Spatial and Temporal Variations in Physical and Chemical Parameters in Water of Rupsha River and Relationship with Edaphic Factors in Khulna South Western Bangladesh

Syeda Mushahida-Al-Noor[1], Sk. Kamruzzaman[2]

[1]Department of Fisheries, University of Rajshahi, Rajshahi 6205, Bangladesh
munianoor@gmail.com

[2]Department of Fisheries, University of Rajshahi, Rajshahi 6205, Bangladesh
skzbd@yahoo.com

Abstract: ***The physical and chemical condition of Rupsha River of Khulna and Edaphic factors of the study area was chemically analyzed for 12 months (January-December, 2011). Temporal variation in physical and chemical parameters was found in all cases. Though spatial variations were slight in case of water temperature, dissolved oxygen amount, turbidity and salinity but changes were significant in case of transparency and the amount of free carbon-dioxide. Spatial variation in case of water pH was very little that can be ignored. There was noticeably temporal variation of water temperature between summer (33.1±3.79 ºC at July) and winter season (11.6±5.89 ºC at December). Transparency was lower in June (15.7±3.61cm) and higher in December (42.4±8.72cm). Turbidity level of the Rupsha river was lower in December (14.2±5.29 NTU) and higher in June (26.22±3.61 NTU). PH of the water of the river was lower in June (7.58±0.14) and higher in December (8.58±0.29). In the present study, slight change was observed incase of temporal variation of dissolved oxygen amount in water. Dissolved oxygen was higher in December (6.71±0.06 mg/l) and lower in June (5.09±0.06 mg/l). Free carbon dioxide is the highest in July (9.75±0.10 mg/l) and the lowest in January (7.19±0.05 mg/l). Alkalinity was lower in January (225±2.65mg/l) and higher in June (362±2.00mg/l). Atmospheric temperature and rainfall showed positive correlation with all physical and chemical parameters except transparency, amount of dissolved oxygen (DO) and pH.***

Keywords: Water quality, physic chemical factors, Rupsha River.

1. Introduction

Rivers are waterways of strategic importance across the world, providing main water resources for domestic, industrial and agricultural purposes (Jain, 2009). Rivers from the south-West coastal region of Bangladesh is considered as immensely significance because they surrounded by world heritage Sunderban mangrove forest (Rouf,2006) and provide feeding and reproduction ground for marine fish (Basher et al.,2005). Rupsha is the most important river from both the fisheries and economic aspects of Bangladesh. This river covers several parts of south-west region such as Batiakatha, Dacope and Khulna. The river is connected to the Sunderban mangroves and drains into the Bay of Bengal.

The physical and chemical characteristics of water are important parameters as they may directly or indirectly affect its quality and consequently its suitability for the distribution and production of fish and other aquatic animals (Swingle, 1969). Temperature, turbidity light intensity, pH, dissolved ions are reported to marshal the activities and composition of organisms (Collins, 1983; Ronald, 1988; Mukhtar *et al*.,

1998). Size, structure and biomass of phytoplankton population and production are closely related to physico-chemical conditions of the water body (Mitchell-Innes and Pitcher, 1992).

Untreated discharge of pollutants to a water resource system from domestic sewers, storm water discharges, industrial wastewaters, agricultural runoff and other sources, all can have short term and long term significant effects on the quality of a river system (Singh, 2007). Ademoroti (1996) reported that water rising from market stalls and slaughter houses, streets washing and flushing sewage which flow through drains into rivers altered the chemical composition of the water body thereby causing pollution. Wild and Domestic animals using same drinking water can also contaminate the water through direct defecation and urination (Jain, 2009). The determination of the physical and

chemical characteristics of water in coastal ecosystem are an important tool that aim not only the characterization of the environment, but also the recharge capacity and sustainable use of living resources, especially in environments that suffer extraction or natural and artificial eutrophication (Santos 2002). The importance of measuring physical, chemical and biological variables was considered at the Technical Consultation on Enhancement of Fisheries (Marshall and Moses, 1994).

Physical and chemical factors such as temperature, turbidity, dissolved oxygen, free carbon-di-oxide and pH of several river system around the world are reported by several workers (Jayaraman et al 2003, Sharma & Gupta 2004; Sridhar et al., 2006; Anilakurmary et al., 2007; Prabu et al., 2008; Raja et al., 2008; Srivastava et., 2009; Damotharan et al., 2010; Prasanna and Ranjan, 2010). This article will provide data on some physical and chemical conditions of Rupsha River near Khulna, to compliments existing data, provides baseline information for management decisions in the management of the fishery and similar water bodies.

