# ASSESSMENT OF PHYSICO-CHEMICAL PROPERTIES OF WATER OF THE RIVER SHITALAKSHYA AND BALU

**BY**

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**DHAKA-1207**

**JUNE, 2016**

# ASSESSMENT OF PHYSICO-CHEMICAL PROPERTIES OF WATER OF THE RIVER SHITALAKSHYA AND BALU

**Registration No. 09-03641**

*A Thesis*
*Submitted to the Faculty of Agriculture,*
*Sher-e-Bangla Agricultural University, Dhaka,*
*In partial fulfillment of the requirements*
*For the degree of*

**MASTER OF SCIENCE**
**IN**
**AGRICULTURAL CHEMISTRY**
**SEMESTER: JANUARY-JUNE, 2015**


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# CERTIFICATE

This is to certify that the thesis entitled, **"ASSESSMENT OF PHYSICO-CHEMICAL PROPERTIES OF WATER OF THE RIVER SHITALAKSHYA AND BALU"** submitted to the Department of Agricultural Chemistry, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURAL CHEMISTRY,** embodies the result of a piece of bona fide research work carried out by **CHANDAN SUTRADHAR** bearing **Registration No. 09-03641** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

**Dated: 27.08.2017**
**Place: Dhaka, Bangladesh**

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# ACKNOWLEDGEMENT

At first the author expresses his gratefulness to Almighty God who has helped him in pursuit of his education in Agriculture and for giving the strength of successful completion of this research work.

The author is highly grateful and greatly obliged to his supervisor, **Dr. Mohammed Ariful Islam**, Associate Professor, Department of Agricultural Chemistry, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh for his continuous encouragement, innovative suggestions and affectionate inspiration throughout the study period.

With deepest emotion the author wish to express his heartfelt gratitude, indebtedness, regards sincere appreciation to his benevolent research Co-supervisor Dr. **Md. Abdur Razzaque**, Professor, Department of Agricultural Chemistry, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh for his intellectual guidance, intense supervision, affectionate feelings and continuous encouragement during the entire period of research work and for offering valuable suggestions for the improvement of the thesis writing and editing.

*Cordial thanks are extended to all respected teachers of the Department of Agricultural Chemistry, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh and the entire staff member of the Department of Agricultural Chemistry (SAU).*
*The author would like to thank to* ***Dr. Sheikh Shawkat Zamil*** *for his valuable and sincere help in carrying out some research work in the Agro-Environmental Chemistry Laboratory of Sher-e-Bangla Agricultural University, Dhaka.*

*The author also expresses his especial thanks to his well-wishers and friends for their help and support during his work.*

*Finally the author expresses his heartfelt indebtedness to his beloved father and mother, brother and sisters for their sacrifice, encouragement and blessing to carry out higher study which can never be forgotten.*

*June, 2015* *The Author*

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## ABSTRACT

This study was conducted to assess some physico-chemical properties of water collected from different point of Shitalakshya and Balu Rivers. Total forty samples were collected from the two rivers to analyze the physico-chemical properties such as Color, Odor, pH, Total Dissolved Solids (TDS), Salinity, Sodium (Na), Potassium (K), Calcium (Ca), Carbonate ($CO_3$) and Bicarbonate ($HCO_3$). The results of the present study shows that most of the parameters were not exceed the maximum permissible limit except Bicarbonate. Bicarbonate was found the ranges of 61 to 91.5 mg/L, whereas the standard limit of Bicarbonate is 1.50 mg/L. So, it can be concluded that the water of Shitalakhya and Balu rivers are contaminated by the factories, waste materials, tanneries and it should be considered as a threat for the aquaculture, agricultural productions, fisheries, livestock, recreational activities and various industrial uses.

