Water Quality Management in Thailand[*1]

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1. Introduction

The Kingdom of Thailand covers a land area of 513,115 square kilometers. The country extends 1,500 km from north to south and 800 km from east to west. The golden axe shape both the South China Sea and the Indian Ocean. Thailand is bordered by Malaysia in the south, the Union of Myanmar in the west and northwest, the Loa People's Democratic republic to the northeast, and Cambodia to the southwest. As reported in 1999, the estimated population was about 62 million with a growth rate of 0.32 percent. The urban population was approximately 12 million with high density in the capital and the regional centers.

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 Chao Phraya River, the lifeline of the Central Plain. The whole region lies above 200 m elevations. The Northeast occupies one-third of the country's total land area and is the most populous and lowest income region. The Northeast is a dry plateau at 100 to 200 m elevations. Large parts of this region regularly experience standing with periods of floods and alternating with periods of drought. Saline soils are also the major problem of this region. As a result, the productivity of the land is generally low.

Based on geographical characteristics, Thailand can be divided into 25 river basins. The average of annual rainfall for the country is about 1,700 mm. The total annual rainfall of all river basins is about 800,000 million m^3 of which 75 % of the amount is lost through evaporation, evatranspiration and the remaining 25 % (200,000 million m^3) is in streams, rivers, and reservoirs (see Appendix A). Thus, the available water quantity was about 3,300 m^3/ capita/year (Office of National Water Resources Committee, 2000).

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

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2. Nation Development Priorities and Plans

2.1 National Water Vision

The national water vision of Thailand was established in 1999. The vision statement is shown below.

> "By the year 2025, Thailand will have sufficient water of good quality for all users through an efficient management, organizational and legal system that would ensure equitable and sustainable utilization of its water resources with due consideration on the quality of life and the participation of all stakeholders"

2.2 National Economic and Social Development Plans

During 1961 to 1966, the First National Economic Development Plan was applied to Thailand as a major plan for development especially agricultural and manufacturing sectors. Currently, the Eighth National Economic and Social Development Plan has been using between 1997 and 2001. The main strategy of the plan is to establish systematic management of water resources at the basin level including the provision of clean drinking water and supervision of water quality, pollution control and drainage systems. Plans and guidelines addressed in the strategy of the plan are included:

- Organizing supervisory and coordination mechanisms for the development of water resources at both national and river basin levels,
- Setting up appropriate system for water allocation with the participation of all stakeholders,
- Applying fees for raw water intake especially for domestic consumption and industrial production,
- Improving the transmission and allocation systems for irrigation and consumption in communities,
- Promoting the cooperation among government agencies, private organizations, local communities, and individuals for environmental conservation by preventing generation of pollution at sources, and
- Conducting public information campaigns to promote the effective use of water, encourage the utilization of water-saving devices and the re-use of cooling water and treated wastewater.

2.3 Water Quality Management Plans

A detailed implementation or action plan does not yet exist in the National Plan. In order to bring the environmental strategies in the plan into action, the related agencies have to use the National Plan as a framework for formulation of programs, projects and measures. Policies of water quality management were set up by the Pollution Control Department (1997) including:

- Rehabilitating water quality in major receiving waters in the country

- Reducing and controlling wastewater discharges from community, industry and agriculture
- Applying the rule of "Polluter Pay Principle" or "PPP" as a tool for pollution control
- Promoting and supporting the participation of private sector in wastewater controls and management

Plans for water quality management to support the policies were set based upon the National Economic Development Plan are as follows:

1. By the end of the Eighth National Economic Development Plan (2001)
    - Lower Chao Phraya River should have dissolved oxygen (DO) to be not less than 2 mg/L and the connecting canals have DO to be not less than 1 mg/L
    - Lower Tha Chin River has DO to be not less than 1 mg/L
    - Rivers in the region centers follow the Surface Water Quality Standards
    - Coastal waters in important tourist spots and in the Gulf of Thailand are beyond the Coastal Water Quality Standards
2. By the end of Ninth National Economic Development Plan (2006)
    - Lower Chao Phraya River has dissolved oxygen (DO) to be not less than 4 mg/L and the connecting canals have DO to be not less than 2 mg/L
    - Lower Tha Chin River has DO to be not less than 2 mg/L
    - Water quality of other receiving waters in the country follows the Surface Water Quality Standards
    - All coastal water quality in the country is beyond the Coastal Water Quality Standards

