http://dx.doi.org/10.22161/ijeab/4.1.1 ISSN: 2456-1878

Physicochemical Status of Sitalakkhya River, an Ecologically Critical Area (ECA) of Bangladesh

Bidhan Bhuson Roy, Rezuana Afrin*, Subodhe Chandra Barman, Md. Younus Mia

Department of Environmental Science and Resource Management, MawlanaBhashani Science and Technology University, Tangail-1902, Bangladesh.
*Corresponding authors e-mail: afrin.mbstu038@gmail.com

***Abstract*—** *The study was conducted to assess the water quality of the Sitalakkhya River, Narayangonj, Bangladesh and observe its temporal changes forthe physicochemical parameters of water from March to May, 2015. The present study showed that the color of water was deep black or black and emittedobnoxious smell. It was found in the study that the temperature, transparency, TDS, EC, pH, DO, alkalinity, hardness, NO_3^-, Cl^- and BOD were ranged from 31.5-34.6^{0}C, 15.25-27.30 cm, 291-781 ppm, 558-2664 ppm, 7.57-8.60, 1.4-3.6 ppm, 123-435 ppm, 203-332 ppm, 0-89.13 ppm, 51.68-237.36 ppm and 3.21-17.3 ppm, respectively. Most of the observed parameters have exceeded permissible limits except pH and Cl^- indicating higher concentrations of organic and inorganic pollutants present in the river.According to the study,significant strong positive correlations were found in temp. vs pH (r= 0.774, p< 0.05), temp. vsCl^- (r= 0.954, p< 0.05), temp. vs BOD (r= 0.747, p< 0.05), TDS vs EC (r= 0.955, p< 0.05), pH vsCl^- (r= 0.808, p< 0.05), pH vs BOD (r= 0.864, p< 0.05) and DO vsNO_3^- (r= 0.758, p< 0.05) in March; temp. vsNO_3^- (r=0.915, p< 0.05), TDS vs EC (r= 0.949, p< 0.05), TDS vs DO (r= 0.765, p< 0.05) and DO vshardness (r= 0.745, p< 0.05) in April andtransparency vsNO_3^- (r= 0.906, p< 0.05), TDS vs EC (r= 0.922, p< 0.05), TDS vs pH (r= 0.836, p< 0.05), EC vspH (r= 0.982, p< 0.05) and pH vs hardness (r= 0.764, p< 0.05) in May. Significant strong negative correlations were found in EC vs alkalinity (r= -0.745, p< 0.05), DO vsBOD (r= -0.876, p< 0.05) and NO_3^- vs BOD (r= -0.765, p< 0.05) in March and TDS vsCl^- (r= -0.774, p< 0.05), EC vsCl^- (r= -0.758, p< 0.05), hardness vs BOD (r= -0.775, p< 0.05) and NO_3^-vsCl^- (r= -0.763, p< 0.05) in April.The hydrochemistry of the water body has revealed that the water is unsafe for human health, aquatic organisms and also for household, irrigational and industrial uses without proper treatment.*

Keywords*— *Sitalakkhya River, water quality, physicochemical parameter.

I. INTRODUCTION

Bangladesh is one of those polluted countries, which currently holds 1176 industries that discharge about 0.4 million m^3 of untreated waste to the rivers in a day [17]. In terms of quality, the surface water of the country is vulnerable to pollution from untreated industrial effluents and municipal wastewater, runoff from chemical fertilizers and pesticides, and oil and lube spillage in the coastal area from the operation of sea and river ports. Water quality also depends on effluent types and discharge quantity from different types of industries, types of agrochemicals used in agriculture, and seasonal water flow and dilution capability by the river system [7].

Dhaka city is surrounded by a number of rivers and canals of which Turag, Sitalakkhya, Buriganga, Dhaleshwari and Balu are the important ones. The surface water along these peripheral rivers of Dhaka city is known to be highly polluted due to municipal and industrial untreated waste waters that are discharged into these rivers [15]. Pollution is so severe in the Buriganga, Sitalakkhya and Balu rivers that it is almost impossible to treat the water for making it suitable for human use. For this critical situation, on September 2009, Department of Environment (DoE) declared Buriganga,Sitalakhya and Balu rivers as Ecologically Critical Area (ECA) [8].

