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Assessment of Physico-Chemical Parameters of Water Samples Collected from the Southern Part of Bangladesh

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Abstract

Bangladesh has a vast natural water resources. In order to determine the water quality parameters such as pH, EC, DO, BOD, TOC, ions *i.e.*, NO_3^-, SO_4^{2-}, PO_4^{3-} and heavy metals, thirty surface water samples were collected from the southern part of Bangladesh including the coastal regions of Patuakhali district and Kuakata sea beach area during the dry season. The pH of water samples was ranged from 7.58 to 8.77 with an average of 8.15. The average conductivity value was 8.83±2 mS/cm. The average DO was 8.33±1.82 mg/L and BOD was 0.31±0.03 mg/L. TOC was found between 0.78 and 1.78 mg/L with an average of 1.24 mg/L. The concentration of NO_3^-, SO_4^{2-}, PO_4^{3-} was determined by ion chromatography and only sulphate ion was detected in a very low concentration. Water samples from different sources were analysed for five metals by AAS and the concentrations of Pb, Cd, Mn, Hg and As were below 0.2, 0.01, 0.22, 0.001 and 0.005 mg/L, respectively.

Keywords: Biological oxygen demand, dissolved oxygen, electrical conductivity, pH, surface water, total organic carbon

I. Introduction

Human being in the world are under terrific threat concerning unwanted changes in the characteristics like physical, chemical and biological status of water, air and soil. Water is one of the most important and copious components of the ecosystem. All living organisms on the earth need water for their persistence and growth. Almost 71% of the earth's total surface is covered with water, but only 2.5% of this amount can be considered as freshwater[1]. Water contamination is a common problem all over the world due to the geological and anthropogenic activities[2]. For drinking, domestic, agricultural, or industrial purposes, it is indispensable to test the water for estimating different physico-chemical parameters before it is used. Some physical tests should be performed for the analysis of its physical appearance such as temperature, color, odor, pH, turbidity, total dissolved solid (TDS) etc. while chemical tests should be performed for its biological oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), alkalinity, hardness, and other characteristics[3]. However, it is a very tough and laborious task for consistent monitoring of all the parameters even there is the availability of acceptable manpower and laboratory facilities. Therefore, in recent years a substitute approach based on statistical correlation has been used to develop a mathematical relationship for comparison of physico-chemical parameters[4,5].

Patuakhali is a part of the Barisal Division in the Southern part of Bangladesh which is the main entrance of the popular Kuakata sea beach. It is situated at the fringe of the Bay of Bengal and lies between 21º48' and 22º36' north latitudes and between 90º08' and 90º41' east longitudes. The total area of the district is 3221.31 sq. km and 71.33 sq. km are under forest[6]. The shoreside areas like western, central and eastern regions of Bangladesh are in different natural phenomenons like flood, cyclone, tidal surge and salinity. 23266 sq km and 23935 sq km are inward and irradiated categories respectively in a total of costal area that is 47201 sq km[7]. Maximum and principal industrial areas are located in Bogra, Chittagong, Dhaka, Gazipur, Narayanganj, Khulna, and Rajshahi district. Effluences including transboundary pollutants from those industrial areas are mixing with water bodies and soil. Therefore, they are converted as geographical area of pollution and cause toxicity of various levels that depends on rainfall and river flow. Every year, dyeing and textile industries release 12.7–13.5 million m^3 waste waters that contaminate 20% of fresh water[8].

The entrance of the maximum raw sewage into the sea and the ocean originates from the developing countries including Bangladesh[9]. Chemical waste from industries that is released into river, wastes and sewage of tremendous cities, ship breaking yards, and cross-border depositions, agrochemicals and persistent organic pollutants (POPs), erosion, deforestation, fast urbanization, tourism, improper solid waste management, extraction of shoreside resources and climate change are important sources of shoreside pollution. These wastes may roam far distances than its sources of origin through canals, irrigation channel and river flow like Turag River to Buriganga, then to the Meghna River and ultimately to the Bay of Bengal[10].

Different cities and settlements of people in the coastal areas do not have the facilities for domestic waste treatment and therefore, freshwater bodies like rivers and lakes are getting highly polluted by industrial untreated wastes[11]. Moreover, over the last few years, industrial production has grown by almost 50% and it is urgent to regulate the treatment of waste products in proper ways[12]. The present study deals with the study of physico-chemical parameters of water samples collected from the southern part of Bangladesh. The obtained results were compared with the reported values recommended by World Health Organization (WHO), Food and Agriculture

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Organization (FAO), Department of the Environment (DOE), European Union (EU) etc.