3. Potential Impact of Water Quality Management

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 water quality problems are organic wastes, bacteria, nutrient, heavy metals, pesticides, and other chemical substances. 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. The measured river quality have been lower than the Surface Water Quality Standard and Classification. The major water quality problems were high coliform bacteria (36 %), low dissolved oxygen (DO, 34 %), high organic matter (in term of biochemical oxygen demand (BOD) (18 %), and nutrients (12 %) as shown in Figure 1 and 2 (Simachaya and Noikeang, 2000). Generally speaking, these problems were perceived to be most serious during summer low flow periods when there is minimal dilution capability available. 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 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. Priority to construct wastewater treatment facilities in municipalities was principally recommended as well as controlling 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 (Simachaya, 1999).

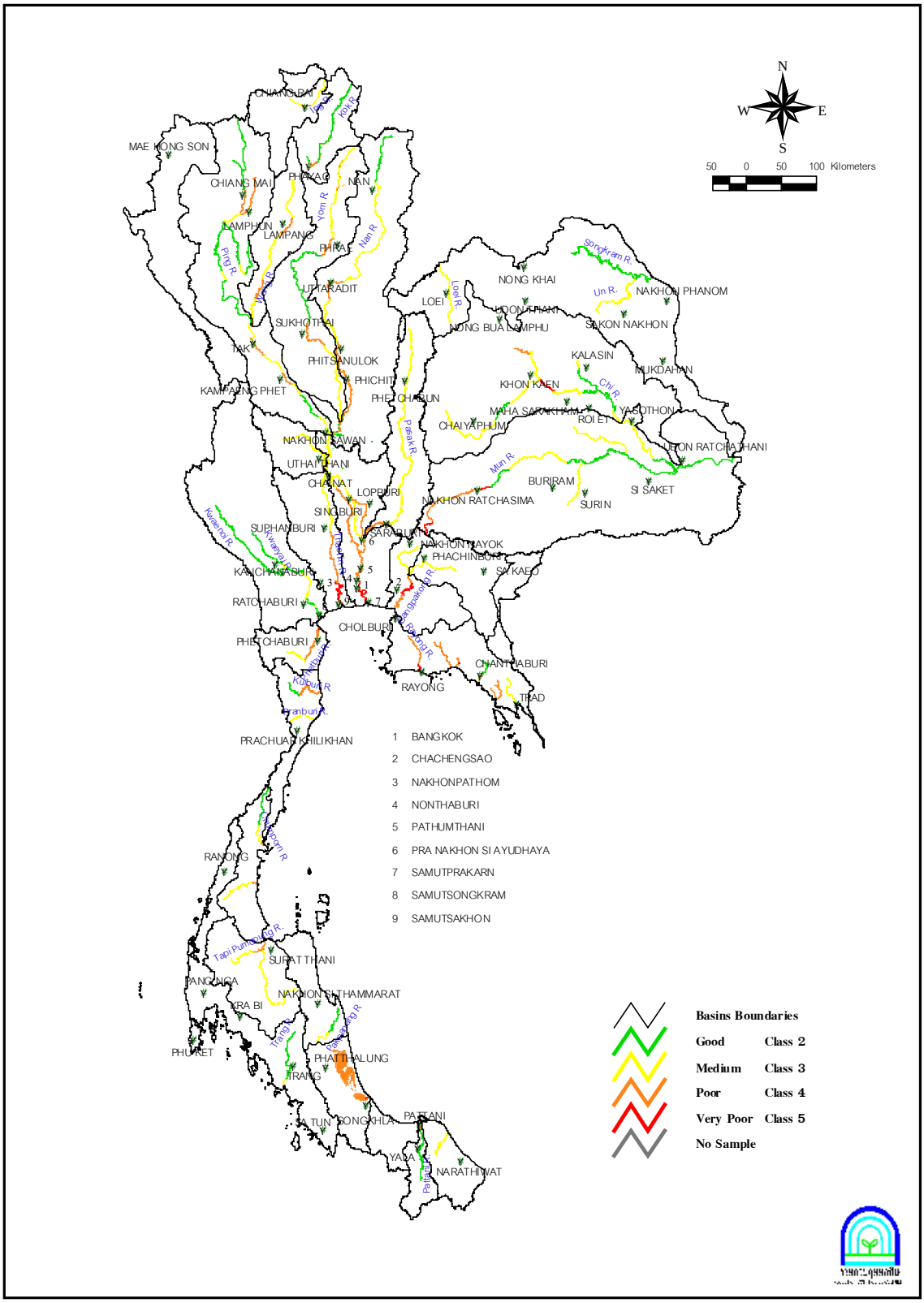
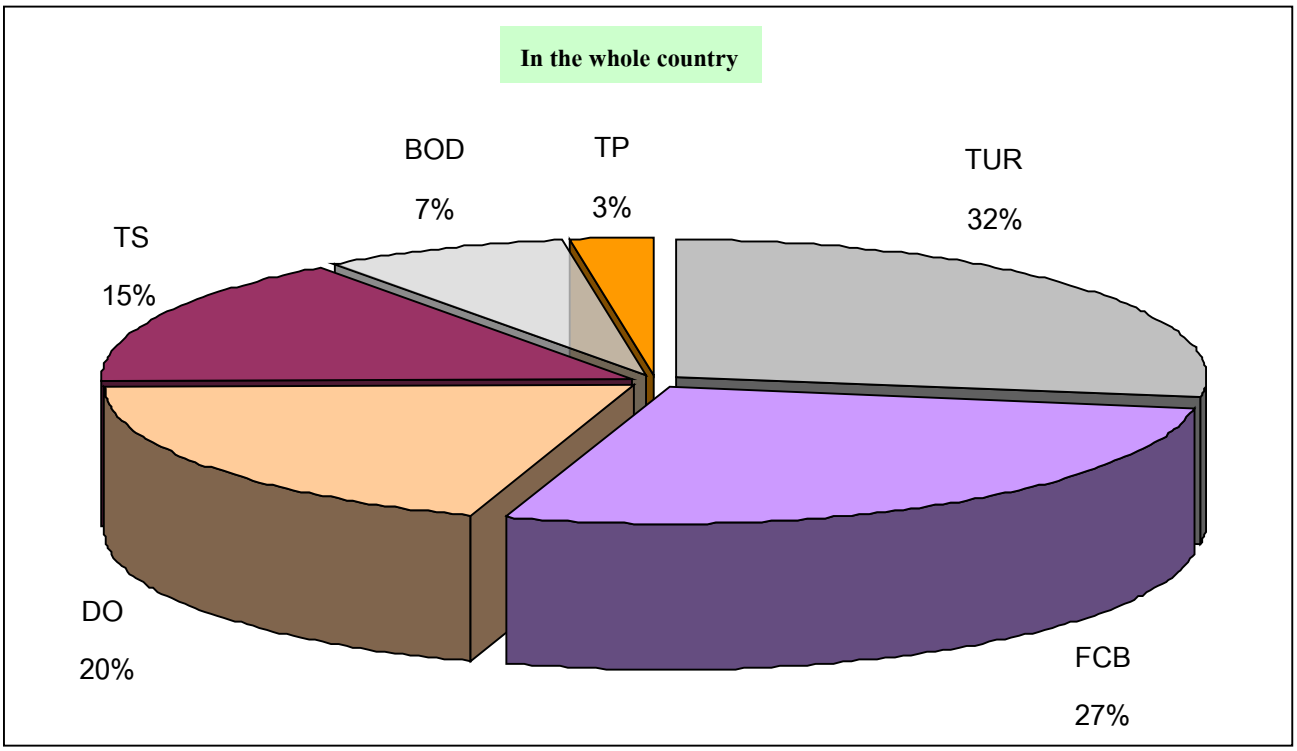
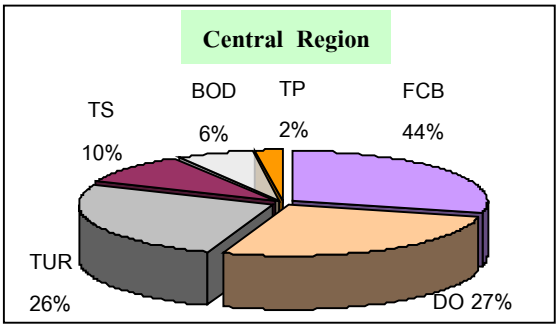
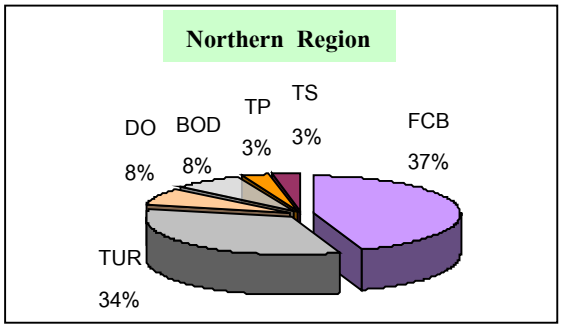
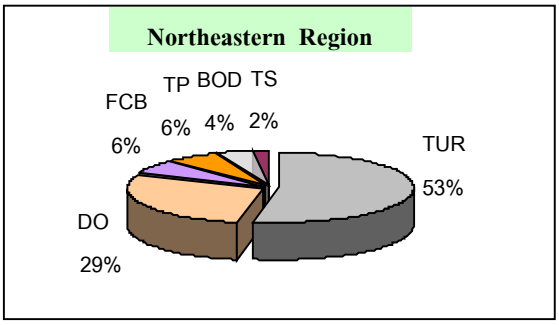


