

Water Quality Monitoring and Modeling Application in Thailand[⊕]

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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,

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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 489 stations, which 392 stations were from surface sources and 97 stations were form groundwater sources in 25 river basins in the country. Water quality samples were taken 4 times a year for surface water and 2 times a year for ground water 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 14 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, DO, COD, conductivity, salinity, total phosphorus, and ammonia nitrogen.

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 (NH₃-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.

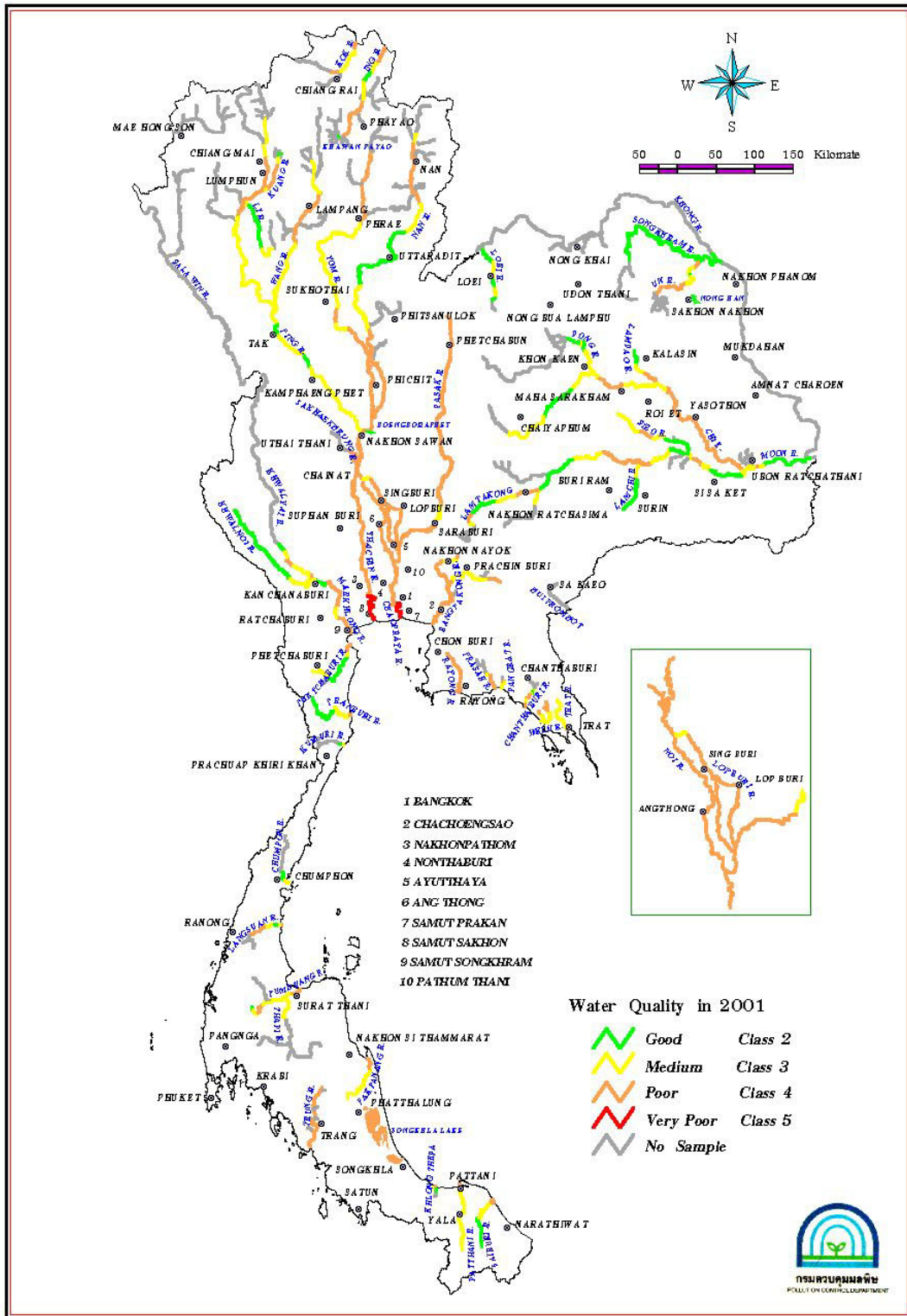


Figure I. Thailand Surface Water Quality In 2001

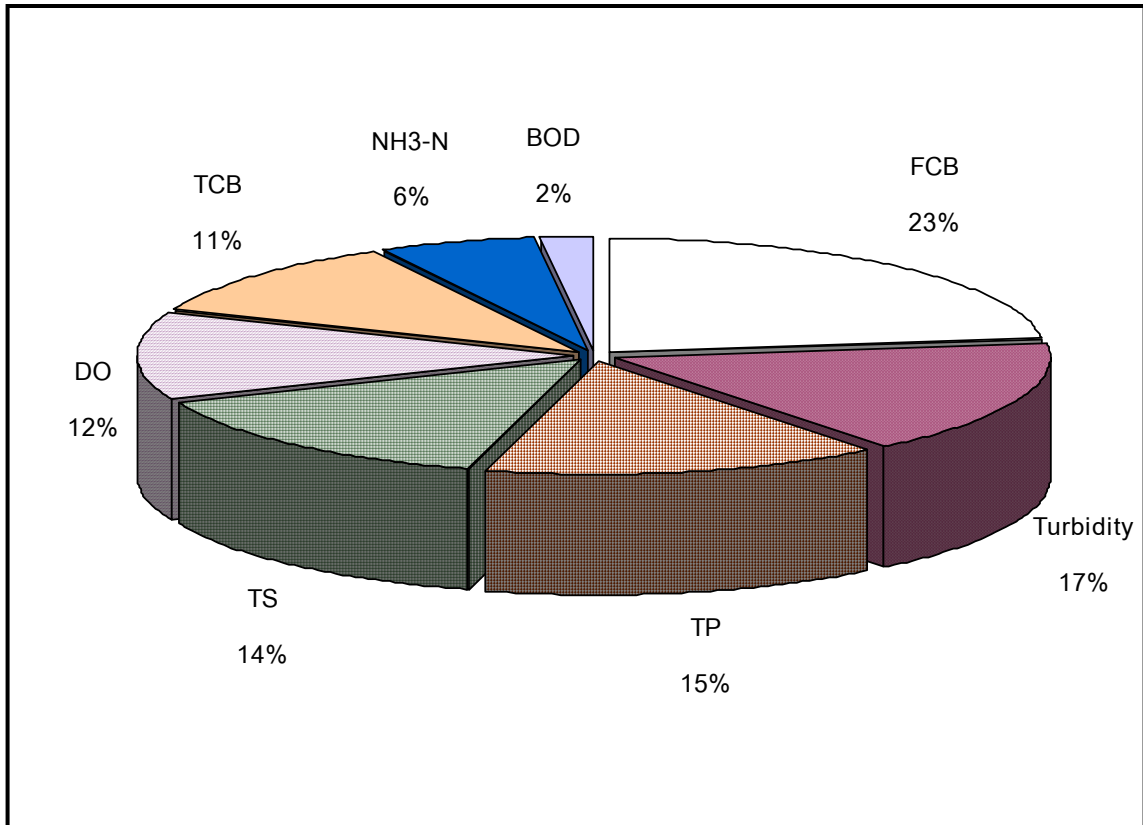


Figure 2 Water Quality Problems of Thai Surface Water Quality in 2001

Water Quality Modeling

In recent years, water quality models have become an important part of most water quality management and planning process. The need to understand cause/effect relationship in water pollution, and the desire to develop a tool that can aid decision-makers in selecting management procedures or technologies, are two important reasons for water quality model application. Thus, water quality models can be power tools when used to determine acceptable contaminant levels or when testing the alternative strategies for water quality management.

PCD has applied water quality models as a tool for water quality management since 1992. After problem identification, water quality model is selected. The major rivers

in the central basin of Thailand were the first priority area of modeling application due to high level of water pollution. Organic matters (DO, BOD), nutrients (nitrogen, phosphorus), and coliform bacteria were selected due to proven problems with existing water quality, such as fish kills, frequent low DO during dry season and high bacteria contamination. These water-quality problems have already been taken into consideration by people in the basin.

In practical, water quality was modeled under critical conditions (worst case) to estimate the potential effects of different loading projection in various years. Critical conditions are the most serious problem for receiving waters because they represent the combined influenced of several adverse effects (e.g. low river-flow, decreasing the dilution factor of receiving waters, couple with increasing pollutant loading). The linkage model between water quality models and Geographic Information Systems (GISs) is in developing process. In addition, PCD has set up the Centre for Environmental Modeling and Risk Assessment (CEMRA) since 2001 as a national body to maintain and develop environmental models and risk assessment procedures.

