, SiO ₂ <u>Organic Matter</u> : COD _{Mn} , COD _{Cr} <u>Inorganic trace elements</u> : 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)	<i>Ad hoc</i> sampling (<i>Project specific or for special purpose</i>)	Parameters monitored are mainly related to industrial waste monitoring.
M. Energy and Mines	Surface water from Hydropower dams	<i>Ad hoc</i> sampling (<i>Project designed upon specific purpose such as hydropower dams</i>)	Parameters monitored are almost temperature, pH, EC, major ions, nutrients, DO, Si and COD.
M. Public Health	Rural water supply	<i>Ad hoc</i> 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	(<i>Ad hoc</i> testing)	Organic Compounds: Pentachlorobenzene, Hexachlorobenzene, 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.

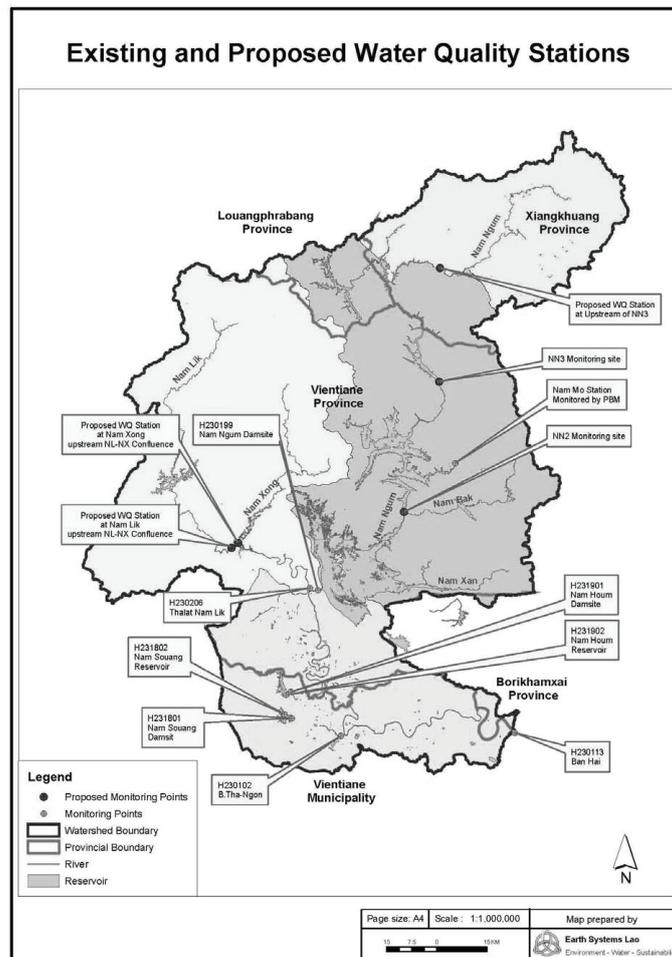
At the Mekong River Basin level, the Chiang Rai Agreement on Mekong River cooperation (1995) elaborates the international agreement to make every effort to avoid, minimize and mitigate harmful effects that might occur to the environment, especially the water quantity and quality, the aquatic (eco-system) 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 fourth 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 Ngom) 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 serious 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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