2. Materials and Methods:

The 6 working station with a more or less regular distance by name were: Station -1: Rupsha ghat, Station-2: Fakirhat, Station-3: Batiaghata, station-4: Dacope, station-5: Terokhada, station-6: Dighalia. From the above six station samples were collected from the month of January to December, 2o11 at regular 10 days intervals. Water temperature (Mercury filled celceous thermometer), turbidity (Nephelometric method, Systronic Type No. 131), transparency (Secchi disks method), pH (digital instrument, modem T-MS30), dissolve oxygen was measured by Winkler-azide modification method (APHA, 1985), free carbon-di-oxide was measured by titration method (APHA, 1985), Alkalinity was measured by titration method (Jankins and Moore, 1977). Monthly data about some edaphic factors like Atmospheric temperature and Rainfall is collected from local meteorological station of Khulna.

Three replicated analysis were done for each parameter in each sampling .The correlation coefficient was calculated to know the relation ship in between and among the parameter by using the following formula,

$$r = \frac{[n\sum XY - \sum X \sum Y]}{\sqrt{[n\sum X^2 - (\sum X)^2][n\sum X^2 - (\sum X)^2]}}$$

Where 'r'is the correlation coefficient, x and y are parameters.

3. Results and Discussion:

Coastal aquatic environment is subjected to variations in the environmental factors such as temperature, dissolved oxygen, light penetration, turbidity, density, etc. These factors are responsible for distribution of organisms in different fresh water habitats according to their adaptations, which allow them to survive in that specific habitat (Jaffries & Mills, 1990). The variation of physical and chemical parameters in sampling station is presented in Table 1,2 and 3 respectively. The temporal variations in the physical and chemical parameters in the sampling stations are shown in Figure 1, 2 and 3 respectively. The spatial variation of the physical and chemical parameters id also observed during the study (Table 4 and Figure 4 & 5). Inter-relationship among various physical, chemical parameters and edaphic factors were shown with the value of correlation coefficient (r-value) in the Table 5. The physical and chemical characteristics of water showed seasonal fluctuations interacting with one another and have a combined effect on animals and plants (Odum, 1971 and Jeffries and Mills, 1990). The mean atmospheric temperature and Rainfall values varied with seasonal variation. The atmospheric temperature was varied from 13.5±3.50ºC (December) to 36.5±2.65ºC (June). Variation in rainfall was significant and it was highest in June and lowest in January. Rainfall is the most important cyclic phenomenon in tropical countries as it brings important changes in the hydrographical characteristics of the marine and estuarine environments (Ashok Prabu et al., 2008). There was noticeably seasonal variation of water temperature between summer (33.1±3.79 ºC at July) and winter season (11.6±5.89 ºC at December). The mean water temperature values of Rupsha River varied from 26.3±0.26 ºC (Station-6) to 29.4±0.35 ºC (Station-4) that stated insignificant spatial variation in water temperature. The recorded low water temperature was because of strong land sea breeze and precipitation during

winter and the recorded high value during summer could be attributed to high solar radiation and photoperiod (Odum, 1971 and Karuppasamy and Perumal, 2000). Some previous studied have been found like Abowei and George (2009) (27-31ºC) and Deekae *et al*. (2010) (25.05-32.20ºC) in case of Niger Delta. The non-spatial variation observed in this study is also in agreement with the report of Abowei and George (2009) who stated that temperature remained steady in the stations of Okpoka Creek in the Niger Delta. This finding is also similar to the report of Ogamba *et al*. (2004) who attributed minimal variation in temperature between stations to the absence of micro climatic variations in temperature. Flowing waters, however, lack wide fluctuations in temperature (Leonard, 1971). Transparency was lower in June (15.7±3.61cm) and higher in December (42.4±8.72cm). Khan and Chowdhury (1994) reported that higher transparence occurred, during winter and summer due to absence of rain, runoff and flood water as well as gradual settling of suspended particles. Kadam et al (2007) also reported similar observation from Masoli reservoir of Parbhani district, Maharashtra of India. The mean water transparency values of Rupsha River varied from 20.6±0.56cm (Station-1) to 35.1±0.72 cm (Station-4) that stated noticeable spatial variation in transparency. Turbidity level of the Rupsha river was lower in December (14.2±5.29 NTU) and higher in June (26.22±3.61 NTU). The results supported by Dagaonkar and Saksena (1992) and Garg et al (2006) who have also reported high turbidity during rainy season. During rainy season silt, clay and other suspended particles contribute to the turbidity values, while during winter and summer seasons settlement of silt, clay results low turbidity. The mean water turbidity values of Rupsha River varied from 16.5±0.88NTU (Station-1) to 19.6±0.52 NTU (Station-5) that stated a slight spatial variation in turbidity. p^H of the water of the river was lower in June (7.58±0.14) and higher in December (8.58±0.29). No significant spatial variation was not seen in case of p^H of the water from different sampling sites. Spatial variation is observed in several cases such as the pH value of water at sewage discharge points were usually lower than that of the river water, also reports similar results in case of river Ganga (Sikander *et al.*,1987 and Shukla *et al.*,1989). The seasonal variation of pH values also observed in this study is comparative with results of previous studies conducted by Dublin-Green (1990) in Bonny River, where the highest pH values were recorded in the dry season and lower values of pH in the late rainy season. In the present study, slight change was observed incase of temporal variation of dissolved oxygen amount in water.

