

Marine Water Quality Standard

The Thailand National Environment Board issued the 7th decree (B.E. 2537) for the control of coastal water quality. According to the decree, Thailand established the original Coastal Water Quality Standard, which has been used to govern and manage coastal water for ten years. When taking into consideration the current state of the economy and environmental awareness as well as the rapid advancement of technologies it has become clear that the original standard is outdated. National Environment Board reconsidered the original standard and agreed that the amendment of the original standard was needed. Subsequently, the 7th decree was renounced on January 20, B.E. 2537 and the new marine water quality standard were designated as follows:

Definition

"Marine water" means that all waters within Thai territorial water, excluding surface waters defined according to the decree regarding the establishment of surface water quality standard issued by the National Environment Board.

"Thai territorial water" means that territorial waters under the sovereignty of Thailand in compliance with Navigation in Thai Waters Act.

"Buffer zones" mean areas between two waters with different uses; its area shall be defined based on the distance of 500 meters from the water that has lower water quality.

Classification of Marine Water:

Class 1 Natural resource preservation areas shall be applied to the water that is not reserved for a particular use and is naturally suitable for breeding or nurturing newborn marine organisms as well as being able to serve as food sources and natural habitats for marine animals and plants as well as sea grass.

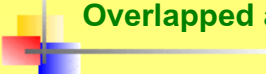
Class 2 Coral reef conservation areas shall be applied to the water densely inhabited by coral reefs, covering the area with 1,000 meter extension from the most exterior ridge of the coral reef.

Class 3 Aquaculture areas shall be applied to the water that is designated by fisheries laws to be used for aquacultural practices.

Class 4 Recreation areas shall be applied to the water allowed by the local administrative organization for swimming or other recreational activities.

Class 5 Industrial or ports zone shall be applicable to the water that is adjacent to an industrial estate whose definition shall conform to the law governing the Industrial Estate Authority of Thailand, or be applicable to port zones, whether it be ports or harbours; the area governed by the standard shall extend from the lowest tide line up to 1,000 meters.

Class 6 Residential districts areas shall applied to the water that is close to residential areas whose definition shall comply with municipal laws, Pattaya Municipality or Bangkok Municipality; the standard shall be applicable specifically to the parts of Pattaya, Bangkok and other municipalities whose borders are attached to the coastal area and extend from the lowest tide line up to 1,000 meters.




Overlapped areas and buffer zones

(a) In the case that there is an overlapping among areas to which different standards are applied, the most stringent standard shall be preferred.

(b) The classification of waters into each type of beneficial use shall proceed with the designation of a buffer zone located between two waters complying with different standards. Besides, water quality standard of a buffer zone shall not exceed the average between different standards of the two waters that have a buffer zone between them, nonetheless, with the following exceptions:

(1) If a buffer zone is situated between the two waters, one of which possesses no standard, the water quality standard of the buffer zone shall not be greater than the standard available.

(2) If the standard of two waters requires that their water quality be the same as it appears in nature, the water quality in a buffer zone shall not exceed half the standard.



Sampling requirements

(1) Conduct the water sampling at the depth of 1 meter above the bottom and below the surface, providing that the water has a depth of less than 5 meters.

(2) Conduct the water sampling at three different depths including 1 meter above the bottom and below the surface as well as at mid-depth in the water, provided that the water depth ranges from 5 to 20 meters.

(3) Conduct the water sampling at five different depths, which are 1, 10, 20, and 30 meters below the surface and 1 meter above the bottom, provided that the water depth ranges from 20 to 40 meters.

(4) Conduct the water sampling at five different depths, which are 1, 20, 40, and 80 meters below the surface and 1 meter above the bottom, provided that the water depth ranges from 40 to 100 meters.

(5) Conduct the water sampling at the depth of 1 meter below the surface and above the bottom as well as at the depth of every fifty meter, provided that the water depth is greater than 100 meters.

(6) Conduct the water sampling at the mid-depth, provided that the water depth is equal to, or less than, 1 meter.

The water sampling shall conform to the six conditions above except for the following circumstances:

(a) In the case of the Total Coliform Bacteria, Fecal Coliform Bacteria and Enterococci Bacteria, the sampling shall be performed at the depth of 30 centimeters below the surface.

(b) In the case of floatable solids, colour, transparency, and oil & grease on the surface, the water sampling shall not be required; nonetheless, the measurement of these parameters shall be carried out at the sampling field.

Moreover, if the water be influenced by tides, sampling shall be performed until the lowest level of the tide is reached.

