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PHYSICO-CHEMICAL ASSESSMENT OF WATER QUALITY PARAMETERS IN RUPSHA RIVER OF KHULNA REGION, BANGLADESH

M. Shahidul Islam[a]*, Suman C.Mohanta[a], M. Abu Bakar Siddique[b], M. Abdullah-Al-Mamun[a], Nazmul Hossain[a],Ummey Hafsa Bithi[b]

[a] Department of Chemistry, Jessore University of Science and Technology, Jessore, Bangladesh.
[b] Analytical Division, BCSIR Laboratories, Dhaka-1205, Bangladesh.
Corresponding author: M. Shahidul Islam

ABSTRACT

The present study was assumed to evaluate the physicochemical parameters of the water and to determine heavy metal concentrations in water of Rupsha River, Khulna, Bangladesh. The water quality parameters were measured for samples collected from twenty-two (22) sampling stations throughout the year 2016-2017. Obtained results were compared with the standard values of “Bangladesh Standards and Testing Institution (BSTI)”and “World Health Organization (WHO)” value as well as experimental results were analysed statistically with MS-Excel and SPSS software and Pearson Correlation Program. The results were as follows: pH: 8.1-9.0, alkalinity: 64-126 mgL^{-1}, EC: 13730-20470 mgL^{-1}, TDS: 6900-11000 mgL^{-1}, total hardness: 1410-2500 mgL^{-1}, TSS: 0.578-4.678 mgL^{-1}, chloride: 444-724 mgL^{-1}, Cr: <0.005-4.33 mgL^{-1}, Cd: <0.001 mgL^{-1}, Co: <0.01 mgL^{-1}, Cu: <0.10-0.28 mgL^{-1}, Fe: 6.97-45.64 mgL^{-1}, Pb: <0.10-0.15 mgL^{-1}, Mn: 0.20-2.19 mgL^{-1}, Ni: <0.10-0.14 mgL^{-1}, Ag: <0.10-0.10 mgL^{-1}, Zn: <0.05-0.63 mgL^{-1}. Among the parameters, some values like pH, EC, TDS, and total hardness were found very much higher than BSTI and WHO allowable limits in water. The accumulations of heavy metals concentrations like Cr, Fe, Pb, Mn, Ni, and Ag were found higher than the standard values of “World Health Organization”. Significant positive and negative correlations were found among different physicochemical parameters from Pearson Correlation Program. Therefore, the water of the Rupsha river in this area is highly polluted and needs monitoring of water quality as well as protective measure to reduce pollution.

Keywords: *Bangladesh, Industrial activity, Khulna region, Rupsha River, Water quality parameters*

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I. INTRODUCTION

Environment pollution is a global concern, it is the instability, disorder, discomfort to the ecosystem due to the contaminants to natural environment[1,2].The industrial wastewaters and runoff from agricultural land are accumulated to the environment majorly by rivers[3]. Water pollution is the pollutants of water bodies (e.g. lakes, rivers, oceans, aquifers and groundwater) as well as highlighted as water quality degradation that alter its physicochemical characteristics of water and impede its normal use. The contaminants originated either as solid, liquid or gaseous form have various effects depending on their amount, potential danger and fragility in the environment where they are released. These pollutants can have irrespective of the sources of pollutants whether human or a natural origin may be responsible for water pollution by decomposition of organic debris. The saltwater invades whereas landslides, earthquakes, volcanic dust eruption causes water blackening[4,5].However,now-a-days water pollution has become severe and the use of water sources as dumps has made environmental contamination in the visible form [3]. The discharge of inadequate treated industrial wastes containing pollutants and contaminants in to water bodies either in direct or indirect ways brings about water pollution[6].The discharge to water of large amount of industrial waste, which contains harmful substances including many toxic heavy metals, toxic chemicals, pesticides and many other chemicals from a variety of industries[7].In addition, organic water pollutants such as detergents, disinfection by-products from chemically disinfected drinking water (such as chloroform), food processing waste, fats and greases, pesticides and herbicides, emission of industrial solvents from improper storage. Besides, inorganic pollutants like acidity caused by industrial ejections, ammonia from food processing waste, chemical waste as industrial by-products, nitrates and phosphorus fertilizers, heavy metals from motor vehiclesand acid mine drainage have significant contribution to water pollution[8].It is alarming to note that drinking water may be polluted with microorganisms, arsenic, polycyclic aromatic hydrocarbons (PAHs), organic pollutants, nitrate, nitrite and heavy metals resulting may people in the threat of unsafe water[9].Presently, heavy metal contamination in water is avitalinternational environmental concern since ground water is also not safe for drinking purpose due to heavy metal contamination[10].The level of heavy metals has report to increase due to industrial, mining and agriculturalactivities[11,12].The liberation of heavy metal wastes into receiving waters may affect in many physical, chemical, and biological disorderssuch as lower the energy levels, damage DNA and change the gene expression[13]. In marineenvironments, the number of living organisms very much decreases due to heavy metals contamination. The development of aquatic organisms has troubled by heavy metalcontaminations and can cause severe defeats in biological wastewater treatment plants [14].Heavy metals are responsible for decreasing of mental developments and central nervous function as well as brain impairment. Furthermore, lungs, kidneys, liver, heart, skin, muscle, blood composition, and other vital organs for human and other living organisms are being spoiled by severe metals infestation.Therefore,physicochemical assessment and monitoring of surface and groundwater resources is of paramount importance [13, 15].