The example of water-quality model application of the Chaopraya River is shown in Figure 3.

Figure 3 shows the output of water quality model simulation. The validated model was used to evaluate the effect of different schemes under various water quality management scenarios in the Chaopraya River Basin based on the information from the year 2000. The configuration of test scenarios was based upon the percentage of waste load reduction compared with the “do nothing” scenario in next 10 and 20 years.

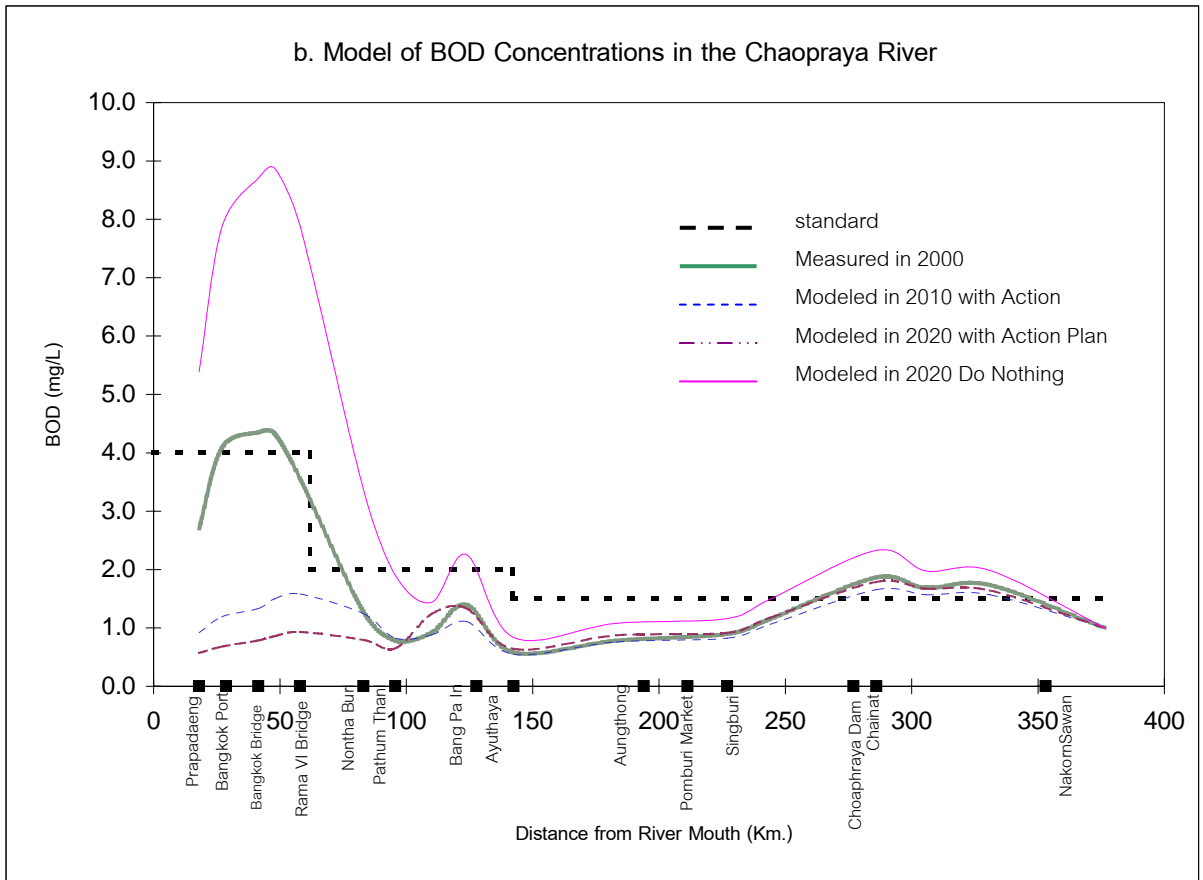
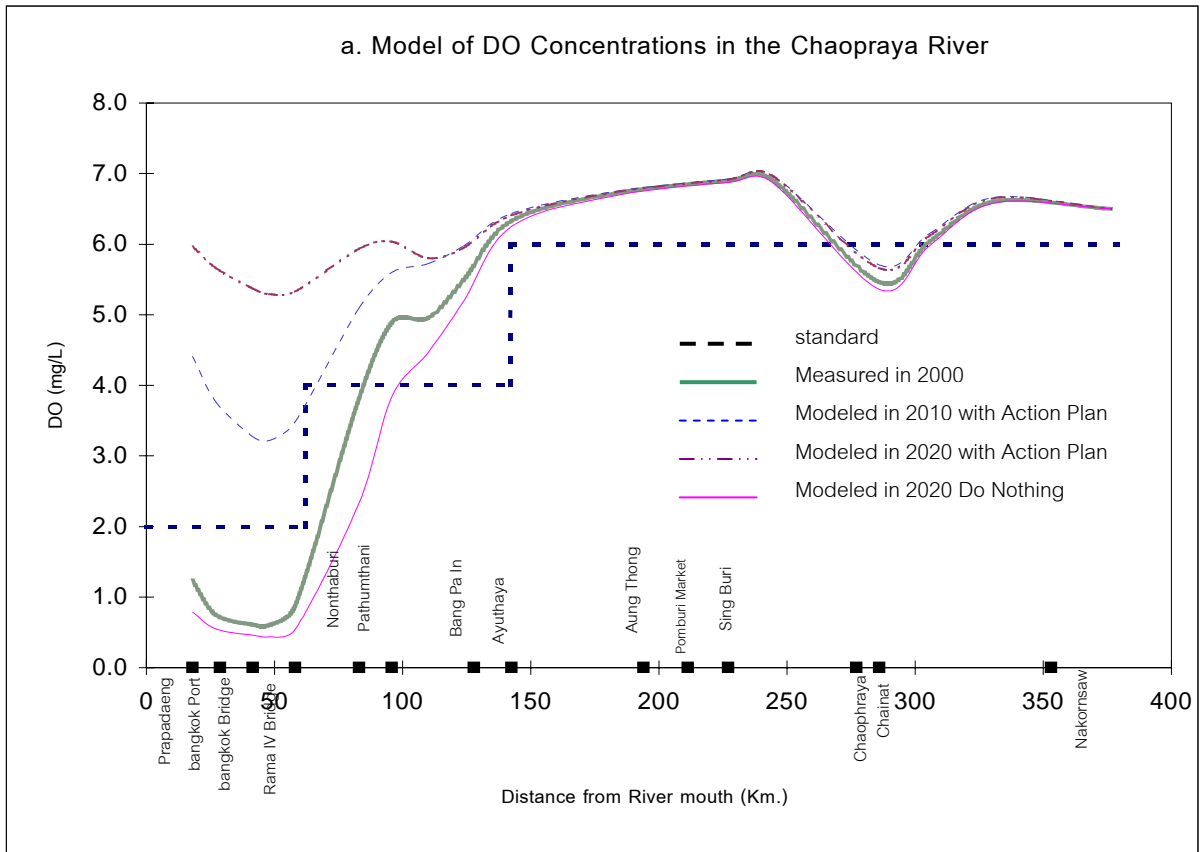