Marine Water Quality Standard

Parameters	Permitted Value for Marine Water Class					
	Class 1 Natural resource preservation	Class 2 Coral reef conservation	Class 3 Aquaculture	Class 4 Recreation	Class 5 Industrial or ports zone	Class 6 Residential districts areas
Floatable Solids	not unpleasant					
Colour	not unpleasant ^[1]					
Odour	not unpleasant ^[2]					
Temperature (°C)	an increase shall not exceed 1 °C from the natural temperature	any change of the natural temperature shall not be allowed	an increase shall not exceed 1 °C from the natural temperature	an increase shall not exceed 2 °C from the natural temperature		
pH	7.0-8.5					
Transparency	a decrease shall not be exceed than 10% of the minimum transparency governed by natural condition ^[3]					
Suspended Solids	an increase shall not exceed the average value within 1 day, 1 month or 1 year ^[4] added by its corresponding deviation value					
Salinity	any change shall not exceed 10% of the minimum salinity ^[5]					
Floatable Oil & Grease	not visible to naked eyes					
Petroleum Hydrocarbon (µg/l)	not exceed than 0.5			not exceed than 1	not exceed than 5	
Dissolved Oxygen (mg/l)	not less than 4	not less than 6	not less than 4			
Total Coliform Bacteria (MPN/100 ml)	not exceed 1,000					
Fecal Coliform Bacteria (CFU/100 ml)	not exceed than 70			not exceed than 100		
Enterococci Bacteria (CFU/100 ml)	-	not exceed 35	-	not exceed 35	-	-
Nitrate -Nitrogen (µg-N/l)	not exceed 20		not exceed 60			
Phosphate-Phosphorus (µg-P/l)	not exceed than 15		not exceed than 45	not exceed than 15	not exceed than 45	
Unionized Ammonia (µg-N/l)	not exceed 70		not exceed 100	not exceed 70		
Total Mercury (µg/l)	not exceed 0.1					
Cadmium (µg/l)	not exceed 5					

^[1] The color of marine water measured in scales of the Forel-Ule solution, ranging from 1 to 22

^[2] No offensive smell from sources, such as, crude oil, "rotten egg", chemicals, litter and decaying organic matters

^[3] The minimum level of transparency shall be ascertained based on marine water samples taken in the same season and from the same station for 1 year during which occurrence of tides exists

^[4] For 1-day average value, sampling /measurement shall be conducted every hour or, at least, 5 times a day at interval of constant period.

For 1-month average value, sampling /measurement shall be carried out every day or, at least, 4 times a month at interval of constant period

For 1-year average value, sampling /measurement shall be carried out every month; besides, it shall be conducted on the same day and at the same time throughout the year.

^[5] The minimum level of salinity shall be determined based on marine water samples taken in the same season and from the same station for 1 year during which occurrence of tides exists

Marine Water Quality Standard (cont.)

Parameters	Permitted Value for Marine Water Class					
	Class 1 Natural resource preservation	Class 2 Coral reef conservation	Class 3 Aquaculture	Class 4 Recreation	Class 5 Industrial or ports zone	Class 6 Residential districts areas
Total Chromium ($\mu\text{g/l}$)	not exceed 100					
Chromium Hexavalent ($\mu\text{g/l}$)	not exceed 50					
Lead ($\mu\text{g/l}$)	not exceed 8.5					
Copper ($\mu\text{g/l}$)	not exceed 8					
Manganese ($\mu\text{g/l}$)	not exceed 100					
Zinc ($\mu\text{g/l}$)	not exceed 50					
Iron ($\mu\text{g/l}$)	not exceed 300					
Arsenic ($\mu\text{g/l}$)	not exceed 10					
Fluoride (mg/l)	not exceed 1					
Residual Chlorine (mg/l)	-	-	-	-	not exceed 0.01	
Phenol (mg/l)	not exceed 0.03					
Sulfide ($\mu\text{g/l}$)	not exceed 10					
Cyanide ($\mu\text{g/l}$)	not exceed 7					
Polychlorinated Biphenyl, PCBs	undetectable					
Radioactivity (Becquerel/l)						
- Alpha	not exceed 0.1					
- Beta (excluding Potassium-40)	not exceed 1.0					
Tributyltin (ng/l)	not exceed 10					
Containing-chlorine pesticides ($\mu\text{g/l}$)						
- Aldrin	not exceed 1.3					
- Chlordane	not exceed 0.004					
- DDT	not exceed 0.001					
- Dieldrin	not exceed 0.0019					
- Endrin	not exceed 0.0023					
- Endosulfan	not exceed 0.0087					
- Heptachlor	not exceed 0.0036					
- Lindane	not exceed 0.16					
Other pesticides						
- Alachlor	undetectable					
- Ametryn						
- Atrazine						
- Carbaryl						
- Carbendazim						
- Chlorpyrifos						
- Cypermethrin						
- 2,4-D						
- Diuron						
- Glyphosate						
- Malathion						
- Mancozeb						
- Methyl Parathion						
- Parathion						