Bangladesh is a riverine country with a large marshy jungle coastline of 580 km in the Bay of Bengal. Like other developed and developing countries of the world the accumulation of heavy metals in river ecosystems is also growingin Bangladesh and getting serious day by day [16]. Khulna city is the third largest industrial city after the position of Dhaka and Chittagong city of the country. A lot of industries have been built up along the Rupsha River of Khulna. The Department of Environment (DoE), Bangladesh has already marked this area as most pollution hotspots [17]. The major industries of Khulna city are chemical complexes, fish processing plants, oil and gas industries, cement factories, paint and dye manufacturing plants, several soap and detergent factories and a number of light industrial units. They directly discharge untreated toxic effluent into Rupsha river which ultimately carried out to the Sundarbans through Bhairab-Rupsha River system [3, 17]. Therefore, there is a need for continuous monitoring of the pollutants load in this river water so as to safeguard the public health preventing from using this water. Thus, the present paper tries to focus on the monitoring of physicochemical quality and present heavy metal pollution status of Rupsha River water around Khulna city.

II. EXPERIMENTAL

2.1 Selection of Study Area

The Rupsha river around Khulna city was the study area. Khulna is the Southwestern district in Bangladesh, the largest delta in the world. Although the country is mainly dominated by three major rivers like the Padma, the Brahmaputra and the Meghna, the Rupsha has an important role for the development and industrialisation of Khulna city, third largest industrialist of the country. It is 50 km away from the largest mangrove Sundarban on the upstream of the Rupsha [3] and different types of industries have been established along the side of this river. In fact, the lower part of the Vhairab river near Khulna city is known as Rupsha [18].Twenty-two (22) important industrial sites of Khulna region were selected for the present study from a recommennaissance survey of the industries near the Rupsha. The sampling locations were: Labanchora, Chanmari bazar ghat, Khulna Rupshaghat, Custom ghat (1), Custom ghat (2), Jail Khanaghat, Shingar char ghat, Labanchora (Seven ring cement industry area), Char mosque ghat, Eastern Natun bazar ghat, Labanchora (Rupsha bridge area), Natun bazar ghat, Rahamatnagartrolarghat, Char rupshaghat, Eastern rupshaghat, Char Rupshaghat (Ship breaking area), Eastern Natun Bazar Ghat (Ship breaking area), Char mosque ghat (Deloar fish field area), Shingar char ghat (Ramna salt Ltd. Area), Waterman para ghat, Natun bazar ghat (Chobi fish traders) and Eastern Jail Khanaghat area.

Fig.-1. Sampling location and sites of Rupsha River.