# Some commonly used Abbreviations

| Full word | Abbreviations |
|---|---|
| Calcium | Ca |
| Potassium | K |
| Phosphorus | P |
| Boron | B |
| Carbonate | $CO_3$ |
| Bi-Carbonate | $HCO_3$ |
| Total Dissolved Soilds | TDS |
| Total Solids | TS |
| Total Suspended Solids | TSS |
| Total Hardness | TH |
| Dissolved Oxygen | DO |
| Carbon Dioxide | $CO_2$ |
| Sulfer Dioxide | $SO_2$ |
| Sulphate | $SO_4$ |
| Carbon Monoxide | CO |
| Electrical Conductivity | EC |
| Diological Oxygen Demand | BOD |
| Chemical Oxygen Demand | COD |
| Water Quality Index | WQI |
| And Others | *et al.* |
| World Health Organization | WHO |
| Asian Development Board | ADB |
| United Nations Development Programme Financial Initiative | UNEPFI |
| Water Quality Management | WQM |
| Pakistan Standard Quality Control Authority | PSQCA |
| Factor Analysis | FA |
| Cluster Analysis | CA |
| Discriminant Analysis | DA |
| Geographic Information System | GIS |

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# CHAPTER I

# INTRODUCTION

Rivers are the most important natural resources for human consumption and development. They provide ecosystem services such as fresh water sources for domestic and agriculture consumption, water regulation, primary production as well as transportation and recreation purposes. However, human activities gradually alter the inland water ecosystem and its catchments through land conversion, sand and gravel extraction, and indiscriminate disposal of sewage, agricultural and industrial wastes to water bodies. Therefore it is necessary to determine the water quality and evaluate its impacts and provide measures to mitigate the problems (Mishra *et al.*, 2009).

Nowadays, pollution has become a serious concern for human life due to the industrial burst in the world. And the rivers are the main choices to hold and bear the responsibility of pollutants, especially in the developing countries. Water pollution caused by chemical substances such as minerals and heavy metals affects tropical rain forest and river ecology. Usually, the presence of an odour suggests higher than normal biological activity and is a simple test for the suitability of drinking water, since the human sense of smell is far more sensitive to low concentrations of substances than human taste. Warm temperatures increase the rate and production of odour causing metabolic and decay products. Different levels of pH may also affect the rate of chemical reactions leading to the production of odour. The minerals as well as the heavy metals can accumulate from water to sediments through settling process and some particles can also find their ways into the biota (Sikder *et al.*, 2012). Bangladesh is said to be the land of rivers (Mahbub *et al.*, 2014).

Increasing industrialization and unplanned urbanization have greatly transformed the natural environment, particularly water sector or natural hydrological system of Bangladesh. To date, the behaviour of organic, inorganic pollutants and trace metals in soils, sediments, ground and surface water at catchments or regional scales is poorly understood. This lack of understanding results in part from a limited knowledge about loading, mobility and turnover of pollutants and is further complicated by the complexity and heterogeneity of the systems (Barth *et al.*, 2007).

Naturally, ground water contains mineral ions. These ions slowly dissolve from soil particles, sediments, and rocks as the water travels along mineral surfaces in the pores or fractures of the unsaturated zone and the aquifer. They are referred to as dissolved solids. Some dissolved solids may have originated in the precipitation water or river water that recharges the aquifer. The term "solids" is widely used for the majority of compounds which are present in natural waters and remain in a solid state after evaporation (some organic compounds will remain in a liquid state after the water has evaporated). Total suspended solids (TSS) and total dissolved solids (TDS) correspond to non-filterable and filterable residue, respectively. A higher TDS means that there are more cations and anions in the water. With more ions in the water, the water's electrical conductivity (EC) increases. By measuring the water's electrical conductivity, we can indirectly determine its TDS concentration. At a high TDS concentration, water becomes saline. Water with a TDS above 500 mg/L is not recommended for use as drinking water (EPA secondary drinking water guidelines). Water with a TDS above 1,500 to 2,600 mg/L (EC greater than 2.25 to 4 mmho/cm) is generally considered problematic for irrigation use on crops with low or medium salt tolerance (Harter, 2003).