II. Experimental

Sample Collection

Thirty water samples were collected from seven different places in Kuakata and Patuakhali districts in the dry season (Table 1 and Fig. 1). Sample collection was started from a particular region and each sample was collected from 100m apart. Specific plastic bottles were used for sampling which were labelled properly. The samples were preserved in ice during the collection until transportation to the laboratory and finally were stored in the refrigerator at -4 ºC.

Table 1. List of collected water samples

Sampling Site No.	Sample Collection Area	Sample ID
1	Kalapara Bridge, Patuakhali	S1- S4
2	Kalapara Ghat, Patuakhali	S5-S9
3	Lal Kakrar Dip, Kuakata	S10-S15
4	Kuakata Sunrise and sunset point	S16-S20
5	Maitbhanga River, Patuakhali	S21-S22
6	Maitbhanga River boatline, Patuakhali	S23-S24
7	Kuakata Buddhist temple riverside	S25-S30

(a) Kalapara Bridge, Patuakhali

(b) Maitbhanga River boatline, Patuakhali

Fig. 1. Sample locations around Patuakhali district

Physicochemical Parameters

The pH and EC of the collected water samples were estimated using a pH meter (Model: JENWAY 3510) at 25-30 ºC and a conductivity meter (Model: JENWAY 4510) respectively. The TC (Total Carbon) of water refers to the presence of inorganic carbon (IC) and total organic carbon (TOC) where TOC illustrates the non-purgeable organic carbon (NPOC) and also refers to organic carbon that is present in the sample in a non-volatile form. TOC in water was measured by a TOC analyzer (Model: TOC-VCPH) and IC was eliminated by acidifying the water samples (pH 2 to 3) and pure gas was bubbled through the sample. Ion chromatography system (881 compact IC pro1, Methohm, Germany) was used for the analysis of soluble anions in water. At first standard solution was prepared for mobile phase by the combination of 3.2 mM Na_2CO_3, 1 mM $NaHCO_3$ and 100 mmol/L H_2SO_4 (suppressor). The water samples were first cotton filtered followed by syringe filtered. Then a series of mixed standard solutions (3.125, 6.25, 12.5, 25 and 50 mg/L) of NO_3^-, SO_4^{2-} and PO_4^{3-} were prepared. 50 µL of each of the sample were introduced with an auto sampler into a sample loop. BOD and DO of water samples were estimated using a BOD incubator and a multi parameter analyzer (Model: Session 156, Hach). BOD indicates the appearance of biologically active living organisms in the water body that utilize dissolved oxygen (DO) and decrease the quantity of it in water[13]. Atomic Absorption Spectrophotometer (Model: 220 AAS Varian, Australia) was used to measure the concentration of water-soluble cations and trace metals in water. At first standard solutions of various concentrations were made ready for every elements. Then, through nebulizer the samples were removed and absorbance of a blank was taken as reference.

III. Results and Discussion

pH

The pH of water samples collected from Patuakhali and Kuakata was measured between 7.58 to 8.77 with an average of 8.15±0.32 (Table 2), which is moderately basic. The highest (8.77) and the lowest (7.58) values of pH were observed at site-4 (Kuakata Sunrise & sunset point) and site-6 (Maitbhanga River boatline, Patuakhali), respectively. At site-7 (Kuakata Buddhist temple riverside) and site-3 (Lal Kakrar Dip, Kuakata), the pH ranges were (8.35-8.12) and (8.28-8.22) respectively (Fig. 2). According to DOE standard pH range of water is 6.5 to 8.5 for different rivers of Bangladesh[14]. The preferable pH range for aquatic animals is 6.5 - 8.0 and out of this scale, the aquatic diversity and reproduction of organisms may be affected negatively[15]. WHO stated that the basicity of water may be increased by the presence of bicarbonate, carbonate, and hydroxyl ions and the acceptable range of pH in drinking water is 6.5-8.5 [16,17]. FAO reported that as an indicator of acidity or basicity, the permissible pH range of water for irrigation is 6.5 to 8.4, and outside of this scale the quality of water is alarming for this purpose[18]. The higher value of pH (8.77) points toward the corrosiveness of river water.