Figure 3 Water Quality Model Application for the Chaopraya River, Thailand

Water Quality Management and Planning

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).

As mentioned earlier, there are three major pollution sources: domestic, industrial, and agricultural wastewater. The contributions of waste loads from those sources are different from place to place. For examples, the major source of pollutant in the Chaopraya River is from domestic wastewater, while agricultural source (especially pig farm) is a major wastewater source of the Thachin River. Various management approaches have been applied to tackle water pollution problems in the country such as:

- Establish receiving water quality standards and classification based on existing beneficial uses and loading reduction policies
- Set up effluent standards for major pollution sources such as building, industry, pig farm, aquaculture pond, etc. (the details of the standards can be found at <http://www.pcd.go.th>)
- Construct central treatment plants of large municipalities especially the municipalities located along the river side
- Monitor receiving water quality and effluent from point-source pollution
- Implement public awareness program such as training, publication, manual etc.
- Set up the restricted zone for protecting the source of water supply (cabinet resolution) such as limitation of industrial expansion especially that factories produce toxic substances and high organic matter discharges
- Promote public participation in water quality management action plans

Summary

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 other development projects. In many parts of the country, surface water quality was 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 (Chaopraya and Thachin 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 basing planing or ecosystem approach which considers both point and non-point source pollution. Lastly, sustainable development of water resources should be also considered.

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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/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 CaCO₃

** = when water hardness more than 100 mg/l as CaCO₃

*** = Water Classification

Source : Notification of the Ministry of Science, Technology and Energy
(B.E. 2537 (1994.)), published in the Royal Government Gazette, vol.
111, No.164, dated February 24, B.E. 2537 (1994)