The river Sitalakkhya is one of the most prominent rivers in the flood plain region of Bangladesh. It is located in Narayangonj City, the second most vital industrial zone of the country. In spite of being an Ecologically Critical Area huge quantities of untreated domestic and industrial wastes are being released every day in the Sitalakkhya River. The water quality of this river is deteriorating rapidly, especially during dry season at certain reaches of the river [1].

The wastes, effluents and agrochemicals contain heavy metals, toxic substances, germs and nitrogen containing toxic substances which pollute the natural system of Sitalakkhya River and it actually acts as a sink. Thus a serious environmental hazards is created which endangers human health and cause problems to aquatic lives. So, the Sitalakkhyariver needs attention to save it from destruction. The objective of the present study is to assess the water quality of Sitalakkhyariver by analyzing physicochemical parameters and make a temporal correlational analysis.

II. MATERIALS AND METHODS

2.1 Study area

The study was conducted from March to May, 2015 at the Sitalakkhya River in Narayangonj (Fig. 1). Sitalakshya River is a distributary of the Brahmaputra. In its initial stages it flows in a southwest direction and then east of the city of Narayangonj in central Bangladesh until it merges with the Dhaleshwari near Kalagachhiya. The river is about 110 kilometers (68 miles) long and at its widest, near Narayangonj, it is 300 meters (980 ft) across.

2.2 Sample collection

Water samples were collected from 6 sites of the river namely S-1 (Taraboghat), S-2 (Taitkkakhal), S-3 (Shenpara), S-4 (Kachpur Bazar) and S-5 (Monjilkhola) and S-6 (Shiddhirgonj) from March to May, 2015. Samples were collected in 250 ml black coated plastic bottles with three replications from each point. Prior to sample collection, all bottles were cleaned with distilled water.

2.3 Sample analysis

The water quality parameters such as temperature and pH were determined by the thermometer and digital pH meter (model-pH Scan WP 1, 2, Malaysia), respectively. Transparency was measued by secchi disc by following proper method [21]. Electrical Conductivity (EC) and Total Dissolved Solids (TDS) were determined by digital EC meter and digital TDS meter (model-HM digital, Germany), respectively. Dissolved oxygen (DO) was determined by digital DO meter (model-D. 46974, Taiwan). Alkalinity was measured by titration method and the EDTA method was used to determine the hardness of water. The biological oxygen demand (BOD) was measured by two steps incubation method [21 and 12].

2.4 Statistical analysis

The physicochemical parameters for all the study sites were analyzed by calculating Pearson's correlation coefficient (r) value.

III. RESULTS AND DISCUSSIONS

3.1 Physicochemical Properties of the Study Area

The observed water color was black in all sampling stations. But phytoplankton enriched dark greenish blue, red or brown color is good for fishes [6] and the standard is colorless [23].

During the study period (at all sampling stations) the maximum water temperature 34.6^{0}C was recorded in May (S6) and minimum 31.5^{0}C was recorded in March (S1) (Table 1). In case of river water temperature, the DoE standard for sustaining aquatic life is within 20 to 30^{0}C both in dry and wet season [4] and all the observed values exceeded the standard limit indicating higher level of pollutants in water. In the study, temperature showed significant strong positive correlation with pH ($r= 0.774$, $p< 0.05$), Cl^- ($r= 0.954$, $p< 0.05$) and BOD ($r= 0.747$, $p< 0.05$) in March and NO_3^- ($r=0.915$, $p< 0.05$) in April. A study found the temperature of the Sitalakkhya river varied from 20.5 to 31.3^{0}C [13]. Many mills and factories are constructed on the bank of this river who use the river's water for cooling purpose and also dispose the wastes into the river thus increase the temperature.