Table-1: Monthly mean Edaphic factors of the study area (Source: Meteorological station of Khulna,2011).

Months	Atm. Tempareture (◦C)	Rainfall (mm)
January	20.2±2.50	15±0.53
February	26.8±3.79	18±0.68
March	27.3±3.06	20±0.72
April	29.1±2.78	28±0.83
May	33.2±3.12	144±1.21
June	36.5±2.65	382±1.54
July	34.7±4.00	281±2.16
August	32.6±2.65	205±2.58
September	31.7±2.78	157±1.65
October	23.2±4.27	112±1.31
November	14.6±3.61	25±0.84
December	13.5±3.50	20±0.54

Table-2: Monthly mean physical parameters of Rupsha river during period of study (Mean±SD).

Months	Water tempareture (◦C)	Transparency (cm)	Turbidity (NTU)
January	19.5±0.29	38.6±5.29	16.33±2.65
February	25.2±0.29	35.33±7.94	17.2±3.61
March	26.1±0.50	30.5±5.29	19.2±2.78
April	28.2±0.58	25.7±5.68	20.2±3.54
May	32.2±2.00	18.5±3.61	23.5±5.29
June	35.7±0.29	15.7±3.61	26.22±3.61
July	33.1±3.79	22.5±6.24	24.3±2.65
August	31.3±3.04	28±2.29	21.3±5.57

September	30.8±3.12	32±1.32	20.5±4.27
October	22.3±3.06	35.3±3.46	16.5±3.61
November	12.67±3.75	40.66±3.46	15.66±2.65
December	11.6±5.89	42.4±8.72	14.2±5.29

Table-3: Monthly means chemical parameters of Rupsha river during period of study (Mean±SD).

Months	p^H	DO (mg/l)	Free CO_2 (mg/l)	Alkalinity(mg/l)	Salinity (ppt)
January	8±0.29	6.43±0.09	7.19±0.05	225±2.65	9.5±3.61
February	7.92±0.14	5.71±0.10	8.56±0.04	236±7.21	11.0±3.46
March	8.58±0.14	6.13±0.02	8.11±0.05	262±4.00	13.0±2.65
April	7.83±0.29	5.93±0.03	8.74±0.11	281±4.00	16.0±4.36
May	8.08±0.29	5.33±0.07	7.13±0.03	325±5.29	17.5±2.65
June	7.58±0.14	5.09±0.06	9.11±0.03	362±2.00	19.0±2.65
July	7.67±0.58	5.08±0.08	9.75±0.10	331±4.36	20.5±2.29
August	8.5±0.29	5.5±0.06	8.94±0.01	324±1.80	18.0±0.50
September	8.5±0.25	5.24±0.03	8.65±0.02	316±2.50	15.0±1.00
October	8.42±0.14	5.55±0.03	8.17±0.07	288±3.61	12.5±1.00
November	8.42±0.14	6.07±0.02	7.44±0.01	266±2.65	10.0±2.18
December	8.58±0.29	6.71±0.06	7.33±0.04	245±5.29	8.5±2.18

Table-4: Mean physical and chemical parameters of Rupsha river in various sampling stations of the Rupsha river (Mean±SD).

Sampling stations	Water tempareture (◦C)	Transparency (cm)	Turbidity (NTU)	DO (mg/l)	Free CO_2 (mg/l)	p^H	Salinity (ppt)
Station-1	27.4±0.87	20.6±2.65	19.6±4.27	4.9±0.08	8.2±0.02	8.6±0.29	18.5±1.50
Station-2	26.8±0.29	22.3±4.00	17.33±3.61	5.2±0.06	7.5±0.07	9.2±0.14	16.2±1.50
Station-3	29.2±0.57	28.8±5.29	17.8±2.65	3.8±0.03	10.8±0.04	8.8±0.25	20.1±1.32
Station-4	29.4±0.50	35.1±2.00	19.4±2.78	4.2±0.02	9.6±0.05	9±0.50	17.5±2.65
Station-5	27.1±1.04	29.2±4.36	16.5±5.29	4.6±0.09	8.6±0.01	9.5±0.29	18.8±1.50
Station-6	26.3±0.58	33.8±3.61	18.2±3.61	3.5±0.07	7.9±0.09	8±0.76	19.4±2.18

Table-5: Correlation among physical and chemical parameters of Rupsha river during period of study (values are shown as r=coefficient of correlation).