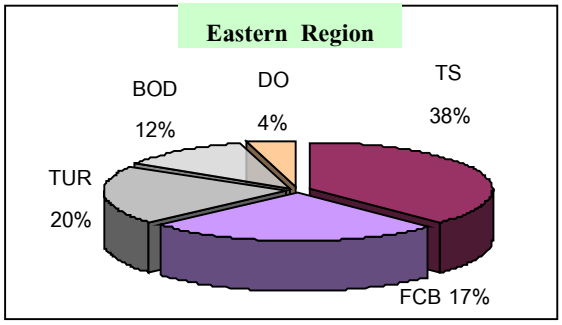
Figure 1 State of Receiving Water Quality in Thailand in 1999

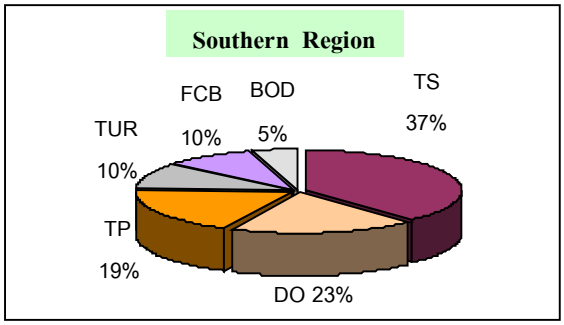












FCB = Fecal Coliform Bacteria

TUR = Turbidity

DO = Dissolved Oxygen

TS = Total Solids

TP = Total Phosphorus

BOD = Biochemical Oxygen Demand

Fig. 2 Surface Water Quality Identification In Thailand, 1999

4. Water Quality Management

Water pollution control programs undertaken by the Thai government are consist of the following components:

4.1 Wastewater treatment and disposal

The Government of Thailand has made significant progress in collection and treatment of urban wastewater over the past decade. However, only small portion of total urban wastewater generated in Thailand is treated. Twenty-nine urban wastewater collection and treatment plants have been constructed in 24 municipalities. However, the facilities can serve only 400,000 m^3/day or about 2.3 million (approximately 10 %) of urban population. Over 40 treatment plants are currently under construction. Major wastewater treatment systems are stabilization ponds, aerated lagoons, oxidation ditches, and activated sludge process. However, most of the operating treatment facilities are in significant levels of treatment efficiency, while two of them are currently out of service.

Previously, the wastewater treatment facilities have been funded by the government budget. There were limited factors for consideration of the wastewater treatment facilities at that time such as the land availability, population size in the areas, available technology in developed countries, and location of the municipalities. The assimilative capability of receiving waters has long been ignored. Thus, complicated and comprehensive treatment facilities were selected to be implemented. After construction is finished, the treatment facilities are transferred to be incharged by the local government. The budget of operation and maintenance of the facilities have to be under the budget of the local government. The mayors and staff of the most municipal administrators are positioned from democratic election. Collection and treatment of wastewater fees seem not to be possible as it might affect their vote for the future. Thus, the wastewater charges have long been hardly implemented because most of people in the urban cities are not willing to pay for the charges.

Although, the government's achievements in addressing urban wastewater management for the country are praiseworthy, there are many problems behind that such as wastewater charge, operation and maintenance, efficient technical staff, and non-functioning equipment. The main problems have been identified as the poor performance in operating and maintaining of wastewater facilities. The cause of inefficient operation and maintenance are mainly from fund shortage and suitably qualified staff resulting from lack of cost recovery. Only two locations as tourism spot areas (Pattaya and Patong) of the 24 municipalities have been implemented and the wastewater fee has recently been applied for business areas with limited amount.