The maximum water transparency value 27.30 cm was recorded in May (S5) and minimum 15.25 cmwas recorded in March (S1) (Table 1). According to WHO, the standard value of transparency is 40 cm and transparency levels are low at all sampling points. In the study, transparency showed significant strong positive correlation with NO_3^- ($r= 0.906$, $p< 0.05$) in May.

The observed maximum TDS value 781 ppm was recorded in April (S1) and minimum 291 ppmwasrecorded in May (S1) (Table 1).High TDS value indicatesthe presence of an appreciable quantities of bicarbonates, sulfates and chlorides of Ca, Mg and Na [14].In the study, TDS showed significant strong positive correlation with ECin March ($r= 0.955$, $p< 0.05$), April ($r= 0.949$, $p< 0.05$) and May ($r= 0.922$, $p< 0.05$); DO ($r= 0.765$, $p< 0.05$) in April and pH ($r= 0.836$) in May and significant strong negative correlation with Cl^- ($r= -0.774$, $p< 0.05$) in April.A study found the TDS of the Sitalakkhyariver varied from 80 to 754 ppm [13]. Dumping of industrial wastes is mainly responsible for increasing TDS level in this river.

The observed maximum EC value 2664 µS/cm was recorded in March (S2) and minimum 558 µS/cm was recorded in May (S1) (Table 1).The standard value of EC is 250 µS/cm [23] and all the values were greater than the permissible limit indicating presence of ionic compounds as well as higher concentration of inorganic pollutants in

