HEAVY METALS IN COAST OF THE NORTHERN BATAM ISLAND

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Abstract

Batam island has been designed as an industrial growth center. The development of human settlement, industries, tourism resort and harbour along the coast can cause the considerable pollution of marine waters. To anticipate and assess the impact of increasing activities in Batam Industrial Development Agency; we carried out a study with objective to know the concentration of heavy metals in coast of Batam island. Result of the study revealed that based on the recorded heavy metals (Pb, Cd, Cu, and Cr) in the coastal water, the coast of northern Batam island was not suggested to develop a marine tourism resort due to most of the concentration of heavy metals higher than concentration which suggested by Decree of the state minister for population and environment number Kep-02/MENKLH/I/1998. To minimized the concentration of heavy metals in water of the coast of northern Batam island, it was suggested to use more tight water quality standart in the area of Batam Industrial Development Authority

I. INTRODUCTION

Heavy metals are metals with a large atomic number. They are very large atoms which are hazardous to life. These metals include such elements as **lead, cadmium, copper,** selenium, arsenic, mercury**, and chromium**. These substances are very dangerous to humans, even in small quantities. Heavy metals have many sources from which they can flow into the water.

Many types of waste water contain heavy metals in solution. Often these waste waters are foured into a general sewage system. Heavy metals are known to exert an adverse effect on biological processes in general. As a rule, it is the metal ion in solution which is toxic to living processes. Under some conditions, metals in suspension have been shown to be toxic to fishes. However, it is mainly the soluble form of the metal which exerts a deleterious effect on biological processes and on living species.

Some of the major metal pollutants that appear to be of primary concern include as **lead, cadmium, copper,** selenium, arsenic, mercury**, and chromium**. Lead is an organic metallic element that bluish-white, heavy, soft, malleable, ductile but inelastic and is found mostly in combination with other elements. Lead is often

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used in the manufacturing of storage batteries and as an anti-knocking additive in gasoline (tetraethyl lead). Some European countries, the US and Canada phased out leaded gasoline by 1990, due to research which indicated that 60% of all lead emissions came from automobile exhaust. Other major sources of lead also include mining, smelting and refining of lead, nickel and copper ores. In water, lead tends to accumulate in aquatic organisms through the foodchain and by direct uptake. Lead is believed to cause hypertension, reproductive disorders, neurological and metabolic problems. The critical point concerning chronic toxicity of lead is that, it is chemically similar to calcium, and therefore it is accumulated in the bone matrix. Whenever the body triggers calcium release from bones, lead is also released into the blood stream. This could cause high levels of lead to enter into the bloodstream, possibly long after the body was exposed to the lead.

Cadmium is an inorganic metallic element that is malleable, ductyile, bluish-white and toxic. Cadmium is usually produced from the by-product of various industrial activities, such as smelter operations and the burning of fossil fuels. These sources are the main contributors to atmospheric cadmium levels. Cadmium pollution in water primarily occurs by direct industrial discharges into waterbodies. Toxicity of this metal usually occurs during occupational exposure, resulting in kidney damage and hypertension. Cadmium in short term is believed to cause nausea, vomitiing. Diarrhea, muscle cramps, salivation, sensory disturbances, liver injury,convulsions, shock and renal failure; whereas in long term will cause kidney, liver, bone and blood damage.

Copper is a common metallic element that is malleable, ductile, reddish-bown and is one of the best conductors of heat and electricity. Copper is often used in the household plumbing; and computer circuitry manufacturing, copper wiring and copper art. Copper is an essential nutrient, required by the body in very small amounts. However, the EPA has found copper to potentially cause the following health effects when people are exposed to it at levels above the Action Level for relatively short periods of time: stomach and intestinal distress, liver and kidney damage, and anemia. Persons with Wilson's disease may be more sensitive than others to the effects of copper contamination.