EC

The electrical conductivity of water indicates the presence of soluble ions. Results reveal that the level of EC of the collected thirty water samples ranged from 3.27 to 14.35 mS/cm where the mean level was 8.83 mS/cm (Table 2). The less level specifies that lower amounts of ions present in water samples (Fig. 3). Environment, Canada (EC) stated that low, middle, and higher ranges of conductivity of river water are 0 - 0.2, 0.2 - 1, and 1 - 10 mS/cm, respectively[19]. Outside of the middle range of conductivity notifies that the water is unsuitable for certain fishes or bugs and due to high conductivity, saline condition may be observed. The saltiness of water may also be generated by climate change and the conductivity of river water may be increased by polluted water directly discharged by industry or humans. According to Bangladesh standard, the recommended EC for inland surface water and in water for irrigation is 1.2 mS/cm[20]. The permissible value of EC for recreational water is 0.5 mS/cm, for irrigation 0.75 mS/cm and for aquaculture it is 0.8 - 1.0 mS/cm[21]. WHO reported that the electrical conductivity of drinking water is 0.40 mS/cm[22]. In this study, the highest EC value (14.35 mS/cm) at site-3 (Lal Kakrar Dip, Kuakata) reveals high salinity which might be due to the presence of various ions like K^+, Na^+, SO_4^{2-}, Cl^-, Ca^{2+}, Mg^{2+}, and this value is followed by 12.44 mS/cm at site-2 (Kalapara Ghat, Patuakhali).

TOC

Determination of organic carbon in water helps to indicate the level of pollution. The larger the carbon or organic content, the more oxygen is consumed. A high organic content means an increase in microorganisms' growth, which contributes to the depletion of oxygen supplies. WHO reported that organic carbon in river water may be increased by living materials or waste materials and effluents discharged from the industry[23]. TOC was analyzed for thirty water samples accumulated from Patuakhali and Kuakata seashore areas and the amount was from 0.78 - 1.78 mg/L with an average value of 1.24 mg/L in all the samples (Table 2). The concentration of TOC was less than 10 mg/L. It was reported by Rikta that the TOC levels in Dhaleshwari river water ranged from 82.82 mg/L to 50.88 mg/L with a mean level of 69 mg/L. For Padma river, the amount of TOC varied from 2.86 - 3.77 mg/L and the average value was 3.17 mg/L, where ten samples were collected and analyzed from each of the rivers[24].

DO and BOD Analysis

BOD is an indicator of water pollution where high value of BOD means more pollution and low value of BOD reveals less pollution. A total of fifteen water samples were selected for analyzing DO and BOD. The DO values were in the wide range from 8.20 to 8.44 mg/L and the mean DO concentration was 8.33 mg/L (Table 2, Fig. 4). The BOD values varied in the range from less than 0.1 - 0.53 mg/L with the mean value of 0.31 mg/L (Table 2, Fig. 5). DO level was generally high at all the sites which shows that the water bodies contained enough oxygen. While temperature and salinity increase, the solubility of oxygen decreases[23]. DO levels of water can also be decreased due to the presence of industrial waste, high organic matter, and nutrients. Concentrations less than 5 mg/L may negatively affect the functioning and survival of aquatic communities and below 2 mg/L may lead to the death of most fish species. In Maitbhanga and Karnaphuli river, DO levels were found in the range of 5.2-6.2 and 4.5-5.7 mg/L in 2014 and 4.8-6.2 and 5.1-5.8 mg/L in 2015, respectively[14]. Sarwar reported that the mean value of BOD in the water samples collected from the Karnaphuli river (in 2003, 2008) was measured as 247.47±73.22 mg/L and Hossen reported that during 2018, BOD level in Karnaphuli river was found only 4.1±0.57 mg/L at Chittagong port area[25,26].

Ion Chromatography Analysis

Water samples were analyzed for nitrate and sulphate ions. The highest concentration of sulfate ion (437 mg/L) was seen in site-7 (Kuakata Buddhist temple riverside), whereas the lowest amount (217 mg/L) was seen in site-2 (Kalapara Ghat, Patuakhali) (Table 2, Fig. 6). None of the samples were detected for nitrate ion and the concentration of sulphate ion was also low (Fig. 7 and Fig. 8). It is stated that the element (nitrogen) is found in the aquatic environment as nitrate and it has an important role in the eutrophication process which is a serious environmental problem due to depletion of oxygen from water[27-29]. However, sulfate ions may be present in polluted water due to the use of coal, oil, and other sulfur-containing fuel. The analysis of nitrate and sulfate ions is a very important indicator of water quality and the presence of these ions in the aquatic system can create adverse effects. The World Health Organization (WHO) and the United States Environmental Protection Agency (USEPA, 2009) have recommended that the maximum concentration of sulfate ion in the drinking water is 500 and 250 mg/L[30].