http://dx.doi.org/10.22161/ijeab/4.1.1 *ISSN: 2456-1878*

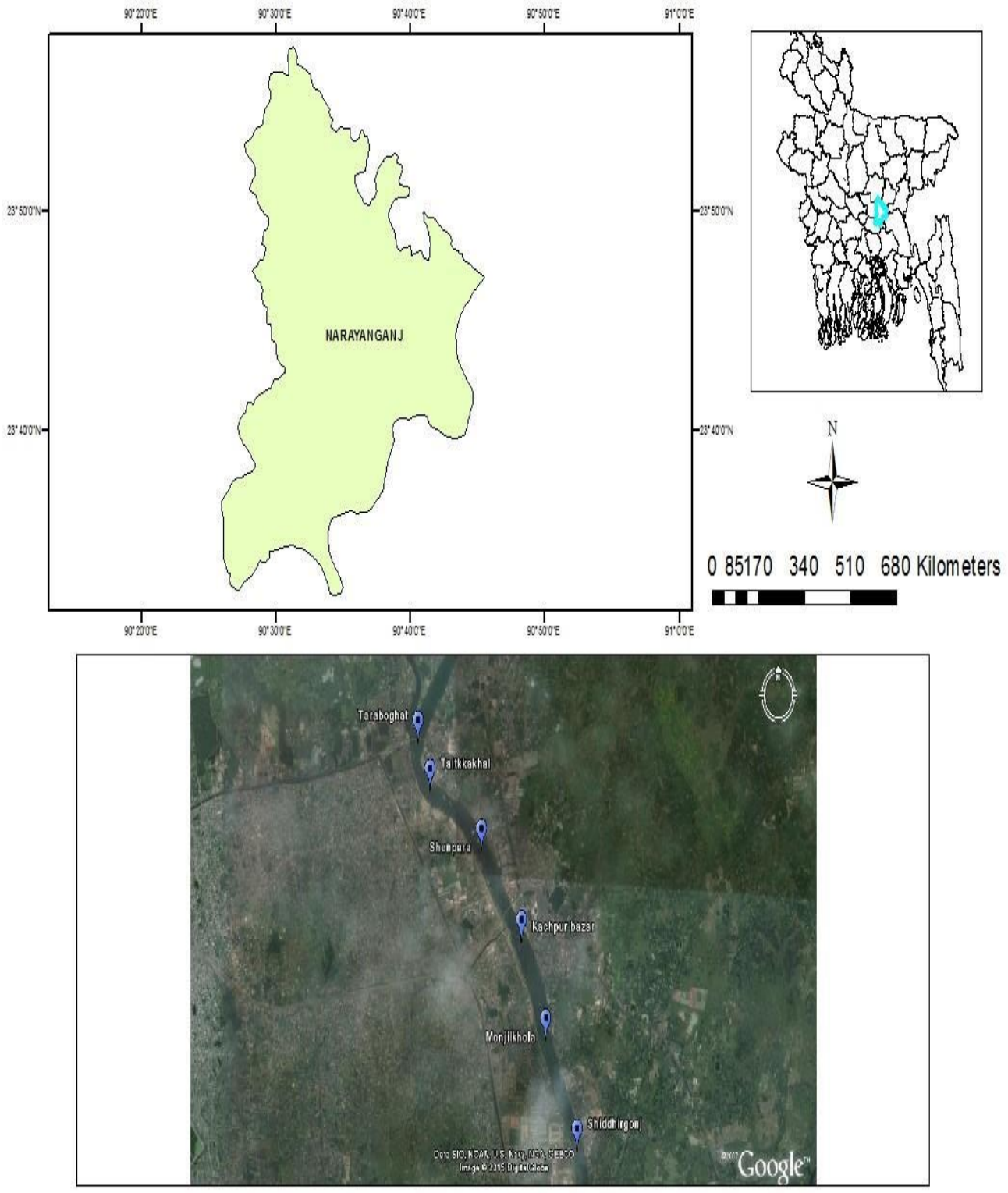

Fig. 1: Map showing the study area with sample collection points.

http://dx.doi.org/10.22161/ijeab/4.1.1 *ISSN: 2456-1878*

water.In the study, EC showed significant strong positive correlation with pH (r= 0.982, p< 0.05) in May; significant strong negative correlation with alkalinity (r= -0.745, p< 0.05) in March and Cl^- (r= -0.758, p< 0.05) in April.A study found the EC of the Sitalakkhyariver varied from 121 to 1167 µS/cm [13]. Releasing chemical wastes containing ionic compounds causes increase in EC level in this river.

In this study, the maximum pH value 8.60 was recorded in April at Station- 2 (S2) and minimum 7.57was recorded in May at Station- 1 (S1) (Table 1) and all the observed values were within the standard range (6.5-9.0). In the study, pH showed significant strong positive correlation with Cl^- (r= 0.808, p< 0.05) and BOD (r= 0.864, p< 0.05) in March and hardness (r= 0.764, p< 0.05) in May. A study found the pH of the Sitalakkhya river varied from 6.9 to 8.0 [13]. Most of the industries use lime to neutralize the acidic condition of the effluents before releasing into the atmosphere thus the pH level of this river water is almost neutral.

The maximum DO value 3.6 ppm was recorded in May (S6) and minimum 1.4was recorded in March (S3) (Table 1). The standard range of DO for fish culture is from 5 ppm to saturation [16] and all the observed values were below the standard level. DO levels of 3 ppm or lower should be regarded as hazardous to lethal under stream and lake conditions [9]. Such low value of DO indicates presence of high organic compounds in water and doesn't support the survival of aquatic life. In the study, DO showed significant strong positive correlation with NO_3^- (r= 0.758, p< 0.05) in March and hardness (r= 0.745, p< 0.05) in April and significant strong negative correlation with BOD (r= -0.876, p< 0.05) in March. A study found the DO of the Sitalakkhyariver varied from 0.5 to 3.5 ppm [13]. Huge industrial and household loads are responsible for decreasing DO level in this river and also indicates huge microbial growth in water.

The maximum alkalinity 435 ppm was recorded in March (S4) and minimum 123 ppmwas recorded in May (S3) (Table 1). The standard level of alkalinity is <100 ppm [18] and all the observed values were higher than this standard value indicating high alkaline condition of water.

The maximum hardness 332 ppm was recorded in April (S2) and minimum 203 ppmwas recorded in March (S4) (Table 1). The counter-ions associated with the bicarbonate and carbonate fraction of alkalinity are the principal ions responsible for hardness [3]. The standard level of hardness is 123 ppm [12] and all the observed values were higher than this standard value. In the study, hardness showed significant strong negative correlation with BOD (r= -0.775, p< 0.05) in April. Increasing level of chemical wastes disposal causes high hardness level of water.