Chromium is an inorganic metallic element that is bluish-white and found only in combination with other elements. Chromium is often used in metal alloys such as stainless steel, protective coatings on metal, magnetic tapes and electroplating; also as pigments for paints, cement, paper, rubber, composition floor coverings and wood preserving. Chromium in short term is believed to cause skin irritation or ulceration; whereas in long term will cause Skin irritation, damage to liver, kidney, circulatory and nerve tissues.

The major problems associated with excessive release of trace metals into the environment are that metals neither biodegrade, nor are they eliminated by incineration processes. These elements tend to be persistent pollutants, and can accumulate in ecosystems and foodchains. In addition, each metal has a specific chemical form (speciation) which determines its solubility in water, and consequently its ability to incorporate into biological systems. Ionic forms, because of their water solubility, are allowed to enter into biologic processes. They have a tendency to non-discriminately bind to enzymatic, electronegative ligands in the organism. It is

believed that in acute toxicity, binding occurs to the first available ligand. This would imply that the route of administration is critical in determining the effects of acute toxicity. During chronic toxicity, the metal distributes itself throughout the body and preferentially binds to the ligand with the highest binding affinity. Cells with high affinity ligands associated with toxicity, are referred to as target cells. Organometallic compounds are able to pass through biological membranes because of their high degree of lipophilicity. Consequently, membranes such as the blood-brain barrier can be permeated and allowed to persist for long periods of time.

Batam islands is one of the key location in Indonesia that has been designed by the government as an industrial growth center. The area of this island is 415 square kilometers and only 20 kilometers fro Singapura. The physical characteristic of the island is tropical vegetation, which is dense in the hilly districts and in the higher elevations of the island's plain. These regions will be developed for industry, housing, tourism, agriculture, office, and retail shopping, government facilities, and commercial business. The development of industry, human settlements, tourism resorts and harbour along coast has caused considerable pollution of marine waters. The beneficial of this growth center is important to increase national income, but in other side the growth itself will make some problems, especially for the environment, since their activities have waste in their production. If these waste did not manage properly, then some changes in the environment will occur, especially coastal water which is the resource for tourism industry.

II. OBJECTIVE.

To anticipate and assess the impact of increasing activities in Batam Industrial Development Authority, and also the activities of ship traffic in the coast of Batam; we carried out a study to know the concentration of heavy metals in coast of Batam island.

III. METHODS.

Study was carried out by sampling in stations, namely station-1 (sta-1), sta-2, sta-3, sta-4, sta-5 and sta-6. These station were lie around Nongsa bay, Tering Gulf, Batu Ampar and Jodoh Gulf in the northern of Batam island (Fig.1).

a. Samples collections

The successive samplings from the all stations were begun on November 1993 and finished on May 1994 with 10 (ten) samplings and recordings. Recording of physical environments and collections of water samples were carried out 2 times in a month, through experimental period. Water temperature, pH, salinity and turbidity were recorded *in situ* before water sampling.