Variables	Atm Temp (◦C)	Water temp (◦C)	Transparency (cm)	Turbidity (NTU)	Rainfall (mm)	p^H	DO (mg/l)	Free CO_2 (mg/l)	Alkalinty (mg/l)	Salinity (ppt)
Atm Temp(◦C)	1									
Water Temp(◦C)	0.9988	1								
Transparency (cm)	-0.9043	-0.9036	1							
Turbidity (NTU)	0.9295	0.9249	-0.9682	1						
Rainfall	0.7429	0.7362	-0.7562	0.8483	1					
p^H	-0.5032	-0.5040	0.6064	-0.5854	-0.4668	1				
DO (mg/l)	-0.8565	-0.8497	0.7613	-0.8221	-0.8166	0.4311	1			
Free CO_2 (mg/l)	0.8372	0.8276	-0.8089	0.8781	0.8548	-0.3572	-0.8227	1		
Alkalinty (mg/l)	0.7897	0.7834	-0.8300	0.8824	0.9154	-0.3149	-0.8613	0.9105	1	
Salinity (ppt)	0.9180	0.9097	-0.9172	0.9498	0.8274	-0.4946	-0.8436	0.9581	0.9016	1

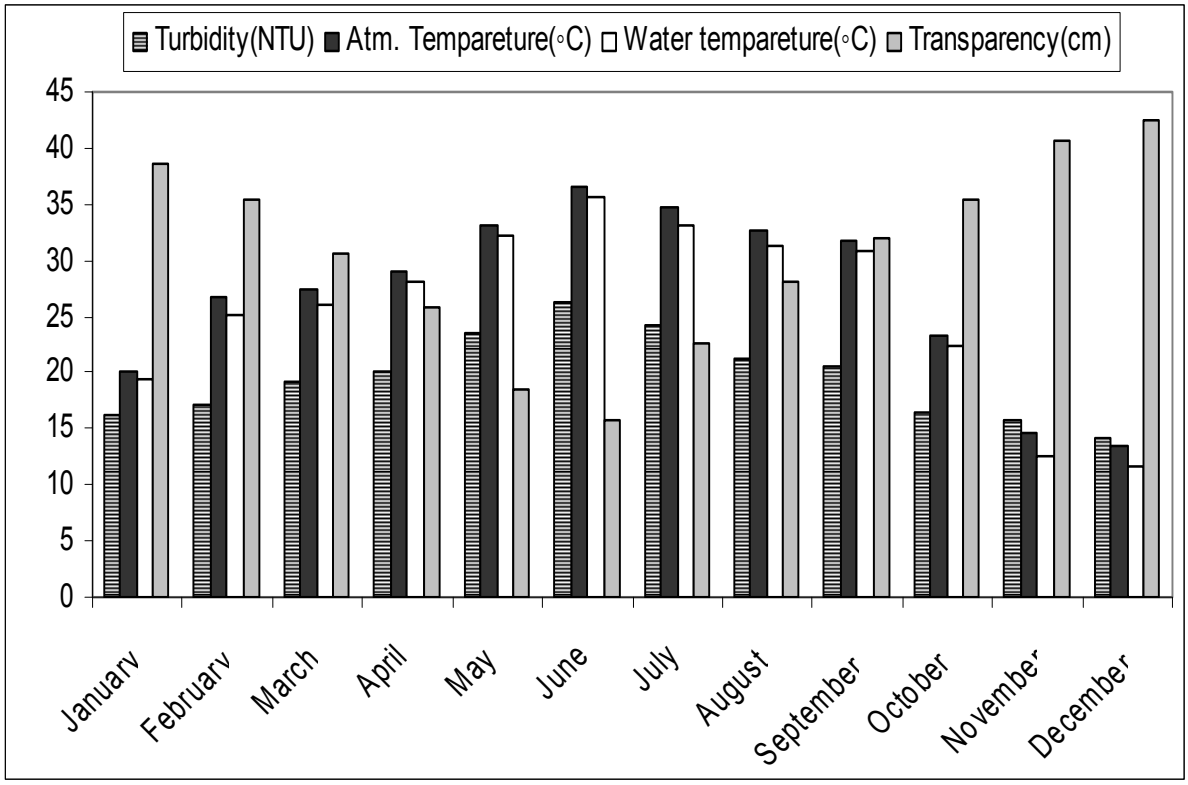

Figure. 1: Temporal variation of meteorological and physical parameters in the Rupsha River during the period of study