In the present study, the maximum Nitrate(NO_3^-) value 89.13 ppm was recorded in April (S3) and minimum 0 ppmwas recorded in March (S3 and S4) (Table 1). Nitrate reactions (NO_3^-) in fresh water can cause oxygen depletion. Thus aquatic organisms depending on the supply of oxygen in the stream can perish. Non-point pollution sources such as agriculture and livestock may have contributed to the increased NO_2^- and NO_3^- in the rivers of developing countries especially in Bangladesh and Indonesia [20]. Here, most of the observed values were higher than the standard NO_3^- value which is 10 ppm [22]. In the study, NO_3^-showed significant strong negative correlation with BOD (r= -0.765, p< 0.05) in March and Cl^- (r= -0.763, p< 0.05) in April. Disposal of wastes containing high ionic compounds causes high NO_3^- level.

The maximum Chloride(Cl^-) value 237.36 ppm was recorded in April (S2) and minimum 51.68 ppmwas recorded in March (S1) (Table 1). Here, all the observed values were within the standard level of Cl^- which is 600 ppm [23].

The maximum BOD value 17.3 ppm was recorded in April (S3) and minimum 3.21 ppmwas recorded in May (S2) (Table 1).The BOD values showed high fluctuations primarily due to the addition of effluent from industries and also because of dilution by river water [2].Unpolluted waters typically have BOD values of 2 ppm or less [5]. Here, most of the observed valueswere higher than the standard BODvalue which is 5-7 ppm [10] because of the discharge of huge untreated sewage in the study area.It also indicated the presence of comparatively more organic waste in the river water [19].High BOD level indicates high amount of biodegradable wastes in the river water.

3.2 Pearson Correlation

Pearson correlations were done among the analyzed physicochemical parameters of Sitalakkhyariver (Table 2, 3 and 4).

http://dx.doi.org/10.22161/ijeab/4.1.1 *ISSN: 2456-1878*

Table 1. Variations in physicochemical properties of Sitalakkhya River (March-May, 2015).

Parameters	**Sampling Stations**	**March**	**April**	**May**	**Standards**
Temperature (^{0}C)	S1	31.5	32.3	33.5	20-30^{o}C [11]
	S2	32.6	31.8	34.3	
	S3	33.7	32.2	33.8	
	S4	33.4	32.2	34.3	
	S5	33.1	32.2	34.4	
	S6	33.4	32.4	34.6	
	Mean ±SD	32.95±0.80187	32.18±0.20	34.15±0.41352	
Transparency (cm)	S1	15.25	19.57	21.50	40cm [23]
	S2	16.25	22.15	25.25	
	S3	16.8	16.6	23.70	
	S4	18.35	19.1	19.50	
	S5	17.07	26.57	27.30	
	S6	15.75	19.50	22.75	
	Mean ±SD	16.58±1.09	20.58±3.42	23.33±2.75	
TDS (ppm)	S1	663	781	291	500pp [22]
	S2	729	394	300	
	S3	670	412	316	
	S4	675	618	319	
	S5	674	424	309	
	S6	656	420	326	
	Mean ±SD	677.83±26.07	508.16±157.25	310.16±12.92	
EC (µS/cm)	S1	1288	1184	558	250 µS/cm [23]
	S2	2664	738	581	
	S3	1267	772	615	
	S4	1298	1175	623	
	S5	1398	792	608	
	S6	1364	778	613	
	Mean ±SD	1546.5±549.70	906.5±212.23	599.66±24.95	
pH	S1	7.88	8.59	7.57	6.5-8.5 [22]
	S2	7.98	8.60	7.77	
	S3	8.30	8.58	8.00	
	S4	7.99	8.26	8.09	
	S5	8.04	8.58	7.97	
	S6	8.07	8.07	7.92	
	Mean ±SD	8.04±0.14	8.45±0.23	7.88±0.18	
DO (ppm)	S1	2.2	3.4	3.55	4-6 ppm [22]
	S2	2.1	3	2.55	
	S3	1.4	2.8	2.4	
	S4	2.0	2.9	2.9	
	S5	2.6	2.6	2.8	
	S6	2.3	2.9	3.6	
	Mean ±SD	2.11±0.13	2.93±0.27	3.13±0.21	