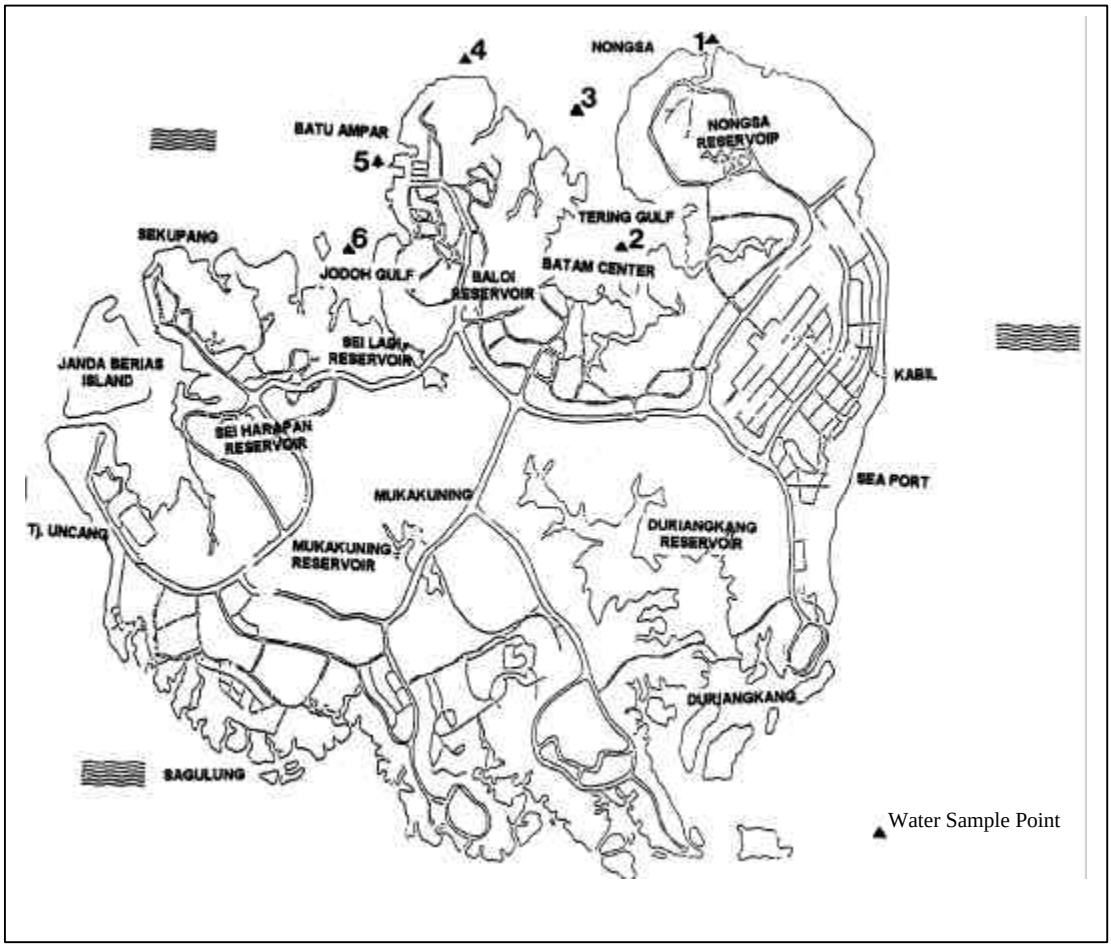

Figure 1. Batam Island

Water samples were collected with a polyvinylchloride resin (PVC) pipe with 3 m length and 10 cm inner diameter. For each sampling, the pipe was lowered down in the water column with being kept upright until the lower end reached to 3 m depth. Then the upper end of the pipe was clogged up with a rubber stopper, followed by gentle lifting of the pipe. Finally the rubber stopper of the top was pulled out, so that the water was flowed out in to plastic pail. In this manner, the water samples were collected through the water column of 3 m depth. In each sampling time, 2 sets of 5 liters water samples were taken out from each sampling point. A part of these sea water samples was brought into laboratory for measuring heavy metals. Details methods and equipments used in the experiment were presented in Table-1.

No	Parameters	Units	Methods	Remarks
1.	Air temperature	^{o}C	-	*In-situ*, termometer
2.	Water temperature	^{o}C	Electrometric	*In-situ*, SCT-meter
3.	Salinity	Per mil.	electrometry	*In-situ*, SCT-meter
4.	Turbidity	NTU	Nephelometric	Laboratory
5.	pH		Electrometry	*In-situ*
6.	Lead (Pb)	Mg/l	AAS	Laboratory
7.	Cadmium (Cd)	Mg/l	AAS	Laboratory
8.	Copper (Cu)	Mg/l	AAS	Laboratory
9.	Chromium (Cr)	Mg/l	AAS	Laboratory

Table-1. Methods and equipments used in the study

IV. RESULT AND DISCUSSION

Result of the analysis of water samples in each station were presented in tables 2, 3 ,4, 5, and 6. In master plan of the Batam Industrial Development Authority (BIDA), the coastal area of Batam island will be developed for marine tourims resort and aquaculture. Base on this utilization, the result of this study also will be referred to Marine and coastal water quality standart for tourism and aquaculture, as written in Decree of the state minister for population and environment number Kep-02/MENKLH/I/1998; concerning water quality standart.