According to British Geological Survey (BGS) (1999) and DPHE/BGS/DFID (2000), 35 million Bangladeshi people who use underground water for drinking purpose are exposed to Arsenic concentration exceeding the national standard (50 µg/L) and 57 millions of people are exposed to concentrations exceeding the World Health Organization (WHO) guideline value of 10 µg/L (Siddique *et al.*, 2009). Water is the most valuable and vital resource for sustenance of life and also for any developmental activity (Kumar *et al.*, 2010). About 80% of the earth surface covered with water. Out of the estimated 1,011 million $km^3$ of the total water present on the earth, only 33,400 $m^3$ of water is available for drinking, agriculture, domestic and industrial consumption (Dara, 2007). Bangladesh is a low lying flat country with big inland water bodies, including some of the biggest rivers in the world and is extremely vulnerable because of its geographical characteristics (Matin and Kamal, 2010).

Huge quantities of industrial effluents, solid waste from river side settlements, petroleum products from ships, launches, cargoes, boats, untreated sewage etc. regularly get dumped into the Buriganga, Turag, Balu and Shitalakshya rivers, which are already severely polluted (Khan *et al.*, 2007).

The Shitalakshya River is the major source of drinking water for the ever-expanding pollution of Dhaka city so the Dhaka Metropolitan Development Program has suggested to initiate environmental protection measures to prevent pollution of Shitalakshya River (Ershad, 2009). The River receives effluents from five jute mills, two fertilizer factories, one sugar mill, one cement industry, one textile industry, one dairy plant, two food processing industry, one hardboard mill, one paper mill and one thermal power plant within 13 km range of its flow in Ghorashal region. Among these industries, Polash Urea Fertilizer Factory, Urea Fertilizer Factory and Ghroshal Thermal power plant are considered as the KPI (Key Point Installation). In industry, surface water is used for cooling, process, steam generation, safety and other miscellaneous purposes. The average consumption of surface water by Polash Urea Fertilizer Factory, Urea Fertilizer Factory and Ghroshal thermal power plant are 15600, 28800 and 28,80,000 t/d respectively from Shitalakshya River at polash region.

However, it is hoped that the findings will not only provide valuable information of concentrations of major and minor minerals of Shitalakhsya and Balu river, but also present a scientific perspective of the effects of minerals into the rivers water so that further regulatory and scientific attention can be drawn to the issue.

The present investigation was undertaken to study the current status and trend of water quality of the Shitalakshya and Balu Rivers with the following objectives –

1. To understand the level and extent of physico-chemical contamination of two rivers.
2. To measure some physico-chemical parameters which are available to determine in the laboratory of Department of Agricultural Chemistry , SAU.

# CHAPTER II

# REVIEW OF LITERATURE

Sikder *et al.* (2016) conducted a research to investigate the air, water and sediment quality which are degraded due to pollution load at Turag River. Gastec technique (Japanese origin) is used to determine the CO, $CO_2$, NOx and $SO_2$ concentration and the concentration range for CO: 2425-7635 μg/m 3, 82-652 $\mu g/m^3$ for NOx, 151.93-553.56 $\mu g/m^3$ for PM10 and 395-510 $\mu g/m^3$ for $CO_2$. Atomic absorption spectrophotometer technique is used for the determination of Cr, Pb, Zn, Cu and Cd because of their potential toxicity. As per US EPA sediment quality guideline, metal concentrations ranged between Cd: 0.10 - 0.90, Cr: 31.00 - 78.20, Cu: 48.10 - 69.00, Pb: 30.30 - 37.20, and Zn: 95.60 - 191.10 mg/kg in the Turag river sediments. Air temperature, Water temperature, pH, EC, Chloride, Turbidity, TS, TDS, DO, BOD5, and COD concentration in water samples were found to range from 26-36°c, 29-34°c, 7.5-7.9, 1850-1900($\mu Scm^{-1}$), 32-42(mg/L), 13.5-14.4cm, 902-970(mg/L), 810-850(mg/L), 0-0(mg/L), 21-24(mg/L), 106-141(mg/L).