III. SAMPLE COLLECTION AND PRESERVATION

To have a preliminary idea of the current status of the water quality in the study area and to select the sampling sites, a survey was carried out. Simple Random Sampling (SRS) method was applied to collect the samples from different spots **(Fig.1)** and conditions as well as multiple samples were collected from the same spots to minimise the tide condition of the river. Furthermore, to take into account the seasonal variation, samples from different sites were collected throughout the hydrological year 2016-17. The collection of samples and their preservation were done according the reported standard methods [15,19]. Amber colour polyethylene bottle properly cleaned and rinsed with 8M HNO_3 followed by several times distilled water washing was used for collecting and preserving the water samples. Water samples were collected 2-4 equal volumes from vertical section at 3 to 9-inch depth of the surface of the middle flow of the river and the samples of the same site were mixed in a volume of 1-1.5L which was transferred to a bottle as well as preserved for the laboratory analysis.

Table1. Water qualitydata of Rupsha River and Standard values

Parameters	**Minimum**	**Maximum**	**Study area (mean value)**	**BSTI**[20]	**Health based guideline by the WHO**[21-23]
pH	8.1	9.0	8.5	6.4-7.4	6.5-8.5
Temperature (^{0}C)	27	34	29.7	20-30	<40
Alkalinity/ mgL^{-1}	64	126	90.45	-	-
EC/ μScm^{-1}	13730	20470	16705	3000	750
% NaCl	36.8	24.9	29.99	-	-
TDS/ mgL^{-1}	6900	11000	8638	Max. 1000	Max. 500
T. Hardness/ mgL^{-1}	1410	2500	2063	200-500	300
TSS/mgL^{-1}	0.578	4.768	1.43	-	-
Chloride/ mgL^{-1}	444	724	566.48	Max. 600	Max. 250
Cd/ mgL^{-1}	<0.001	<0.001	<0.001	0.005	0.003
Cr/ mgL^{-1}	<0.005	4.33	0.45	0.05	0.05
Co/ mgL^{-1}	<0.01	<0.01	<0.01	0.05	0.05
Cu/ mgL^{-1}	<0.10	0.28	0.14	Max. 1	Max. 2
Fe/ mgL^{-1}	6.97	45.64	22.51	0.3-1.0	Not exceeding 0.1
Pb/ mgL^{-1}	<0.01	0.15	0.055	0.05	0.01
Mn/ mgL^{-1}	0.20	2.19	0.70	0.1	Not exceeding 0.05
Ni/ mgL^{-1}	<0.10	0.14	0.12	0.05	0.02
Ag/ mgL^{-1}	<0.10	0.10	0.10	0.02	0.05
Zn/ mgL^{-1}	<0.05	0.63	0.36	5.0	5.0

BSTI= Bangladesh Standards and Testing Institute[20].

Table2. Pearson correlation among all the parameters using SPSS statistical software[2,24].