Throughout the study water temperature in the station-1 fluctuated between 25.0-29.0 ^{o}C (Table-2), in the station-2 fluctuated between 27.5-28.0 ^{o}C (Table-3), in the station-3 fluctuated between 26.5-29.0 ^{o}C (Table-4, in the station-4 fluctuated between 28.0-28.5 ^{o}C (Table-5), in the station-5 fluctuated between 27.0-29.0 ^{o}C (Table-6), and in the station-6 fluctuated between 28.0-29.0 ^{o}C (Table-7). No marked changes in water temperatur were observed in the six stations throughout the experimental periods; and the observed temperature were still normal for tropical country, indicated the the coustal water was not polluted by heat pollution yet.

The turbidity of water is a measure of the extend to which light passing through water due to suspended and coloidal materials. Turbidity is concerned waetr courses due to aesthetic considerations, filter ability and desinfection. During the study water turbidity in the station-1 fluctuated between 0.35-62 NTU (Table-2), in the station-2 fluctuated between 0.35-25 NTU (Table-3), in the station-3 fluctuated between 0.36-25 NTU (Table-4), in the station-4 fluctuated between 0.38-30.0 NTU (Table-5), in the station-5 fluctuated between 0.36-30.0 NTU (Table-6), and in the station-6 fluctuated between 0.2-66.4 NTU (Table-7). Table-2-7 shown that that in the beginning of study water turbdity was high (25-30 NTU) in all station, suggested due to sampling was collected after rain. Afterward it seem that in the station-1 water turbidity was higher than the other. This phenomenon was suggested due to the location of station-1 was in estuary of Nonsa river.

Salinity is the dissolved solids present in a kilogram of filtered seawater after oxydations of nutrients. During the study salinity in the station-1 fluctuated between 20.5-31.5 permill. (Table-2), in the station-2 fluctuated between 24.0- 29.0 permill (Table-3), in the station-3 fluctuated between 25.0-29.0 permill (Table-4, in the station-4 fluctuated between 24.0-29.5 permill (Table-5), in the station-5 fluctuated between 19.0-29.0 permill (Table-6), and in the station-6 fluctuated between 23.0-29.5 (Table-7). No marked changes in salinity were observed in the six stations throughout the experimental periods.

pH is defined as the negative logarithm of the hydrogen ion concentration. The hydrogen-ion concentration controls the chemical state of many water bodies elements. Changes in pH influence other important plant nutrient such as phosphate, ammonia, iron and trace metals. In this study pH fluctuated between 7,5-8.0 in station-1 (Table-2); between 7,9-81 in station-2 (Table-3); between 7,5-9,0 in station-3 (Table-4); between 7.7-8.1 in station-4 (Table-5); between 7,9-8.0 in station-5 (Table-6) and between 7,9-8.1 in station-6 (Table-7). Normally pH of surface water range between 6.5-9.0. It means pH of coastal water in northern Batam

island was normal; and refers to Kep-02/MENKLH/I/1988 with the coastal of northern Batam island are fullfil requirement for tourism resort and aquaculture.

Lead and lead compounds belongs to the stronger environmental poisons. Maximum contaminant level of lead is 0.015 ppm. During this study the concentration of lead was fluctuated between 0.001- 0.013 ppm in station-1 (Table-2); between 0.001-0.012 ppm in station-2 (Table-3); between 0.001- 0.023 ppm in station-3 (Table-4); between 0.001- 0.015 ppm in station-4 (Table-5); between 0.001-0.025 ppm (Table-6); and between 0.001-0.028 ppm (Table-7). Kep-02/MENKLH/I/1998; revealed that although the concentration of lead untill 0.05 ppm was permitted for development of tourism area, but concentration of 0.00002 ppm was suggested. The result of this study revealed that the concentration of lead in all station was smaller than 0.05 ppm, but higher than 0.00002 ppm. It means based on the concentration of lead in the water, although it was not suggested the development of marine tourism area in the coast of Northern Batam Island was permitted.