Flura *et al.* (2016) performed a research to assess the physico-chemical and biological parameters of Meghna Rivers water in three spots during the period of January, 2014 to December, 2014. Nineteen (ten were physical and nine were chemical) physico-chemical parameters of water *viz* Waterdepth, Water temperature, Air temperature, Water colour, Odour of water, Bottom type, Transparency,Conductivity, Turbidity, Total Dissolve Solids (TDS), Dissolve Oxygen (DO), Free carbon dioxide, pH, $NH_3$, Total alkalinity, Total hardness, Biological Oxygen Demand (BOD) (B), Biological Oxygen

Demand BOD (N) and Chemical Oxygen Demand (COD), plankton community of both phytoplankton and Zooplankton were studied in aforesaid sampling spots of Meghna river. Maximum water depth was recorded from Meghna ghat area. Among these sampling spots highest transparency was recorded from Bhairab region. Dissolve oxygen concentration was found highest 7.5 mg/L in Chandpur. Free carbon dioxide was found maximum in Meghna ghat area 3.7 mg/L. The findings of physic-chemical and biological parameters of water indicate water quality of Meghna river are safe for aquatic lives, but the continuous sewage disposal may create problems in the future.

Nahar *et al.* (2016) evaluated a study in 2014 to assess the physico chemical properties of the water from the Gorai river in Kushtia, Bangladesh. To conduct this research, six samples from six points were collected from surface water of this river that covered only the Kushtia town. Samples were collected from Charulia, Barokhada, Jugia, Kamlapur, Thanapara and Ghoshpara at 1km interval. Another three samples were collected from Jagati sugar mill area and two domestic effluents those were discharged to the main river flow to evaluate the impact of these effluents on the river water quality. Different water quality parameters such as temperature, pH, Electrical Conductivity, Total Dissolved Solids, Dissolved Oxygen, Alkalinity, Hardness, Sodium, Potassium, Phosphate, Sulphate, Chloride, Iron, Lead, Cadmium and Chromium were examined. From this study it was observed that most of the parameters exceeded the permissible limits.

Bhasin *et al.* (2016) analysed the various parameters like dissolved oxygen (DO), chemical oxygen demand (COD), biological oxygen demand (BOD), total coliform (TC), fecal coliform (FC), turbidity, transparency, total alkalinity, total hardness, chloride, calcium was performed. Water Quality Index (WQI) values ranged from 284.0-1112.34 and shows all study site to be under pollution stress. Results of the present investigation showed that water quality of the river was more deteriorated during summer followed by monsoon and winter season. Higher pollution load was observed in Ramghat followed by Managalnath, Triveni, Mahidpur and Kshipra village study sites. According to CPCB (Central Pollution Control Board) water of Kshipra river was found to be of D class and river was observed to be under great pollution stress. Immediate remedial measures are recommended to control pollution and improve water quality of the river which was important for proper management and conservation of this holy river.

Islam and Azam (2015) investigated the seasonal variation in physic-chemical and toxic metal concentrations of Shitalakhya, Buriganga and Turag river around Dhaka city as different kinds of industries dispose their waste into rivers. The results envisaged the, deteriorate of water quality with significant seasonal changes. In order to characterize the seasonal variability of surface water quality in these three rivers, WQI was calculated from 14 parameters, periodically measured at three sampling sites of each river round a year. The results indicated a relatively good water quality was found in monsoon and the seasonal order of pollution magnitude was post-monsoon>pre-monsoon>monsoon. Water quality conditions were critical during post monsoon, due to increase of anthropogenic interferences, low rainfall and river flow.

Agbaire *et al.* (2015) studied some physicochemical parameters of water from artificial concrete fish ponds in Abraka and its environs with a view of finding the fitness of the water environment for fish farming. The mean and standard deviation of results obtained are as follows: pH (7.03±0.06), conductivity (15.88±1.96µS/cm), Temperature (26.73±1.730C), DO (10.11±0.63mg/L), BOD (3.02±0.77mg/L), TDS (22.11±2.4 mg/L), TSS (87.97±9.63mg/L), Turbidity (9.23±1.63NTU), Total hardness (4.91±0.90mg/L), phosphate (1.41±0.45mg/L), chloride (8.60±1.53mg/L), nitrate (3.81±0.55mg/L), sulphate (3.71±1.00 mg/L), Magnesium (1.16±0.15 mg/L), calcium (0.42±0.27mg/L), potassium (11.74±2.01 mg/L). These results were largely within the WHO, SON and FEPA limits for drinking water.