Methods of Examination

Parameters	Methods
Floatable Solids	Surface Observation
Colour	using Forel-Ule color scale in evaluation
Odour	based on olfactory senses performed by at least three people (Samples shall be kept in two glass bottles or TFE-lines)
Temperature	1) Thermometer or 2) Electrical Sensor Method
pH	pH meter
Transparency	Secchi disc (designed for marine water)
Suspended solids	Gravimetric Method
Salinity	1) Argentometric or 2) Electrical Conductivity Method or 3) Density or 4) Refractometer
Floatable Oil & Grease	Surface Observation
Petroleum Hydrocarbon	Pre-concentration followed by Fluorescence Spectrophotometry
Dissolved Oxygen	1) Azide Modification or 2) Membrane Electrode Method or 3) Winkler Method
Total Coliform Bacteria	Multiple Tube Fermentation Technique
Fecal Coliform Bacteria	Membrane Filter Technique
Enterococci Bacteria	
Nitrate-Nitrogen	Cadmium Reduction Method to convert Nitrate to Nitrite before using Colorimetric Method
Phosphate-Phosphorus	Colorimetric Method
Unionized Ammonia	Phenol-Hypochlorite Method
Total Mercury	Pre-concentration followed by 1) Cold-Vapor/Hydride Generation-Atomic Absorption Spectrometric Method or 2) Cold-Vapor/Hydride Generation-Atomic Fluorescence Spectrometric Method or 3) Inductively Coupled Plasma Method
Cadmium	Pre-concentration followed by
Total Chromium	1) Electrothermal Atomic Absorption Spectrometric Method or 2) Inductively Coupled Plasma Method

Means of marine water quality assessment (cont.)

Parameters	Means of examination
Chromium Hexavalent	after pre-concentration, perform either of the followings 1) Electrothermal Atomic Absorption Spectrometric Method or 2) Inductively Coupled Plasma Method
Lead	
Copper	
Manganese	Pre-concentration followed by 1) Flame Atomic Absorption Spectrometric Method or 2) Electrothermal Atomic Absorption Spectrometric Method or 3) Inductively Coupled Plasma Method
Zinc	
Iron	
Fluoride	SPADNS Colorimetric Method
Residual chlorine	N, N-diethyl-p-phenylenediamine Method
Phenol	Distillation followed by 4 -Aminoantipyrine Colorimetric Method
Sulfide	Methylene Blue Colorimetric Method
Cyanide	Pyridine Barbituric Acid Colorimetric Method
PCBs, Polychlorinated Biphenyl	Pre-concentration followed by Gas Chromatography with Electron Capture Detector
Pesticide	Pre-concentration followed by 1) Gas Chromatography with Mass Spectrophotometry or 2) High Performance Liquid Chromatography (HPLC)
Arsenic	Pre-concentration followed by 1) Hydride Generation-Atomic Absorption Spectrometric Method or 2) Electrothermal Atomic Absorption Spectrometric Method or 3) Inductively Coupled Plasma Method that possesses Chloride interference elimination system
Radioactivity - Alpha - Beta - Potassium-40	- Co-precipitation Method - Evaporation Method - Gamma Spectrometry Method (USEPA) or calculation based on salinity value
Tributyltin	Pre-concentration followed by 1) Gas Chromatography with Flame Photometric Detector 2) Gas Chromatography with Mass Spectrophotometry or 3) High Performance Liquid Chromatography-ICP-MS

Note: Marine water sampling techniques and all associated apparatuses shall comply with either the guideline set forth by the Pollution Control Department or guidelines stated in Standard Method for the Examination of Water and Wastewater (APHA, AWWA and WEF, updated) Method of Seawater Analysis (Grasshoff ,1999) Practical Handbook of Seawater Analysis (Strickland and Parsons, 1972) A Manual of Chemical and Biological Methods for Seawater Analysis (Parsons et.al., 1984) Recommended guidelines for measuring organic compounds in Puget Sound water, sediment and tissue samples (Puget Sound Estuary Program, 1997) Prescribed Procedures for Measurement of Radioactivity in Drinking Water (Krieger and Whittaker, 1980) Proceedings of the organotin symposium, Comprehensive method for determination of aquatic butyltin and butylmethyltin species at ultra trace levels using simultaneous hybridization/extraction with GC/FPD detection (Matthias et. Al. 1986 a,b). In addition, marine water sampling techniques and all associated apparatuses shall conform to other new guidelines that are later adopted by the Pollution Control Committee. Such guidelines might be relevant to examination methods, elimination of Chloride interference, or pre-concentration.