Correlations

	Temperature	pH	NaCl	TDS	TSS	Chloride	Alkalinity	EC	Hardness	Pb	Cr	Ni	Cu	Zn	Ag	Fe	Mn
Temperature	1	.928**	-.865**	-.90**	-.27	-.844**	.763**	-.8**	-.737**	.95**	-.36	-.532*	-1*	.349	-.20	.000	-.180
pH	.928**	1	-.783**	-.85**	-.32	-.775**	.586*	-.6**	-.723**	.89**	-.20	-.376	-.3	.406	-.09	-.03	-.052
NaCl	-.865**	-.783**	1	.98**	.53*	.945**	-.354	1.0**	.754**	-.7**	.49*	.584**	1**	-.122	.347	.243	.398
TDS	-.898**	-.853**	.977**	1	.46*	.941**	-.433	.97**	.752**	-.8**	.40	.589**	1**	-.218	.260	.189	.305
TSS	-.273	-.317	.531*	.455*	1	.552**	.162	.63**	.296	-.068	.47*	.260	1**	.290	.43*	.70**	.56**
Chloride	-.844**	-.775**	.945**	.94**	.6**	1	-.332	.92**	.669**	-.7**	.49*	.646**	1**	-.108	.345	.300	.407
Alkalinity	.763**	.586*	-.354	-.433	.16	-.332	1	-.36	-.295	.91**	-.08	-.139	-1	.280	-.03	.50*	.207
EC	-.783**	-.635**	.997**	.97**	.6**	.921**	-.362	1	.610**	-.56*	.44	.509*	1**	.103	.338	.326	.443
Hardness	-.737**	-.723**	.754**	.75**	.30	.669**	-.295	.61**	1	-.7**	.29	.252	.5*	-.211	.174	.105	.191
Pb	.952**	.891**	-.739**	-.79**	-.07	-.731**	.914**	-.56*	-.670**	1	-.28	-.422	-.4	.349	-.14	.167	-.055
Cr	-.363	-.204	.491*	.403	.47*	.487*	-.082	.440	.298	-.282	1	.124	1**	.62**	.95**	.55**	.86**
Ni	-.532*	-.376	.584**	.59**	.26	.646**	-.139	.51*	.252	-.422	.12	1	.5*	-.336	-.15	.155	.285
Cu	-.524*	-.337	.729**	.63**	.6**	.746**	-.076	.70**	.491*	-.383	.9**	.512*	1	.378	.71**	.53*	.82**
Zn	.349	.406	-.122	-.218	.28	-.108	.280	.103	-.211	.349	.6**	-.336	.4	1	.73**	.54*	.69**
Ag	-.198	-.094	.347	.260	.43*	.345	-.032	.338	.174	-.141	1**	-.147	1**	.73**	1	.51*	.76**
Fe	.000	-.035	.243	.189	.7**	.300	.502*	.326	.105	.167	.5**	.155	.5*	.536*	.51*	1	.80**
Mn	-.180	-.052	.398	.305	.6**	.407	.207	.443	.191	-.055	.9**	.285	1**	.69**	.76**	.80**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

IV. EXPERIMENTAL METHOD

Parameters like temperature, pH, EC and TDS were tested at the sampling spots. Alkalinity, Chloride and hardness were estimated chemically through titrimetric method, argentometric method, EDTA titration method respectively in the laboratory for fresh samples immediately after sample collection. For EC, TDS, TSS and

%NaCl a combined meter (Model-HI255, HANNA) was used. On the other hand, the heavy metals (Pb, Cd, Cr, Co,Ni, Cu, Zn, Ag, Fe and Mn) were analysed with atomic absorption spectrophotometry (AAS)[Varian Model-AA240FS] after the wet-digestion of samples [25-27]. MS-Excel and SPSS software were used for the statistical analysis of the obtained data. Pearson correlation among the different parameters were also determined to find the reliability of the results and dependence of the individual parameters with others [24].

V. RESULTS AND DISCUSSION

Table 1 shows the results of physico-chemical analysis of water of the Rupsha river, Khulna region calculated on the basis of WHO and BSTI standards. The pH of water is an important parameter since it plays significant role in describing the acidity and alkalinity of water as well as the coagulation, disinfection and corrosion control process involved. For example, lower pH value indicates higher potential level of corrosion [28].The descriptive statistics of the water pH value for most of the samples were found in the alkaline, pH range 8.1 to 9.0 **(Table 1),**i.e. the water of the Rupsa River is alkaline**.** The pH of waterwas also found positively correlated with alkalinity and Pb**(Table 2)**.The EC of water which is a measure of ionic content and activity was found in the range 13730 μScm^{-1} to 20470 μScm^{-1} and positively correlated with % NaCl, TDS, TSS, chloride, hardness. EC values were remarkably higher than both BSTI and WHO standard. TDS values ranged from 6900 mgL^{-1} to 11000 mgL^{-1} were positively correlated with % NaCl, TSS, chloride, EC, hardness, Pb, Ni and Cu exceeded the limit of BSTI standard (Max 1000 mgL^{-1}). TSS of water was also found to vary from 0.578 mgL^{-1} to 4.768 mgL^{-1} and positively correlated with chloride, EC, Cu, Mn and Fe. Thus, the water in the study area contained greater amount dissolved solids and suspended solids. Alkalinity test for water quality is an important test since alkalinity of water maintain the suitable pH range 6.0-9.0 for fishes and other aquatic lives [29].Alkalinity of water was found to vary from 64 mgL^{-1} to 126 mgL^{-1} and positively correlated with temperature, pH, Pb, and Fe. The total alkalinity may majorly be the presence of carbonates and bicarbonates in water since the phenolphthalein alkalinity test was negative for all the samples analysed.