Miah *et al.* (2015) observed the water quality assessment of different sources (surface water and ground water) in the coastal belt region of Noakhali was conducted. Physical parameters of the supplied samples like Color, Odor, Temperature, and Taste were identified. Beside this pH, Conductivity, Total dissolved solid (TDS), Hardness, Alkalinity, Chloride, cations, Arsenic(As), Cadmium (Cd), Lead (Pb), Mercury(Hg), Chromium(Cr), Dissolved Oxygen were measured to understand the physicochemical parameters, salinity and the presence of toxic metal ions in water. pH values for surface water were 6.3- 7.49 and those of ground water were 7.33-8.5; Total hardness for surface water was 70-132 ppm and ground water was 180-296 ppm as $CaCO_3$; Electrical conductivity (EC) for surface water was 576-1040 µs and that of ground water was 5210-8170 µs . Ground water (deep) source contains highest level of Chloride and TDS which is 1683ppm and 1152 ppm respectively. The alkalinity of the underground water was 2115 ppm &

518ppm which was higher than the surface water which was 68.5 ppm 112.5 respectively. The DO values were 2.4ppm & 3ppm for ground water and 4.05 & 4.95ppm for surface water. All the measured concentration of toxic metal ions (As, Cd, Pb, Hg, Cr) were below standard permissible limit.

Behera *et al.* (2014) studied on the Physico-chemical properties of water sample collected from Mangrove ecosystem of Mahanadi River Delta, Odisha, India. This present study, investigated the physicochemical parameters of water samples which were compared with the water quality standard of Bureau of Indian Standard (BIS) and pollution control board of the state. These variations of different parameters investigated as follows: dissolved oxygen (2.9-10.9 mg/L), pH (6.05-8.6), Temperature (24.2-30.9°C), TDS (4510–11900 mg/L), electrical conductivity (5.16–17.33 mS/cm), chloride content (4389-12575 mg/l), total hardness (800-2090 mg/l), calcium (125.4-400.8 mg/l), magnesium (153.16-474.13 mg/l), phosphate (0.55-2.59 mg/l), and nitrate (13.03-24.01 mg/l). Among different study sites with high load of calcium, nitrate, chloride and phosphate in most of the study sites indicated the pollution status of this estuarine water.

Akter *et al.* (2014) analysed the water quality in the aquatic body of Dhaka Export Processing Zone (DEPZ) area was studied on the basis of some physiochemical parameters and heavy metal concentrations. The range of pH for all of the samples was found from 7.1 to 8.17 and 120 to 450 mg/L for TDS. The Values of EC were found from 90 to 300 µs $cm^{-1}$. For pH, EC and TDS, though the ranges were within the limits but there was an increasing trend of the values was observed in every case which is highly alarming. The range of COD values was estimated from 90 to 300 mg/L and in most of the samples the values exceeded the standard range. The heavy metal containments of the surface water indicated that the concentrations of Cr, Cu, Ni, Zn, Hg and As were obtained below the permissible limit, detection by WHO, 1996. On the other hand, concentrations of Cd, Co, Fe, Pb, Mn and Hg were exceeded the permissible limits. Correlation matrix shows a significant correlation among Pb, Cu, Co, Mn and Fe. Enrichment factor shows high concentrations of Cd, Cr and Hg. Stated environmental condition is highly vulnerable for human being, that’s why this is the time to take proper steps for remediation and preventing the pollution around Dhaka Export Processing Zone (DEPZ) water body which is directly related to the industrial emission of DEPZ.