Conversion Table of Total Ammonia into Unionized Ammonia

Table showing the proportion of unionized ammonia in marine water at a variety of pH and temperatures

pH	Temperature, °C													
	6	8	10	12	14	16	18	20	22	24	26	28	30	32
7.0	0.0013	0.0016	0.0018	0.0022	0.0025	0.0029	0.0034	0.0039	0.0046	0.0052	0.0060	0.0069	0.0080	0.0095
7.2	0.0021	0.0025	0.0029	0.0034	0.0040	0.0046	0.0054	0.0062	0.0072	0.0083	0.0096	0.0110	0.0126	0.0150
7.4	0.0034	0.0040	0.0046	0.0054	0.0063	0.0073	0.0085	0.0098	0.0114	0.0131	0.0150	0.0173	0.0198	0.0236
7.6	0.0053	0.0065	0.0073	0.0086	0.0100	0.0116	0.0134	0.0155	0.0179	0.0206	0.0236	0.0271	0.0310	0.0369
7.8	0.0084	0.0099	0.0116	0.0135	0.0157	0.0182	0.0211	0.0244	0.0281	0.0322	0.0370	0.0423	0.0482	0.0572
8.0	0.0133	0.0156	0.0182	0.0212	0.0247	0.0286	0.0330	0.0381	0.0438	0.0502	0.0574	0.0654	0.0743	0.0877
8.2	0.0210	0.0245	0.0286	0.0286	0.0385	0.0445	0.5140	0.0590	0.0676	0.0772	0.0880	0.0998	0.1129	0.1322
8.4	0.0328	0.0383	0.0445	0.0445	0.0597	0.0688	0.0790	0.0904	0.1031	0.1171	0.1326	0.1495	0.1678	0.1946
8.6	0.0510	0.0593	0.0688	0.0688	0.0914	0.1048	0.1197	0.1361	0.1541	0.1737	0.1950	0.2178	0.2422	0.2768
8.8	0.0785	0.0909	0.1048	0.1048	0.1376	0.1566	0.1773	0.1998	0.2241	0.2500	0.2774	0.3062	0.3362	0.3776
9.0	0.1190	0.1368	0.1565	0.1782	0.2018	0.2273	0.2546	0.2836	0.3140	0.3456	0.3783	0.4116	0.4453	0.4902
9.2	0.1763	0.2008	0.2273	0.2558	0.2861	0.3180	0.3512	0.3855	0.4204	0.4557	0.4909	0.5258	0.5599	0.6038
9.4	0.2533	0.2847	0.3180	0.3526	0.3884	0.4249	0.4618	0.4985	0.5348	0.5702	0.6045	0.6373	0.6685	0.7072
9.6	0.3496	0.3868	0.4249	0.4633	0.5016	0.5394	0.5762	0.6117	0.6456	0.6777	0.7078	0.7358	0.7617	0.7972
9.8	0.4600	0.5000	0.5394	0.5778	0.6147	0.6499	0.6831	0.7140	0.7428	0.7692	0.7933	0.8153	0.8351	0.8585
10.0	0.5745	0.6131	0.6498	0.6844	0.7166	0.7463	0.7735	0.7983	0.8207	0.8408	0.8588	0.8749	0.8892	0.9058
10.2	0.6815	0.7152	0.7463	0.7746	0.8003	0.8234	0.8441	0.8625	0.8788	0.8933	0.9060	0.9173	0.9271	0.9384

Source: Emerson, K., R.C. Russo, R.E. Lund and R.V. Thurston (1975)

Conversion Formula of Total Ammonia into Unionized Ammonia

$$\begin{aligned}
 pK &= 0.09018 + 2729.92/T_{Temp} \\
 pK &= -\log_{10}(K) \\
 pH &= -\log_{10}[H^+] \\
 F\mu &= 1/1 + ([H^+]/K) \\
 \text{Unionized Ammonia} &= F\mu(\text{Total Ammonia})
 \end{aligned}$$

where

T_{Temp} = water temperature (K) ($K = ^\circ C + 273.15$)

$F\mu$ = the ratio of Unionized Ammonia to Total Ammonia

$[H^+]$ = H^+ concentration

K = the dissociation constant

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