Cadmium is an inorganic metallic element that is malleable, ductile, bluish-white and toxic. Troughout this study the concentration of cadmium was fluctuated between 0.001- 0.085 ppm in station-1 (Table-2); between 0.001-0.135 ppm in station-2 (Table-3); between 0.001- 0.075ppm in station-3 (Table-4); between 0.001-0.144 ppm in station-4 (Table-5); between 0.009-0.124 ppm (Table-6); and between 0.001-0.304 ppm (Table-7). Kep-02/MENKLH/I/1998; revealed that although the concentration of chromium untill 0.01 ppm was permitted for development of tourism area, but concentration of 0.00002 ppm was very desired. The result of this study revealed that the concentration of Cadmium smaller than 0.01 ppm was a little, and most of the concentration of cadmium in each station was bigger than 0.01. Its means based on the cadmium concentration in the water, the coast of Northern Batam Island was not fulfilled requirement for development of marine tourism area.

Copper is essential component of many enzym. Short-term copper deficiencies or excess may be regulated by a variety of organisms thus minimizing its potential toxic effects. Throughout the study copper was fluctuated between 0.001- 0.094 ppm in station-1 (Table-2); between 0.001-0.089 ppm in station-2 (Table-3); between 0.001- 0.084 ppm in station-3 (Table-4); between 0.001- 0.088 ppm in station-4 (Table-5); between 0.001-0.540 ppm (Table-6); and between 0.001-0.114 ppm (Table-7). Decree of the state minister for population and environment number: Kep-02/MENKLH/I/1998; revealed that although the concentration of copper between 0.001-1..0 ppm was permitted for development of tourism area, but concentration smaller than 0.001 ppm was desired. Its means although the coast on Northern Batam Island fulfill requirement for developing marine tourism area, but because of the copper concentration of 0.001 was only recorded in the beginning of study, then continious monitoring was needed.

During the study the concentration of chromium was fluctuated between 0.001- 0.940 ppm in station-1 (Table-2); between 0.001-0.089 ppm in station-2 (Table-3); between 0.001- 0.080 ppm in station-3 (Table-4); between 0.001- 0.078 ppm in station-4 (Table-5); between 0.001-0.066 ppm (Table-6); and between 0.001-0.370 ppm (Table-7). Decree of the state minister for population and environment number: Kep-02/MENKLH/I/1998; revealed that although the concentration of

chromium untill 0.01 ppm was permitted for development of tourism area, but concentration of 0.00004 ppm was very desired. The result of this study revealed that the concentration of Chromium which smaller than 0.01 ppm was only recorded in the beginning of study, thereafter most of the concentration of Chromium in each station was bigger than 0.01. Its means based on the concentration of chromium in the water, the coast of Northern Batam Island was not fulfilled requirement for development of marine tourism area.

V. CONCLUSIONS AND SUGGESTIONS.

All above discussion could be concluded that based on the recorded heavy metals (Cu, Cr, Ca and lead) in the water, the coast of northern Batam island was not suggested to develop a marine tourism resort due to most of the concentration of heavy metals higher than concentration which suggested by Decree of the state minister for population and environment number Kep-02/MENKLH/I/1998.