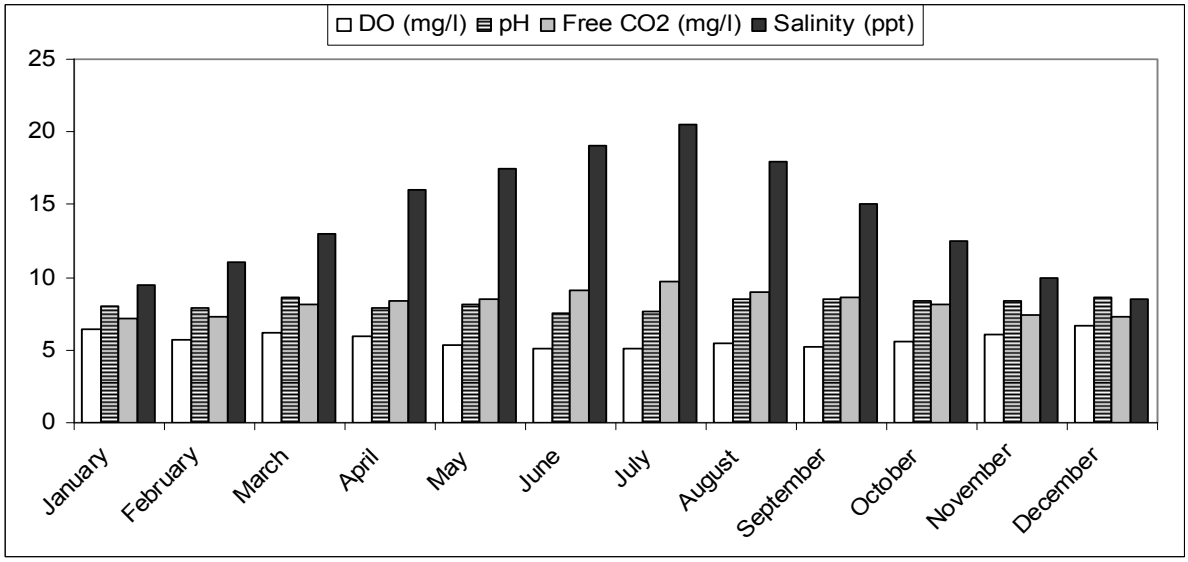

Figure. 2: Temporal variation of Chemical parameters in the Rupsha River during the period of study

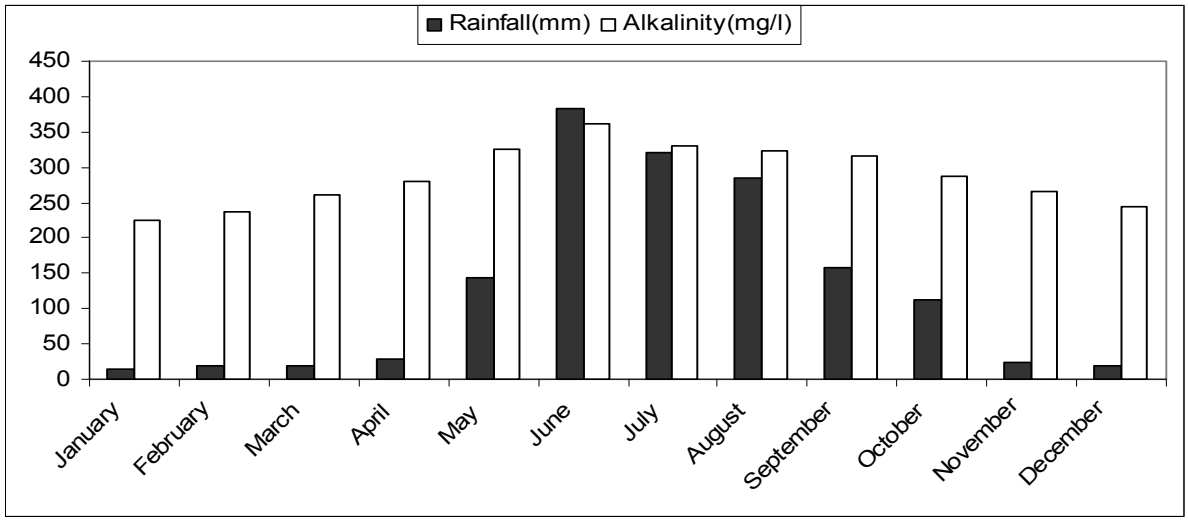

Figure. 3: Temporal variation of physical and chemical parameters in the Rupsha River during the period of study