Table 2. Water quality parameters of the samples collected from Patuakhali and Kuakata sea beach area

Water SampleID	Sampling Area	Site No.	pH	Conductance (mS/cm)	TOC (mg/L)	Sulphate ion (mg/L)	DO (mg/L)	BOD (mg/L)
S-01	Kalapara Bridge, Patuakhali	01	8.10	5.30	0.78	244	8.30	0.1
S-02			7.89	5.32	0.93	244	8.40	0.21
S-03			7.77	9.86	0.95	257	8.44	0.26
S-04			7.98	3.27	1.10	276	8.41	0.37
S-05	Kalapara Ghat, Patuakhali	02	8.14	3.43	1.78	221	8.32	0.38
S-06			8.02	6.61	1.45	217	8.21	0.38
S-07			8.15	6.60	1.49	296	8.40	0.40
S-08			8.05	6.23	1.65	336	8.41	0.53
S-09			8.11	12.44	1.31	300	8.31	0.24
S-10	Lal Kakrar Dip, Kuakata	03	8.28	14.35	1.21	237	8.30	0.26
S-11			8.24	6.49	1.56	281	8.31	0.25
S-12			8.24	5.85	1.45	337	8.32	0.46
S-13			8.22	9.86	1.35	348	8.30	0.39
S-14			8.27	3.78	1.53	349	8.20	0.1
S-15			8.25	7.03	1.68	328	8.32	0.29
S-16	Kuakata Sunrise & sunset point	04	8.38	7.16	1.41	270		
S-17			8.56	9.86	1.36	228		
S-18			8.36	5.62	1.54	223		
S-19			8.77	3.42	1.53	261		
S-20			8.25	7.03	1.49	347		
S-21	Maitbhanga River, Patuakhali	05	8.05	4.20	1.55	282		
S-22			8.09	4.45	1.26	262		
S-23	Maitbhanga River boatline, Patuakhali	06	7.58	6.29	1.49	279		
S-24			7.65	7.92	1.67	324		
S-25			8.23	8.01	1.52	358		
S-26	Kuakata Buddhist temple riverside	07	8.21	9.24	1.41	310		
S-27			8.17	7.86	1.14	338		
S-28			8.14	8.36	1.20	414		
S-29			8.12	9.12	1.42	437		
S-30			8.35	6.28	1.39	310		

Metal Analysis

River water is very keen to polluted by waste materials like heavy metals because of their easy access. The metals are important for plant growth in a very small level. When their concentration increases to a high level, it turns into toxins and poisons[31,32]. Thirty samples from seven various places were analyzed for Pb, Cd, and Mn. Fifteen samples from the same places were analyzed for As and Hg by AAS. The concentration of Pb, Cd, Mn, As and Hg was expressed as mg/L using the equations obtained from figure 9(a), 9(b), 9(c), 9(d), and 9(e) and the values were found < 0.20 , < 0.01, < 0.02, < 0.005, and < 0.001 mg/L, respectively. The permissible limit by WHO for Pb, Cd, Mn, As and Hg is 0.01, 0.003, 0.5, 0.01 and 0.001 mg/L, respectively and by EU for the same metals the values found 0.05, 0.005, 0.05, 0.05 and 0.001 mg/L, respectively[23]. Bhuyan reported that the concentration of Pb, Cd, Hg, and Mn in the Brahmaputra River was found 0.11, 0.001, 0.001, and 1.44 mg/L, respectively [33]. Heavy metals in water depend on the physicochemical parameters of water such as pH, turbidity, conductivity, salinity and TDS. As water samples were collected from surface level where due to high stream in the rivers, all metals got diluted and because of this reason very low concentration for trace metals were observed.