Gupta *et al.* (2013) studied on Assessment of Physicochemical Properties of Yamuna River in Agra City. The present study was done to find out the physico-chemical properties of the river Yamuna water from 9 different sampling sites in the City of Agra. These water samples were collected from 9 locations (viz Runkata, Naire Ghat, Kailash Mandir, Etmad-ud-daula, Pohiya Ghat, Balkeshwar, Rambagh Hathi Ghat and Tajganj) of Agra City, during the months of March- April, 2011 and these river water samples were taken to the laboratory and examined. The analysis was done for the parameters like Total Dissolved Solids, Electrical Conductivity, Turbidity, pH, Total Hardness, Total Alkalinity, Calcium, Chloride and Magnesium. pH showed that the River water of Yamuna is alkaline in nature. Total Dissolved Solids and Turbidity was found above the permissible limits of WHO.

Kotadiya *et al.* (2013) ascertained the "Water Quality Index" (WQI) of a Ghuma Lake, supplying fresh water in a rural area of Ghuma village in Ahmadabad district. The WQI was determined by studying 12 physicochemical characteristics like pH, electrical conductivity, hardness, DO, BOD, TDS, alkalinity, Mg hardness, Ca hardness, Nitrate, Sulphate and Chloride.

Popa *et al.* (2012) studied on Study of Physico-Chemical Characteristics of Wastewater in an Urban Agglomeration in Romania. This study investigated the level of wastewater pollution by analyzing its chemical characteristics at 5 wastewater collectors. The samples were collected before they discharge into the Danube during a monitoring campaign of 2 weeks. The Inorganic and Organic compounds, biogenic compounds and heavy metals, have been analyzed using potentiometric and spectrophotometric methods. The Experimental results shown that the quality of wastewater varies from site to site and it greatly depends on the origin of the waste water.

Kesalkar *et al.* (2012) stated the Physico-chemical characteristics of wastewater from Paper Industry and presented the characteristics of wastewater taken from the paper industry in which waste-paper was used as a raw material. The wastewater from this paper industry had been characterized by extreme quantities of BOD, COD, pH, DO, TDS and SS, color. These samples were examined and compared with the effluent discharge of Indian standards. The raw waste water consisted of Total Dissolved Solids ranges from 1043-1293mg/l, pH of 6.8-7.1, Suspended Solids of 1160-1380mg/l, BOD varies from 268 - 387 mg/l and COD varies 1110 –1272 mg/l respectively. After the treatment, Total dissolved solids ranges from 807-984 mg/l, pH varies 7.1 -7.3, Suspended Solids 322-505 mg/l BOD ranges from 176- 282 mg/l and COD and 799-1002 mg/l, respectively. The Result showed that the TDS and pH were in the permissible limits and BOD, COD, SS does not meet the permissible standards after treatment. The paper mill does not meet with the Standards set by Central Pollution Control Board of India.

Thakare *et al.* (2012) performed a study of the metal pollutants of the water of Wardha and Dham Rivers at Wardha, Maharashtra. The water was collected from 10 different points on the Dham River and 9 different points on the Dham River. It was tested for seven metals – Cu, Mn, Fe, Zn, Ni, Na and K and 9 other physicochemical parameters. The results obtained showed that the values of all the parameters were within the safe standards laid down by Indian Standard Bureau. Hence the water of these rivers was completely harmless for human beings and fit for irrigation and domestic use.

Ugwu and Wakawa (2012) analysed the impact of growing population in the city of Abuja in Nigeria by studying the seasonal physiochemical characteristics of the Usma River. The study revealed that all parameters measured were within the permissible level except Total Suspended Solid, which exceeded for all seasons. The values for electrical conductivity and total dissolved solids showed that the discharges of domestic and industrial wastes in the river water as a result of human activities were responsible for the increased levels of pollution.

Sharma *et al.* (2011) carried out a study on "Narmada River" water at Hoshangabad, in Madhya Pradesh. The objective of the study was to review the physicochemical parameters from the sample water. The study showed that the values of the parameters at some of the sampling sites were in excess of the standards set by agencies such as Indian Standard Bureau, WHO. This was due to dumping of substantial wastes in the river waters. Thus, the potable nature of the water was lost.