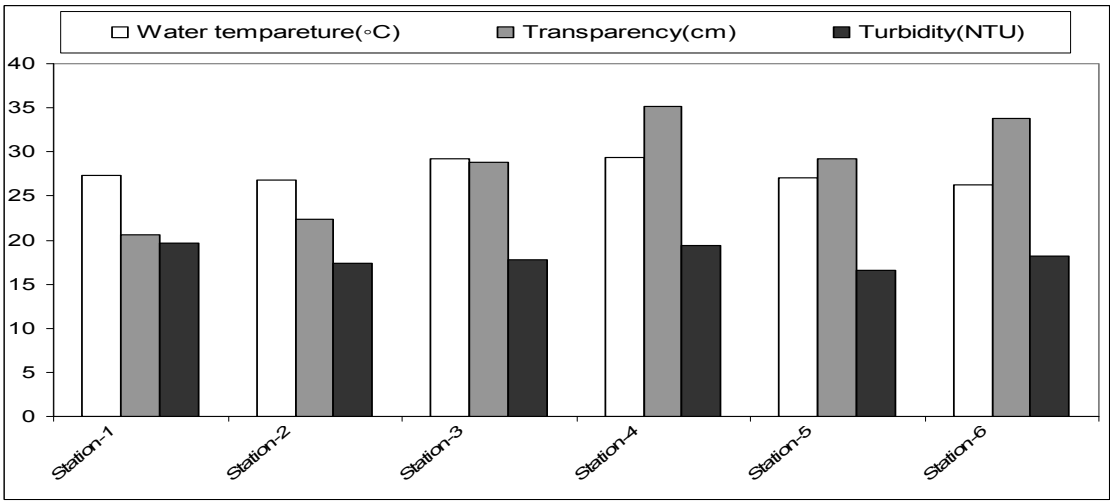

Figure. 4: Spatial variation of meteorological and physical parameters in the Rupsha River during the period of study

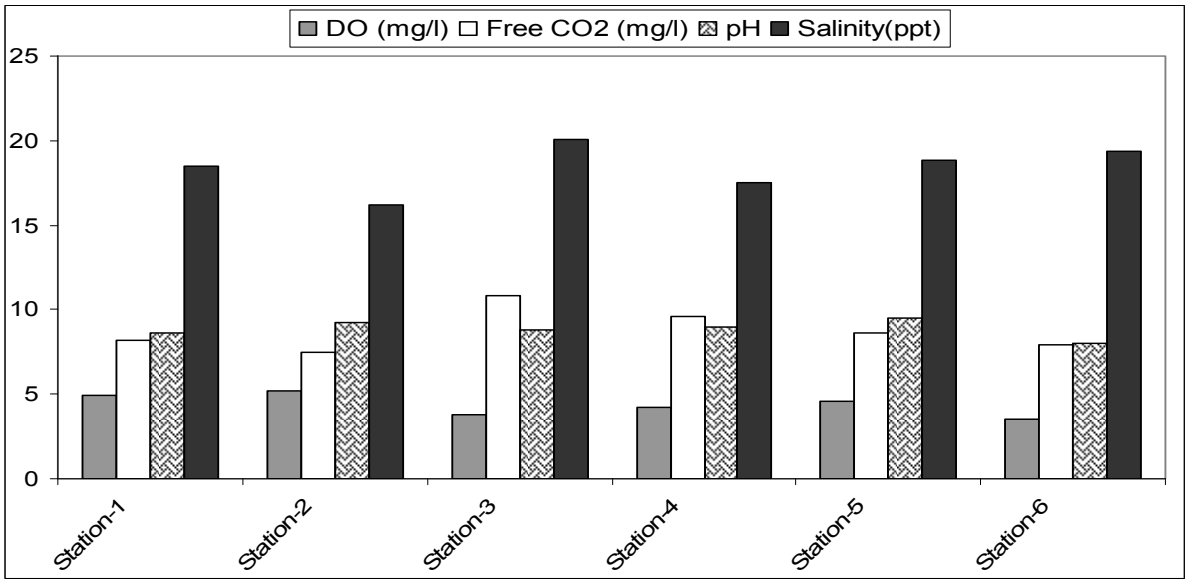

Figure.5: Spatial variation of Chemical parameters in the Rupsha River during the period of study

Dissolved oxygen was higher in December (6.71±0.06 mg/l) and lower in June (5.09±0.06 mg/l). A very slight spatial variation in amount of dissolved oxygen has been observed between sample of station-2 and station-6. The obtained

result can be compared with the finding of Biney(1990) that brackish waters have mean dissolved oxygen concentrations with a range of 6-8 mg/L. He reported that differences in dissolved oxygen concentrations between coastal and freshwater ecosystems had more to do with whether the environments were riverine or lacustrine and the type of discharges a particular water body receives (Binay,1990). In Elechi Creek, municipal drains depositing wastes (organic, inorganic and debris) into the estuary leading to degradation in dissolved oxygen level of water (Egborge, 1994). The finding of present study can also be compared with the previous finding, reported for River Osun (Welcomme, 1979), Zambezi River (Hall *et al*., 1977), Qua Iboe River (Akpan, 1993) who observed that tropical African aquatic systems generally have low DO in the dry season than the wet season. A slight change was observed incase of temporal variation of free carbon dioxide amount in water. Free carbon dioxide is the highest in July (9.75±0.10 mg/l) and the lowest in January (7.19±0.05 mg/l). Spatial variation in amount of free carbon-di-oxide has been observed between sample of station-2 (7.5±0.6 mg/l) and station-3(10.8±0.8mg/l).Alkalinity was lower in January (225±2.65mg/l) and higher in June (362±2.00mg/l). Water with alkalinity less than l0 mg/l rarely produce large crops, water intermediate between 10-50 mg/l may give useful results (Rath, 1993). The salinity acts as a limiting factor in the distribution of living organisms, and its variation caused by dilution and evaporation is most likely to influence the fauna in the inter-tidal zone (Gibson,1982). Salinity was significantly lower in December (8.5±2.18ppt) and comparatively higher in June (20.5±2.29ppt). The mean water salinity values of Rupsha River varied from 16.2±0.29ppt (Station-2) to 20.1±0.32 cm (Station-3) that stated slight spatial variation in salinity. Generally, changes in the salinity in the brackish water habitats such as estuaries, backwaters and mangrove are due to the influx of freshwater from land run off, caused by monsoon or by tidal variations (Ashok Prabu *et al.*, 2008). From the previous studies it is observed that higher values during summer could be attributed to the low amount of rainfall, higher rate of evaporation and also due to neritic water dominance in the study area (Rajasegar, 2003).