Heavy metals are poison and very dangerous for living organism, including human being, thus it must be minimized. To minimized the concentration of heavy metals in water of the coast of northern Batam island, we suggest to use more tight water quality standart in Batam Industrial Development

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PARAMETER	UNIT	The .... sampling										MAX	MIN
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th		
Air temperature	^{0} C	27.5	29	30	30	30	31	30.5	30	31	30	31	27.5
Water temperature	^{0} C	25	28.5	26	27.5	29	28	28	29	29	28	29	25
Turbidity	NTU	25	0.35	0,40	0.49	15	32	62	25	0.9	1.25	62	0.35
Salinity	0/00	23.5	29.5	21,5	20.5	22.5	29.6	31.6	30.5	29.5	29.5	31.6	20.5
pH		7.9	7.5	7.8	8.0	8.0	7.9	7.6	7.8	7.8	7.4	8	7.4
Lead (Pb)	mg/l	0.069	0.001	0.001	0.032	0.015	0.018	0.055	0.01	0.035	0.085	0.085	0.001
Cadmium (Cd)	mg/l	0.009	0.013	0.002	0.004	0.002	0.001	0.005	0.002	0.001	0.001	0.013	0.001
Copper (Cu)	mg/l	0.001	0.001	0.001	0.094	0.038	0.054	0.001	0.032	0.025	0.022	0.094	0.001
Chromium (Cr)	mg/l	0.001	0.001	0.001	0.053	0.015	0.025	0.489	0.92	0.85	0.37	0.92	0.001

Table-2. The result of water analysis in station-1

PARAMETER	UNIT	The .... sampling										MAX	MIN
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th		
Air temperature	^{0} C	30	30	28.5	31.5	31	30	30	30	30	30	31.5	28.5
Water temperature	^{0} C	28	28.5	28	27.5	28	28	28	28	28	28	28.5	27.5
Turbidity	NTU	25	0.38	0.35	0.55	7.5	0.55	16	0.95	0.35	7.65	25	0.35
Salinity	0/00	25	29	25.5	25	25	24	25	26	24	24	29	24
pH		8.0	7.9	8.1	8.1	8.0	8	8.1	7.9	8	8.1	8.1	7.9
Lead (Pb)	mg/l	0.09	0.135	0.001	0.054	0.009	0.012	0.051	0.045	0.031	0.001	0.135	0.001
Cadmium (Cd)	mg/l	0.012	0.008	0.001	0.002	0.002	0.001	0.004	0.009	0.001	0.005	0.012	0.001
Copper (Cu)	mg/l	0.001	0.001	0.089	0.087	0.005	0.001	0.009	0.085	0.087	0.049	0.089	0.001
Chromium (Cr)	mg/l	0.001	0.001	0.076	0.087	0.065	0.059	0.044	0.072	0.009	0.089	0.089	0.001

Table-3. The result of water analysis in station-2

PARAMETER	UNIT	The .... sampling										MAX	MIN
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th		
Air temperature	^{0} C	26	30	27	31	31	30	30	30	30	30	31	26
Water temperature	^{0} C	28	29	26	27.5	28	28	29	29	29	29	29	26
Turbidity	NTU	25	0.44	0.44	0.36	0.45	1.75	2.8	4.25	3.75	4.2	25	0.36
Salinity	0/00	25.5	29	26	27.5	26.5	25.5	28	27.5	26.5	25	29	25
pH		8.0	7.9	8.0	8.1	8	9.0	7.1	8	7.5	7.8	9.8	7.1
Lead (Pb)	mg/l	0.065	0.063	0.051	0.042	0.057	0.065	0.07	0.016	0.009	0.075	0.075	0.009
Cadmium (Cd)	mg/l	0.001	0.023	0.003	0.005	0.008	0.007	0.005	0.006	0.005	0.001	0.023	0.001
Copper (Cu)	mg/l	0.001	0.001	0.066	0.084	0.038	0.041	0.025	0.03	0.04	0.025	0.084	0.001
Chromium (Cr)	mg/l	0.001	0.001	0.08	0.076	0.001	0.006	0.005	0.008	0.009	0.005	0.08	0.001