IV. Conclusions

This study describes physical and chemical parameters of surface water at different points of the Southern part of Bangladesh. The values of pH ranged 7.58 - 8.77 with mean value of 8.15; conductivity 3.27 - 14.35 mS/cm; TOC 0.78 - 1.78 mg/L with mean value of 1.24 mg/L; amount of sulfate ion 217- 437 mg/L; BOD 0.1 - 0.53 mg/L with mean value of 0.31 mg/L; DO 8.20 - 8.44 mg/L with mean value of 8.33 mg/L. The higher pH (8.77) at site-4 indicates the corrosiveness of river water. The highest EC values 14.35 mS/cm and 12.44 mS/cm found at site-3 and site-2, respectively (Kalapara Ghat, Patuakhali) (Lal Kakrar Dip, Kuakata) reveal high salinity with the presence of various ions like K^+, Na^+, SO_4^{2-}, Cl^-, Ca^{2+}, Mg^{2+}. Nitrate ion was not detected and the amount of sulphate ion was within the recommended limit by WHO. The high DO and low BOD values indicate good water quality for the aquatic environment. The experimental results revealed that the collected water samples are slightly basic, well-oxygenated, have a lower amount of sulphate ion, and lower contamination by trace elements. Therefore, the quality of water is quite good.

Acknowledgments

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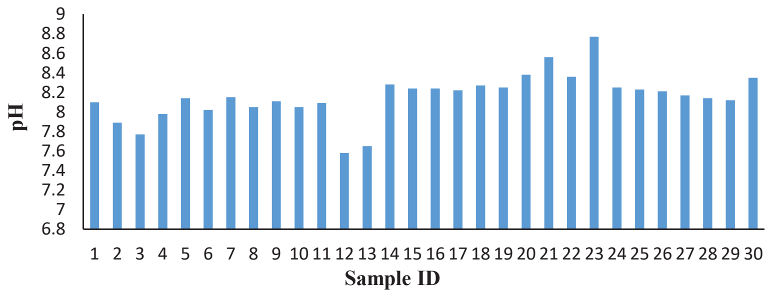