5. Conclusion

From the conducted study, it is found that the water quality of the Rupsha river was comparatively in well condition though the river accepted several anthropogenic source of chemicals and wastes. The pollution sources were different at every sampling site; thereby it found that there were some parts of Rupsha river which were still capable of conserving biodiversity. The present study is baseline study on spatial and temporal variation of physico-chemical variables of the Rupsha River which will prove effective in case of ecosystem management, river conservation and bio-diversity protection of the river. The findings of the present study will be helpful for the future researcher to work on these aspects and replace the discrete data about physico-chemical variables of river Rupsha and establish a faithful document explaining variation and inter-relation among different physical and chemical parameters of river water.

References

[1] Abowei, J.F.N. and A.D.I. George, 2009. Some Physicochemical Characteristics of Okpoka Creek, Niger Delta, Niger, Nigeria. Res. J. Environ. Earth Sci.,1(2): 45-53.
[2] Ademoroti, L.M.A., 1996. Environment Chemistry and Toxicology. Foluelex Press Ltd, Ibadan, pp: 217.
[3] Akpan, E. R., Offem J. O. (1993). Seasonal variation in water quality of the Cross River, Nigeria. Rev. Hydrobiol.Trop. 26 (2):95 – 103.
[4] Anilakumary KS, Abdul Aziz PK, Natrajan P., 2007. Water quality of the Adimalathma estuary southwest coast of India, Journal of Marine biological association of India, 49, pp 1-6.
[5] APHA, 1995. Standard Methods for the Examination of Waste Water. 14th Edn., APHA, AWIWAWPCHCF,Washington.
[6] Ashok Prabu,V., Rajkumar,M. and Perumal,P., 2008. Seasonal variations in physico-chemical characteristics of Pichavaram mangroves, southeast coast of India. J. Environ. Biol. ISSN : 0254-8704 29(6), 945-950
[7] Biney, C.A., 1990. A review of some characteristies of freshwater and coastal ecosystem in Ghana. Hydrobiologia, 208: 45-53.
[8] Dagaonkar, A. Saksena, DN.,1992, Physico-chemical and Biological characterization of temple tank, Kaila Sagar, Gwalior, Madhya Pradesh. J. Hydrobiol. 8 (1): 11-19.
[9] Damotharan, P., Permal, NV and Perumal, P., 2010, Seasonal variation of physicochemical characteristics of Point Calimere coastal waters (South east coast of India).Middle-East Journal of scientific research, 6(4): 333-339.
[10] Deekae, S.N., J.F.N. Abowei and A.C. Chinda, 2010. Some physico-chemical parameters of Luubara Creek,