Table-4. The result of water analysis in station-3

PARAMETER	UNIT	The .... sampling										MAX	MIN
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th		
Air temperature	^{0} C	30	29.5	27	31.5	30	31	30	30	30	30	31.5	27
Water temperature	^{0} C	28	28.5	28	28	28	28.5	28	28	28	28.5	28.5	28
Turbidity	NTU	30	0.38	0.41	0.31	0.41	6.45	8.44	3.12	0.49	0.98	30	0.31
Salinity	0/00	25	29.5	25	24	24	26	25.5	27	26	25.5	29.5	24
PH		8	8	7.7	8.1	8	8.1	7.9	7.9	8.1	8	8.1	7.7
Lead (Pb)	mg/l	0.124	0.001		0.139	0.019	0.035	0.144	0.015	0.112	0.084	0.144	0.001
Cadmium (Cd)	mg/l	0.012	0.015	0.002	0.002	0.003	0.008	0.005	0.001	0.009	0.006	0.015	0.001
Copper (Cu)	mg/l	0.001	0.001	0.088	0.075	0.041	0.031	0.033	0.021	0.009	0.011	0.088	0.001
Chromium (Cr)	mg/l	0.001	0.001	0.078	0.075	0.039	0.024	0.036	0.011	0.015	0.031	0.078	0.001

Table-5. The result of water analysis in station-4

PARAMETER	UNIT	The … Sampling										MAX	MIN
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th		
Air temperature	^{0} C	29	30	28	31.5	31	31	31	31	31	31	31.5	28
Water temperature	^{0} C	28	28.5	28	27.5	29	28	28	29	28	29	29	27.5
Turbidity	NTU	30	0.37	0.39	0.36	14.2	0.95	12	10.8	0.9	13	30	0.36
Salinity	0/00	22	29	26.5	19	26.5	25.5	26	26	25.5	26	29	19
pH		8.0	7.9	7.9	7.9	8.1	7.9	8	8	7.9	8	8.1	7.9
Lead (Pb)	mg/l	0.124	0.065		0.074	0.062	0.041	0.021	0.023	0.041	0.009	0.124	0.009
Cadmium (Cd)	mg/l	0.019	0.025	0.005	0.003	0.001	0.004	0.008	0.006	0.014	0.01	0.025	0.001
Copper (Cu)	mg/l	0.001	0.001	0.126	0.063	0.048	0.39	0.54	0.58	0.39	0.044	0.58	0.001
Chromium (Cr)	mg/l	0.001	0.001	0.066	0.063	0.021	0.009	0.019	0.024	0.035	0.006	0.066	0.001

Table-6. The result of water analysis in station-5

PARAMETER	UNIT	The .... sampling										MAX	MIN
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th		
Air temperature	^{0} C	29	31.5	28	31.5	31	31	32	31	31	31	32	28
Water temperature	^{0} C	28	28.5	28	28	29	28	29	29	28.5	28.5	29	28
Turbidity	NTU	30	0.37	0.42	0.4	0.2	42	66.4	6.8	0.89	1.45	66.4	0.2
Salinity	0/00	26.5	29.5	26	23	26.5	25.5	29.2	26	26	26	29.5	23
pH		8	7.9	7.8	7.8	8.1	7.9	8.1	8	7.9	7.9	8.1	7.75
Lead (Pb)	mg/l	0.01	0.016	0.082	0.012	0.041	0.001	0.304	0.025	0.014	0.019	0.304	0.001
Cadmium (Cd)	mg/l	0.028	0.014	0.004	0.005	0.011	0.009	0.012	0.004	0.002	0.005	0.028	0.002
Copper (Cu)	mg/l	0.001	0.001	0.114	0.082	0.042	0.081	0.001	0.091	0.042	0.009	0.114	0.001
Chromium (Cr)	mg/l	0.001	0.001	0.085	0.082	0.042	0.054	0.370	0.061	0.009	0.061	0.37	0.001

Table-7. The result of water analysis in station-6