Shinde *et al.* (2011) studied the physicochemical parameters and the correlation coefficient of Harsool-Savangi Dam, Aurangabad. In order to draw water samples, 4 distinct locations were selected along the course of the river. The period covered was one year from January to December 2009. The values of the parameters indicated that the water was rich in nutrients and fit for irrigation and fish culture. Only in the monsoon, the total hardness increases making it unfit for drinking. The correlation coefficient indicated positive and negative significant correlation of physic-chemical parameters with each other.

Yadav *et al.* (2011) conducted a study on Kosi River in Rampur District, Uttar Pradesh, India. The objective of the study was to evaluate the quality of the river water. An aggregate of fifteen sampling stations were selected along the course of the Kosi River in order to draw sixty water samples for the study. Various physical characterics and physicochemical parameters of water were examined. These included temperature, pH, trassperancy, total hardness (TH), total alkalinity (TAK), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), chloride, nitrate, phosphate and fluorides. All sample observations were found to be beyond the permissible limits laid down. Therefore the river water was unfit for consumption, domestic and irrigation purposes.

Deepali *et al.* (2010) studied on Metals Concentration in Textile and Tannery Effluents, Associated Soils and Ground Water. An inquisition has been made to ascertain the concentration of metals in the effluents and associated with soil and groundwater samples collected from various tannery and textile industries located near the Haridwar. The physicochemical examination for metallic parameters has been conducted by using spectrophotometer and Atomic absorption spectrometer (AAS). The outcome showed that all the metals such as Mn, Cr, Cu, Fe, Pb and Cd beat the standard limits in effluents of tannery and textile industries and the associated soil samples, while Chromium (Cr) contamination in groundwater samples were observed only in the samples collected from areas nearby tannery industries. The findings also indicated that the contamination of Cr was higher than other metals. The calculated metal levels in the soil and water were compared with the safe limits laid down by WHO.

Singh *et al.* (2010) revealed the physico-chemical properties of water samples from Manipur river system, India. An Assessment of physicochemical parameters had been carried out during April 2008 to March 2009 from 4 rivers namely the Manipur, Thoubal, Iril and Imphal located in Manipur, India. The Sites 1,2,3 and 4 were subjected to various anthropogenic activities of men, cursory through the urban residential areas while sites 2 and 3 from Manipur river were located in a forested watershed and free from human disturbances.

The Maxima of conductivity 467µS/cm, TDS 870 mg/l, $NO_3$-N 0.550 mg/l, K 9.00 mg/l and $PO_4$-P 0.068 mg/l were recorded during rainy season while the maximum of free total alkalinity 168.0 mg/l, Chloride 42.63 mg/l, $CO_2$ 22.3 mg/l and total hardness 136.0 mg/l were observed during the summer from the rivers indicating degradation of water quality during these seasons. The values of free $CO_2$ beyond the maximum limit (22.30 mg/l) and DO were below the minimum permissible limit (4.43 mg/l) during summer season at site 5.The values of the studied parameters were more during rainy season in Thoubal river followed by Iril, Imphal, and Manipur rivers. The results were indicated that most of the physical and chemical parameters from Manipur river system were within the limits of WHO for drinking.

Dinrifo *et al.* (2010) studied on Physico- chemical properties of Rain Water Collected from Some Industrial Areas of Lagos State Nigeria. This study had been carried out to determine the physic-chemical properties of rainwater from 4 different industrial sites in Lagos State Nigeria. These rain water samples were collected from 4 locations (viz. Ikeja, Odongunyan, Imota and Oshodi) of Lagos Metropolis, in the time of May, July and September 2009 and the rainwater samples were taken to the laboratory and analyzed. The first 3 locations were industrial layouts whereas the final one was a rural area on the outskirt of Lagos. The result assayed on the rainwater samples indicated that at the f4 locations average values were: turbidity (0.2, 0.25,0.18 and 0.16 NTU); total hardness (21.3, 20.0, 20.0, 15.1 mg/l) ;chloride (15,13.3, 14.3 and 11.1 mg/l); color ( 7.0, 9.0, 6.7 and 5.0 Hazen units) respectively. The PH values of the samples from the 3 industrial locations showed slight acidity (i.e. PH < 6.5), particularly for the month of

May 2009. This showed that it was possible to have acidic rain in these areas and thus suggested for immediate corrective actions.