Fig. 2. pH of water samples

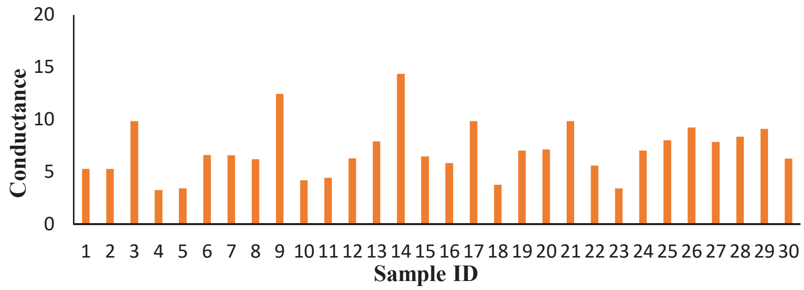

Fig. 3. EC (mS/cm) of water samples

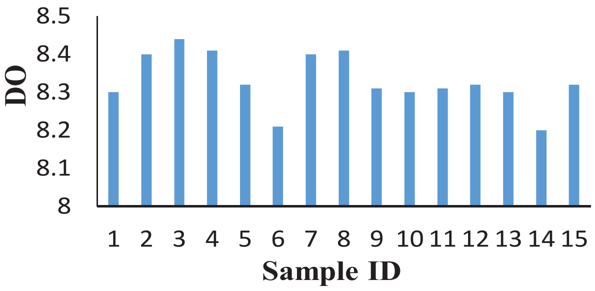

Fig. 4. DO (mg/L) in water samples

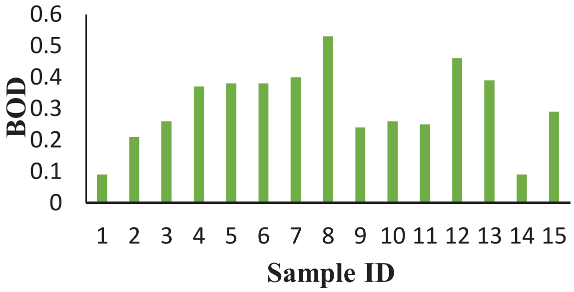

Fig. 5. BOD (mg/L) in water samples

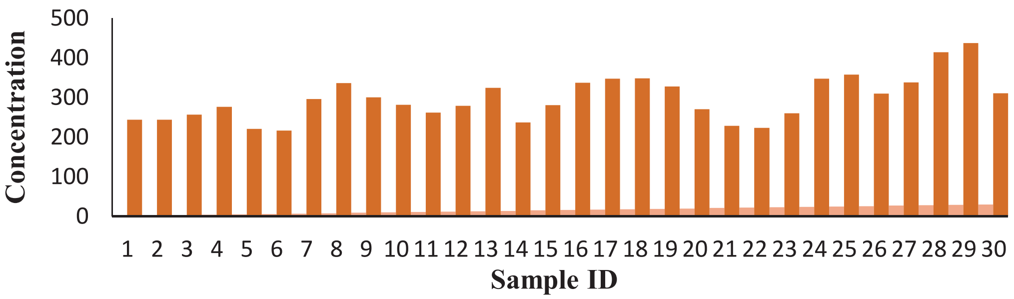

Fig. 6. Sulphate ion (mg/L) in water samples

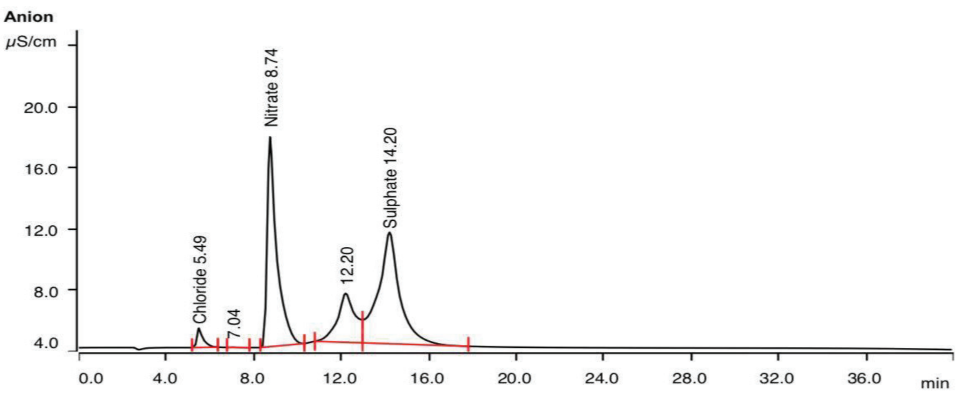

Fig. 7. Ion chromatogram for a standard solution (50 ppm)