Due to the economic crisis in Thailand since 1997, implementing wastewater treatment facilities have been reduced. About 130 wastewater projects have been set up in the national plan for 1999, but only 40 wastewater projects could be implemented. In the early stage, capital investments of wastewater facilities were funded entirely by the government grants. The Polluter Pay Principal (PPP) has been trying to be applied in Thailand since the new environmental regulation was enacted in 1992. Since then polluters pay only little or none for discharging wastewater into public sewer and treatment systems.

Additionally, new regulations have indicated the transferring of authorization of wastewater treatment task from central government to local governments. The local governments usually play only a limited role in planning and funding of capital investments as lack of efficient staff to handle wastewater management systems. The local institutional and financial systems in environmental management are currently of little consideration. Local staffs have been received very little training on operation and maintenance for the treatment systems. Laboratories for wastewater analysis in control center of each treatment plant, for example, have not been used. The budgets of local governments are not adequate for routine operation and maintenance of treatment plants and most of the budgets have been proposed for other infrastructures such as roads, buildings, and market centers. Public participation is being strong against waste management projects in Thailand. The public is generally received effective communication concerning the risk from waste discharges. Thus, many projects have been delay due to the lack of enough information and ignorance of the steps of public involvement.

4.2 Waste minimization

Waste minimization is the process to identify various techniques at the pollution sources. This method is included waste recycle and reuse. Some areas have been applied treated wastewater to land application and agricultural fields. Some factories have used treated water in the cooling system. However, there is recently no enforcement of this aspect. Only campaign and reinforcement are practicing.

4.3 Cleaner production

The term of “cleaner production” encompasses all phase of production process and product life cycle (Aziz, 1996). The Royal Thai Government by the Ministry of Science, Technology and Environment is now developing 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 protection, reduction, and control of pollution, national resources and environmental management, quality of life with benefits from the country’s development”.

4.4 Legal framework

In the year 1992 Thailand has its environmental law called “The Enhancement and Conservation of National Environmental Quality Act". Wastewater management before the time of the 1992 Act was mainly under responsibility of two departments: the Industrial Works Department, Ministry of Industry and the Public Works Department, Ministry of Interior. After 1992, the Pollution Control Department (PCD) and the Office of Environmental Policy and Planning (OEPP) under the Ministry of Science Technology and Environment (MOSTE) have started to be involved in wastewater management by undertaking national and regional water quality management planning and facilitating local authorities for their responsibilities of their own wastewater management. Thailand has adopted a “command and control approach”, based on European and American pollution control model with the establishment of effluent standards and their subsequently enforcement.

In order to control and manage water quality problem in Thailand, the regulations can be grouped into three categories as follows:

- The application on environmental impact assessment (EIA) for determination the impact and mitigation plan for development projects with various types and sizes such as dam with storage volume of 100 million cubic meters or more, irrigation project of 12,800 hectares or more, hotel or resort with 80 rooms or more, thermal power plant with capacity of 10 MW or more, all size of mining, etc.
- The establishment and application of effluent standards such as industrial effluent standards, domestic effluent standards, effluent standards for pig farms and fish/shrimp farms etc.
- The ambient water quality standard and classification based on water quality situation, socio-economic aspects, and availability of treatment technologies

The ambient water quality standards has been established since 1994 and served as guidelines of supposing the receiving waters based on major beneficial uses (see Appendix B).

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 [for example, 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 [for example, 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 [for example, DO > 2 mg/L, BOD < 4 mg/L)

Class 5: Waters are not classification in class 1-4 which is no water quality requirement and used for navigation

4.5 Institutional and financial arrangement

Environmental fund was established by collecting from various sources: Fuel Oil Fund, Revolving Fund for Environmental Development and Quality of Life, service fees and penalties collected by virtue of the Enhancement and Environmental Quality Promotion Act, 1992, grants from the government, donation, and others. The Fund can be used to control water quality problem under the following strategies:

- Grants to government agency or local administration for investment in and operation on the central treatment plant
- Loans to local government or state enterprise for making available of wastewater treatment facilities
- Aids or grants to support any activity concerning the promotion and conservation of environmental quality

4.6 Monitoring and enforcement

Water quality monitoring program plays an important role in water resource management. Water quality monitoring consists of data and sample analysis performed by using acceptable protocols. Monitoring includes analysis of data to support decision-

makers. Under new environmental regulation (the Enhancement and Conservation of National Environmental Quality Act, 1992), there are two types of monitoring programs: effluent and receiving water quality monitoring. The owner or possessor of point sources of pollution is required for the collection of statistics and data, the making notes and reports of the effluent monitoring program. The monitoring of receiving water quality is done by the government agencies to maintain the quality of waters and to produce the state of annual water quality report for the country.