http://dx.doi.org/10.22161/ijeab/4.1.1 *ISSN: 2456-1878*

Alkalinity (ppm)	S1	415	180	135	>100 ppm [18]
	S2	365	232	130	
	S3	385	236	123	
	S4	435	240	147	
	S5	425	212	162	
	S6	420	260	150	
	Mean ±SD	407.5±26.78	266.66±27.56	141.16±14.42	
Hardness (ppm)	S1	216	320	230	123 ppm [12]
	S2	208	332	243	
	S3	218	224	256	
	S4	203	294	251	
	S5	226	222	263	
	S6	215	232	238	
	Mean ±SD	214.33±8.02	270.66±50.56	246.83±12.16	
NO_3^-(ppm)	S1	17.05	86.16	46.43	10 ppm [22]
	S2	2.90	2.99	49.16	
	S3	0	89.13	47.33	
	S4	0	88.43	44.49	
	S5	17.22	85.55	48.29	
	S6	18.71	87.15	46.57	
	Mean ±SD	9.32±9.22	73.24±34.44	47.045±1.63	
Cl^-(ppm)	S1	51.68	197.51	136.39	600 ppm [23]
	S2	55.75	237.36	138.44	
	S3	66.63	209.75	137.95	
	S4	62.17	207.15	136.11	
	S5	63.4	215.27	139.01	
	S6	65.25	225.14	142.05	
	Mean ±SD	60.81±5.85	215.36±14.12	138.33±2.1	
BOD (ppm)	S1	8.1	9	6	5-7 ppm [10]
	S2	11	7.25	3.21	
	S3	17.3	14	6.87	
	S4	13.2	6.1	8.29	
	S5	9.5	10	7.38	
	S6	11	13.27	5.91	
	Mean ±SD	11.68±3.24	9.94±3.18	6.28±1.75	

http://dx.doi.org/10.22161/ijeab/4.1.1 *ISSN: 2456-1878*

Table.2: Pearson Correlations among the different parameters of surface water in Sitalakkhyariver in March, 2015.

	Temp.	Transpar.	TDS	EC	pH	DO	Alkalinity	Hardness	NO_3^-	Cl^-	BOD
Temp.	1										
Transpar.	0.617	1									
TDS	-0.133	0.087	1								
EC	-0.2	-0.149	0.955*	1							
pH	0.773*	0.228	-0.176	-0.235	1						
DO	-0.343	-0.176	-0.038	0.076	-0.660	1					
Alkalinity	0.072	0.314	-0.724	-0.745*	-0.290	0.467	1				
Hardness	-0.016	-0.324	-0.387	-0.344	0.291	0.293	0.093	1			
NO_3^-	-0.413	-0.614	-0.483	-0.284	-0.395	0.758*	0.436	0.601	1		
Cl^-	0.954*	0.471	-0.367	-0.401	0.808*	-0.251	0.196	0.239	-0.173	1	
BOD	0.747*	0.475	-0.016	-0.150	0.864*	-0.876*	-0.298	-0.186	-0.765*	0.657	1

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

Table.3: Pearson Correlations among the different parameters of surface water in Sitalakkhyariver in April, 2015.