Ogoni Land. Niger Delta, Nigeria. Res. J. Environ. Earth Sci., 2(4): 199-207.
[11] Dublin-Green, C.O., 1990. Seasonal variations in some physico-chemical parameters of the Bonny Estuary,Niger Delta. NIOMR Technical Paper, 59: 21-25.
[12] Egborge, A.M.B., 1994. Salinity and the distribution of rotifers in the lagos harbour - badagry creek system, Nigeria. Hydrobiologia, 272: 95-104.
[13] Egborge, A.M.B., 1994. Water Pollution in Nigeria: Biodiversity and Chemistry of Warri River, 1: 34-77.
[14] Garg RK, Saksena DN, Rao RJ., 2006. Assessment of physic-chemical water quality of Harsi Reservoir, district Gwalior, Madhya Pradesh, Journal of Ecophysiology and Occupational Health, 6, pp 33-40.
[15] Gibson, R.N.,1982. Recent studies on the biology of intertidal fishes. Oceanogr. Mar. Biol. Ann. Rev., 20: 363-414 .
[16] Hall, A., Valente, I.M.C and Davies,B., 1977. The Zambezi River in Mozambique: The Physico-chemical Status of the middle and Lower Zambezi Prior to the closure of the Cubora Bassa Dam. Freshwater. Biol. 7, 187-206.
[17] Jaffries, M. and D. Mills, 1990. Freshwater Ecology. Principles and Applications. pp: 335–7. Belhaven Press, London and New York.
[18] Jain, A.K., 2009. River Pollution. 1st Edn., APH Publishing, New Delhi, ISBN: 8131304639, pp: 330.
[19] Jayaraman PR, Ganga DT, Vasudevan NT., (2003), Water Quality Studies on Karamana River, Thiruvananthapuram District, South Kerala, India, Pollution research, 22(1), pp 89-100.
[20] Karuppasamy, P.K. and P. Perumal, 2000. Biodiversi ty of zooplankton at Pichavaram mangroves, South India. Adv. Biosci., 19:23-32.
[21] Khan, M. A. G and Choudhary S.H., 1994. Physical and chemical limnology of lake Kaptai: Bangladesh, Tropical Ecology, 35(1), pp 35-51.
[22] Leonard, L.C., 1971. Water and Water Pollution. Vol. 1. pp: 256–63. Marcel Dekker, Inc. New York, USA.
[23] Macan, T.T., 1980. Freshwater ecology. 2nd ed. Longman, London.
[24] Moses, B.S., 1983. Introduction to Tropical Fisheries.University Press, Ibadan, pp: 105.
[25] Odum, E.P., 1971. Fundamentals of Ecology. 3rd Ed. pp: 278–84. Toppan Company, Ltd., Japan.
[26] Perona, E., Bonilla, I. and Mateo, P., 1999. Spatial and temporal changes in water quality in a Spanish river. Sci. Total Environ., 241: 75-90.
[27] Prasanna M, Ranjan P C., 2010. Physico-chemical properties of water collected from Dhamra estuary, International Journal of Environmental Science, 1(3), pp 334-342.
[28] Raja P, Amarnath AM, Elangovan R, Palanivel M., (2008). Evaluation of physical and chemical parameters of River Kaveri, Tiruchirappalli, Tamil Nadu, India, Journal of Environmental Biology, 29(5), pp 765-768.
[29] Rath, R., 1993. Freshwater aquaculture. Scientific Publishers, Jodhpur.
[30] Santos, F. P. Biologic characterization and primary production in Guarapua bay (Cairu-BA): a subsidy to the environment recharge capacity research. Bahia Federal university. 2002, 106p.
[31] Sharma MR, Gupta AB., 2004. Seasonal variation of physico-chemical parameters of Hathli stream in outer Himalayas, Pollution research, 23(2):265-270.
[32] Sharma, L.L and Darve, V.S., 1991, Water quality of 26 waters of Rajasthan in relation to phytoplankton. In Proc. Of the second Asian fisheries Forum. Asian fisheries society manila, Philippines, pp 915-918.
[33] Shukla B.D., Suresh C., Tripathy R., Deep Kumari V. and Pande V.S.,1989. Physico-chemical and biological characteristics of river Ganga from Mirzapur to Ballia, Indian J. Envrion. H1t,31(3): 218-227
[34] Sikoki, F.D. and N. Zabbey, 2006. Environmental gradients and Benthic community of the middle reaches of Imo River, South-Eastern Nigeria.Environ. Ecol., 24(1): 32-36
[35] Singh, L.B., 2007. River Pollution. 1st Edn., APH Publishing, New Delhi, ISBN-10: 8131300854, pp: 192.
[36] Sridhar R, Thangaradjou T, Senthil Kumar S, Kannan L., (2006), Water quality and phytoplankton characteristics in the Palk Bay, southeast coast of India, Journal of environmental biology, 27, pp 561-566.
[37] Srivastava N, Harit G, Srivastava R., (2009), A study of physico-chemical characteristics of lakes around Jaipur, Inida, Journal of environmental biology, 30(5), pp 889-894.
[38] Swingle, H.S., 1969. Methods of analysis for waters,organic matter and pond bottom soils used in fisheries research. Auburn University, Auburn,Alabama, pp: 119.
[39] Welcomme, R. L., (1985): River Fisheries. FAO Fish. Tech. Pap, 262, 330p.
[40] Wilson, E.M., 1990. Engineering Hydrology Macmillan Press Ltd Houndmills, Basingstoke Hampshire RG216XS and London, pp: 348.

Author Profile

Syeda Mushahida-Al-Noor received her M.Sc.(Aquaculture) and B.Sc.(Fisheries) from Department of Fisheries, University of Rajshahi , Rajshahi 6205, Bangladesh.

Sk. Kamruzzaman received his M.Sc. (Fisheries) and B.Sc.(Zoology) from Department of Zoology, University of Rajshahi , Rajshahi 6205,Bangladesh. Later he received his M.Phil from Department of Fisheries, University of Rajshahi, Rajshahi 6205, Bangladesh.