4.7 Cooperation with related agencies and local communities

Cooperation is an important and practicable approach for water quality management because pollution problems are usually related to a number of agencies and local communities. The Pollution Control Department has cooperated with related agencies to solve specific problems such as the establishment of working group to monitor wastewater discharges from pollution sources.

4.8 River Basin Management Approach

New directions for urban water quality management are being considered based upon assimilative capacity of receiving waters, budget availability, and prioritized projects within basin-wide approach. The most flexible means of water quality management are being practiced such as simulation models, geographic information systems, and database management systems. Waste loads allocation is being considered depending on assimilative capacity of water body and guidelines to attain receiving water quality standards. Thus, river basin management approach is being practices such as in the Thachin River Basin. The details can be found at the Web Site http://welcome.to/thachin.

5. Recommendations

In Thailand, new directions for wastewater controls are being considered based upon assimilative capacity of receiving waters, budget availability, and prioritized projects within basin-wide approach. Simple wastewater system based on natural conditions are also being addressed such as wet land applications, stabilization ponds, and crop irrigation systems. Treated wastewater reuse and recycle will be applied especially in arid and seasonally arid areas. The flexible means of wastewater management are being practiced such as simulation models, geographic information systems, and database management systems. Waste loads allocation is being considered depending on assimilative capacity of water body and guidelines to attain receiving water quality standards, while the effluent standards of major point sources have been established and implemented since 1995. Optionally, the Government of Thailand has policy to aim at increasing the role of private sector in wastewater management as well as public involvement and participation on water quality monitoring programs. Best management practices (BMPs) should be considered as a tool for water quality management especially for non-point source pollution controls.

6. Conclusions

Currently, surface water quality in most part of Thailand can be considered as fair conditions, while some rivers flowing in large communities are adversely impacted. 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 affects aquatic resources, water uses for various proposes as well as human health. Monitoring program of the river water quality indicated deteriorated water quality in the lower parts of the major rivers (Chao Phraya and Tha Chin rivers). Discharges from the urban wastewater have been the major pollution source. Most rivers flowing through the urban areas contained high organic contamination and high coliform bacteria.

Enforcement of related regulations has to be seriously practiced. To management water quality in the whole watershed, integrated approaches should be taken into account in future such as ecosystem approach which considers both point and non-point source pollution. Sustainable development should be also considered.

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Appendices

A. Watershed Areas and Annual Runoff of the Major River Basin in Thailand

Basin No	River Basin Name	Watershed area [sq.km.]	Annual run-off [million m^3.]
1	Part of Salawin	17,920.19	8,156
2	Part of Mekong	57,422.07	15,800
3	Kok	7,895.38	5,119
4	Chi	49,476.58	8,035
5	Mun	69,700.44	21,767
6	Ping	33,891.71	6,686
7	Wang	10,790.74	1,429
8	Yom	23,615.59	1,430
9	Nan	34,330.16	9,518
10	Lower Chao Phraya	20,125.25	4,925
11	Sakae Krang	5,191.43	519
12	Pasak	16,292.24	2,708
13	Tha Chin	13,681.24	2,815
14	Mae Klong	30,863.76	12,943
15	Prachinburi	10,481.32	4,502
16	Bang Pakong	7,978.15	4,900
17	Part of Tonle Sap	4,149.97	1,193
18	East Coast Gulf	13,829.72	25,960
19	Phetchaburi	5,602.91	1,140
20	West Coast-Gulf	6,745.33	1,013
21	Peninsular-East Coast	26,352.78	35,624
22	Tapi	12,224.53	17,380
23	Thale Sap Songkhla	8,494.97	7,301
24	Pattani	3,857.82	3,024
25	Peninsular-West Coast	21,172.25	9,918
	Total	**512,065.81**	**214,128**

Sources: Office of the national Water Resources Committee (2000)

B. The 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/100ml	P80	n	1000	4000	-	-
- Faecal Coliform	"	P80	n		5.0		
7. NO - N	mg/l	Max.allowance	n		0.5		
8. NH -N	"	"	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	Becqurel/l	"	n		0.05		
- Gross β	"	"					

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. 2538 (1985.)), published in the Royal Goverment Gazette, vol. 103, No.60, dated April 15, B.E. 2529 (1986)