	Temp.	Transpar.	TDS	EC	pH	DO	Alkalinity	Hardness	NO_3^-	Cl^-	BOD
Temp.	1										
Transpar.	-0.270	1									
TDS	0.345	-0.239	1								
EC	0.321	-0.263	0.949*	1							
pH	-0.529	0.270	0.058	-0.087	1						
DO	0.049	-0.384	0.765*	0.602	0.112	1					
Alkalinity	-0.005	-0.266	-0.668	-0.483	-0.693	-0.528	1				
Hardness	-0.530	-0.060	0.529	0.493	0.244	0.745*	-0.384	1			
NO_3^-	0.915*	-0.255	0.348	0.388	-0.339	-0.128	-0.072	-0.597	1		
Cl^-	-0.599	0.314	-0.774*	-0.758*	-0.131	-0.327	0.573	0.046	-0.763*	1	
BOD	0.508	-0.313	-0.425	-0.539	-0.149	-0.275	0.289	-0.775*	0.421	-0.005	1

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

http://dx.doi.org/10.22161/ijeab/4.1.1 *ISSN: 2456-1878*

Table.4: Pearson Correlations among the different parameters of surface water in Sitalakkhyariver in May, 2015.

	Temp.	Transpar.	TDS	EC	pH	DO	Alkalinity	Hardness	NO_3^-	Cl^-	BOD
Temp.	1										
Transpar.	0.264	1									
TDS	0.638	-0.168	1								
EC	0.591	-0.052	0.922*	1							
pH	0.554	-0.027	0.836*	0.982*	1						
DO	-0.010	-0.411	-0.019	-0.314	-0.437	1					
Alkalinity	0.629	0.193	0.314	0.342	0.326	0.360	1				
Hardness	0.312	0.479	0.373	0.678	0.764*	-0.718	0.300	1			
NO_3^-	0.099	0.906*	-0.377	-0.326	-0.296	-0.425	-0.155	0.187	1		
Cl^-	0.657	0.427	0.520	0.285	0.142	0.264	0.333	-0.018	0.347	1	
BOD	-0.021	-0.344	0.449	0.593	0.611	0.052	0.450	0.484	-0.686	-0.272	1

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

IV. CONCLUSION

The present status of waste water management in Bangladesh is not satisfactory and most of the waste water is discharged indiscriminately without maintaining any sort of proper steps which is degrading the water quality critically. The present study was conducted to evaluate the physicochemical parameters of water collected from 6 sites of Sitalakkhyariver from March- May, 2015 and observe temporal changes of the parameters. According to the study, water temperature, transparency, TDS, EC, pH, DO, alkalinity, hardness, NO_3^-, Cl^-, BOD were ranged from 31.5-34.6^{0}C, 15.25-27.30 cm, 291-781 ppm, 558-2664 ppm, 7.57-8.60, 1.4-3.6 ppm, 123-435 ppm, 203-332 ppm, 0-89.13 ppm, 51.68-237.36 ppm and 3.21-17.3 ppm, respectively indicating presence of high organic and inorganic compounds or pollutants in water.

In the study, pH showed significant strong positive correlation with Cl^- (r= 0.808, p< 0.05) and BOD (r= 0.864, p< 0.05) in March and hardness (r= 0.764, p< 0.05) in May; DO showed significant strong positive correlation with NO_3^- (r= 0.758, p< 0.05) in March and hardness (r= 0.745, p< 0.05) in April; DO showed significant strong negative correlation with BOD (r= -0.876, p< 0.05) in March; hardness showed significant strong negative correlation with BOD (r= -0.775, p< 0.05) in April and NO_3^-showed significant strong negative correlation with BOD (r= -0.765, p< 0.05) in March and Cl^- (r= -0.763, p< 0.05) in April.

The present study found that the physicochemical condition of Sitalakkhya River was very poor in the month of March and April. But with the increase in the water flow the condition improved slightly in the month of May. From the compression with the previous year's data the study found that the situation is getting worse with time.

REFERENCES

[1] Ahmed, T. and Badruzzaman, A.B.M.(2007). Effect ofthermal effluenton water quality of Sitalakhya river,The Institution of Engineers, Bangladesh. *Journal of Civil Engineering*.35(1), 59-70.

[2] Alam, M. J. B., Islam, M. R., Muyen, Z., Mamun, M. and Islam, S. (2007). Waterquality parameters along Surmarivers. *International Journal of Science and Technology, Winter*.4 (1), 159-167.

[3] Burton, G.A., Jr., and Pitt, R.E.(2002). Storm Effects Handbook: A Toolbox for Watershed Managers, Scientists, and Engineers. Lewis Publishers, Boca Raton, FL.