It has been reported that there is an inverse relation between hardness of water and cardiovascular diseases though reliable evidence are not unavailable [30].Nevertheless, total hardness of water is an important parameter for industrial and household usage. It was found to vary from 1410 mgL^{-1} to 2500 mgL^{-1}, i.e. values of hardness for all the samples exceeded the limit of WHO standard (Max 500 mgL^{-1}) and was positively correlated with % NaCl, TDS, and EC. Chloride of water was also found higher values varying from 444 mgL^{-1} to724 mgL^{-1} and it showed positive correlation with temperature, TDS, TSS, EC, hardness, Ni and Cu. High chloride concentration increases corrosive property of water as a result of increased the electrical conductivity of water.Iron content in the samples ranged from 6.97 mgL^{-1} to 45.64 mgL^{-1} and average value exceeded the standard limit. So, use of this water may create rapid rise of respiration, pulse rates, congestion of blood vessels, hypotension and drowsiness to human body[28]. The concentrations of Mn was estimated in the range 0.20 mgL^{-1} to2.19 mgL^{-1} which is higher than the standard value, 0.05 mgL^{-1}. Although Manganese does not have the toxicity of producing cancer or damaging reproductive, thehigh-level manganese content may noticeably impart colour, odour, or taste to the water[31]. Nickel was observed to vary from <0.10 mgL^{-1} to0.14 mgL^{-1} and the average value was greater than the permissible limit of BSTI & WHO and revealed that consumption of this water may cause harmful health effect in humans like allergic reaction, stomach ache as well as blood and kidney diseases[32].Excess lead content in the drinking water is reported to be responsible for mild anaemia, brain damage, vomiting, loss of appetite, convulsions, uncoordinated body movements and stupor, eventually producing coma and death as its toxic symptoms[28]. Pb content in the water samples was found in the level from <0.01 mgL^{-1} to 0.15 mgL^{-1} indicated higher than standard value and makes water unusable. Silver ranged from <0.10 mgL^{-1} to 0.10 mgL^{-1} and found more than the standard value of BSTI and WHO. Toxic effects on fish in fresh water have been observed at concentrations as low as 0.17 μgL^{-1} whereas for fresh water aquatic life, total recoverable silver should be within 1.2 mgL^{-1}[19].Health effects related to chromium especially hexavalent chromium exposure include diarrhoea, stomach and intestinal bleedings, cramps, liver and kidney damage. Hexavalent chromium is mutagenic. Toxic effects may be passed on to children through the placenta [33]. Chromium concentration of water samples was found to vary from <0.005 mgL^{-1} to 4.33 mgL^{-1}, greater than standard limit. However, Cd, Co, Cu and Zn contents in all the samples ranged within the acceptable limits.

VI. CONCLUSIONS

The present physicochemical study revealed that water of the study areas is alkaline and the values of chloride, TDS, total hardness and total alkalinity of this region exceeded the BSTI limit. Similarly, heavy metals like Cr, Fe, Pb, Mn, Ni, and Ag were far higher than the standard values of the BSTI and WHO though the level of Cd, Co, Cu and Zn were found within the permissible limit of both standards. However, the parameters are positively correlated. Hence, it may be concluded that the water of the coastal river Rupshain this region is polluted to a significant extent and consequently, this pollution of aqua systems must induce further adverse effect to the local human beings as well as other living organism through the irrigation and household water use. Therefore, it is very important to monitor of the coastal activity to get valuable information for the environmentalists, policy makers as well as different stakeholders of coastal environment and to protect the coastal ecosystems. A systematic and periodic inspection of each industry beside Rupsha river is necessary to issue the certificate of compliances by the Department of Environment (DoE). More extensive short and long term scientific study should immediately be started to assess the impacts of industrial activities on coastal water.

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