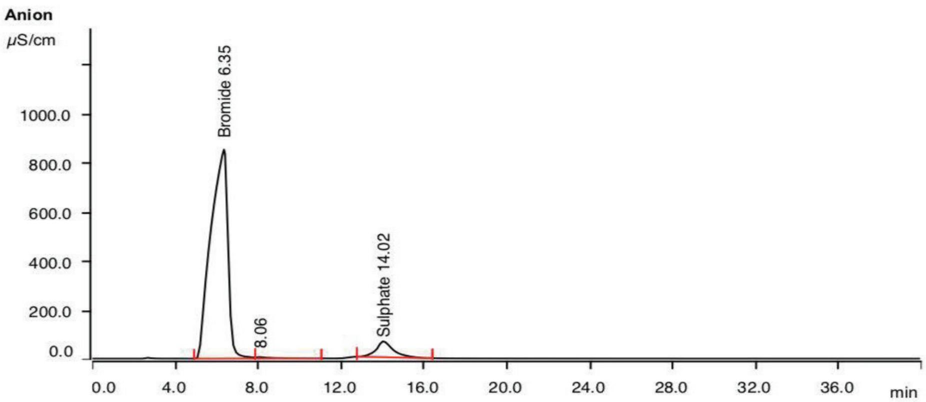

Fig. 8. Ion chromatogram of water sample collected from Kuakata region

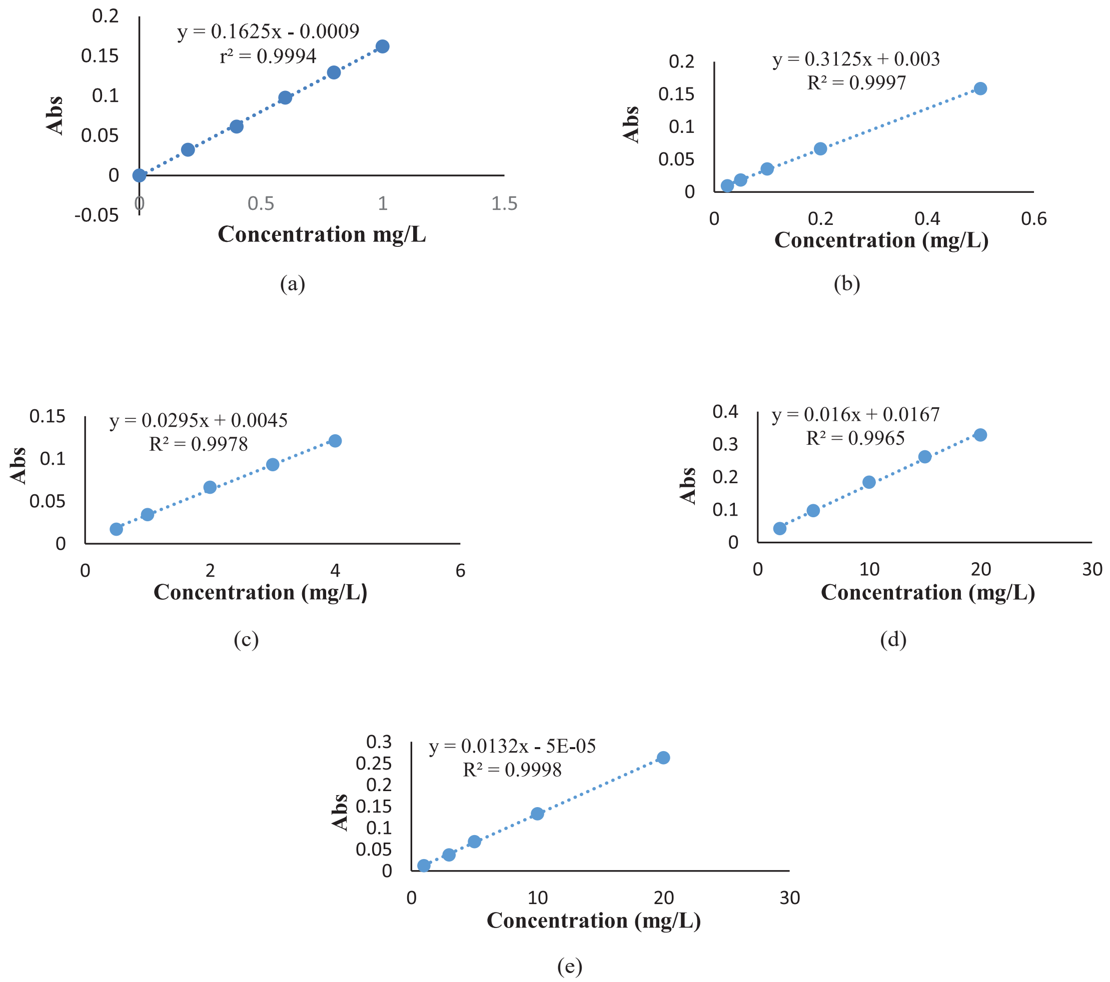

Fig. 9. Calibration curves of (a) Mn, (b) Cd, (c) Pb, (d) As, (e) Hg ions

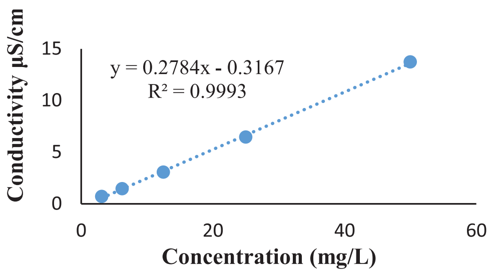

Fig. 10. Calibration curve of NO_3^- ion

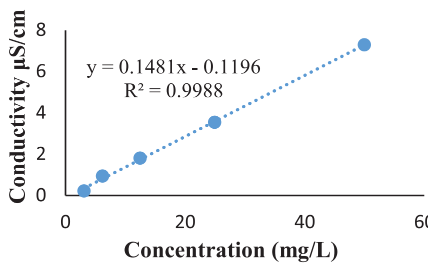

Fig. 11. Calibration curve of SO_4^{2-} ion

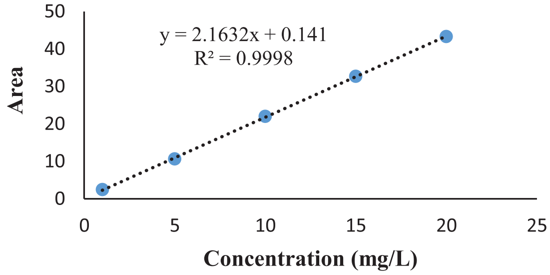

Fig. 12. Calibration curve of NPOC

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