[4] Bhoumic, U., Das, P. and Paria, T.(2006). Impact of Industrial pollution on the Biology of the River Karnafuli. Department of Zoology, University of Chittagong, Bangladesh.

[5] Chapman, M.K. and Kimstach, V.(1996). "Selection of Water Quality Variables," In Water Quality Assessment: A Guide to Use of Biota, Sediments and Water in Environmental Monitoring, 2nded.

[6] Das, G.S., Tiwari, B.K. and Tripathi, R.S.(2002). "Coal mining in jaintiahills,Meghalaya: An ecological perspective,"In:jaintiahills, Meghalaya Tribe: Its Environment, Land and People. Reliance Publishing House, New Delhi, pp.121-128.

[7] DHV(1998). Meghna Estuary Study. Draft Master Plan, Volume 1, Main Report for BWDB, Dhaka, Bangladesh.

[8] DoE and LGED(2010). Limited environmental & social impact assessment and environmental & social management framework Bangladesh: Dhaka environment and water project. Volume 1, Department of Environment and Local Government Engineering Department, Bangladesh.

[9] Ellis, M.M.B.A., Westfall and Ellis, M.D.(1946). "Determination of Water Quality. Fish and Wildlife Services,"U. S. Dept. Interior, Res Rept. In Welch, P. S. 1952.Limnology, 2nd ed., vol.9, pp.11. McGraw-Hill Book Company, New York, pp. 182.

[10] EPA (Environmental Protection Agency), U. S. (2001). Drinking Water Criteria Document for Silver (Final Draft). Environmental Criteria and Assessment Office, Cincinnati, OH. ECAO-CIN-026, PB 86-118288.

[11] EQS (Environmental Quality Standard).(1997). Bangladesh Gazette, registered nr.DA-1, Ministry of Environment, Government of Bangladesh.

[12] Huq, S.M.I. and Alam, M.D.(2005). A hand book of analysis of Soil, Plant and Water. BACERDU, University of Dhaka, Bangladesh, Xxii-pp.246.

[13] Islam, J. B., Sarker, M., Rahman, A. K. M. L. and Ahmed, K. S.(2015). Quantitative assessment of toxicity in the Shitalakkhya River, Bangladesh (in press). *Egyptian Journal of Aquatic Research*, http://dx.doi.org/10.1016/j.ejar.2015.02.002.

[14] Karanth, K. R.(1994). Ground Water Assessment, Development and Management. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India, pp. 248-250.

[15] Karn, S. K. and Harada, H. (2001). Surface water pollution in three urban territories of Nepal, India, and Bangladesh. *Environmental Management*. 28(4): 438-496.

[16] Meade, J. W.(1998). Aquaculture Management. CBS Publisher and Distributors, New Delhi, India, pp. 9.

[17] Rabbani, G. and Sharif, M.I. (2005). Dhaka City state of Environment (SoE). UNEP in collaboration with BCAS and DoE, pp. 40.

[18] Rahman, M.S. (1992). Water quality management in aquaculture. BRAC Prokashana, Bangladesh, pp. 84.

[19] Sawyer, C.N., McCarty, P.L. and Parkin, G.F. (2003). Chemistry for Environmental Engineering and Science. 5thed., New York, McGraw-Hill.

[20] Sikder, M. T., Yasuda, M, Yustiwati, Syawal, S. M., Saito, T., Tanaka, S. and Kurasaki, M.(2012). Comparative Assessment of water quality in the major river of Dhaka city and west java. *International Journal of Environmental Protection (IJEP)*,2: 8-13.

[21] Trivedy, R.K. and Goel, P.K. (1984). Chemical and biological methods for water pollution studies. Environmental publications, KARAD, pp. 42-74.

[22] USEPA(1994). Drinking Water Regulations and Health Advisories, Office of Water U.S. Environmental Protection Agency, Washinton, D.C. 202-260-7571.

[23] WHO(1993). Guidelines for Drinking Water Quality, World Health Organization, Geneva, Switzerland.