Mahananda *et al.* (2010) carried out a research on the physico-chemical analysis of surface and ground water of Bargarh District, Orissa, India. The piece of investigation which were carried out to study the quality of ground water as well as surface water of Bargarh district of Orissa in India. The study area was situated at a height 176.362 mts above sea level and 59km to west of the district Sambalpur. The present work had been done for monitoring 2 types of ground water (dug well water and bore well water) of 10 wards of the town as well as three types of ponds, such as-temple pond, large community pond & small community pond of the town. The Attempts were taken to study and analyze the physical and chemical characteristics of various parameters of water like pH, Alkalinity, Temperature, Total suspended solids, and Total dissolved solids, Chemical Oxygen Demand, Dissolved oxygen, Nitrate, Chloride, Potassium, Phosphate, Sodium, Fluoride, Total Coli forms (Pond water) etc. gave a picture of quality parameters in both the bore well and dug well water as well as pond water of the town. The observation of the result, concluded that these parameters which were taken for the study of water quality were below the pollution level of ground water which was to satisfy the requirement for the use of various purposes such as domestic, agricultural, industrial etc. But in case of the surface water, the water quality of small community pond were above the permissible limit.

Ullah *et al.* (2009) studied on the assessment of groundwater contamination in an industrial city, Sialkot, Pakistan. This study had been designed to assess the groundwater quality in relation with heavy metal pollution and its implication to human health. The groundwater water samples were collected from 25 localities during October-November 2005 in the industrial city of Pakistan. Nearly 22 physiochemical parameters including pH, Temperature, Electric Conductivity (EC), Salinity, Total Dissolved Solids (TDS), Turbidity, Chloride (Cl), Sulfate ($SO_4$) ,Total Hardness, Fluoride, Iodide, Ferric (Fe+3), Manganese (Mn), Nitrate ($NO_3$), Alkalinity, Zinc (Zn), Total Chlorine, Lead (Pb), Iron (Fe), Nickel (Ni) ,Copper (Cu) and Chromium (Cr) were recorded. These results were compared with standard guidelines from WHO and Pakistan Standard Quality Control Authority (PSQCA) for groundwater quality. The Cluster Analysis (CA) were used, it grouped all sites into four zones based on their spatial similarities and dissimilarities of physiochemical properties. Zone 1 were highly contaminated with high level of turbidity, TDS, EC, $SO_4$, Cl, Zn, total hardiness, Pb and Fe concentrations were above the permissible levels of both WHO and PSQCA. In nineteen sampling sites Cr+6 was detected. Factor Analysis (FA) and Discriminant Analysis (DA) revealed significant variables including pH, EC, $SO_4$, $NO_3$, Cl, TDS, Total Hardness, Fluoride, Iodide, Total Chlorine, alkalinity, Pb, Fe and Mn which were responsible for variations in the quality of groundwater and affect water chemistry. The results proved that the groundwater of the study area cannot be as considered good quality as it is highly turbid (57% of total sites) and with high levels of Pb, Fe and Zn which were above the standards of WHO and PSQCA permissible limits. Using Geographic Information System (GIS) the spatial distribution maps of water quality parameters were produced.

Hema and Pandey (2008) carried out a study in the River of 'Tamiraparni River' which flows throughout the year. The objective was to analyse the pollution levels. The study was with special reference to discharges of sewage water and the presence of Coliform Bacteria in the river water.

Kamal *et al.* (2007) performed a study of Mouri River at Khulna, in Bangladesh. For the purposes of the study physicochemical properties of water were anlaysed. They collected water samples from six different sites regularly over the interval January-March 2002. A total of twenty two physicochemical parameters were studied some of which are Temperature, pH, BOD, COD, Sulphate, Phosphate, Nitrate, Sodium, Iron etc. are major indicators. It was observed that the river was not significantly polluted during the period of observation. A statistical analysis done on sample data revealed that temperature of the water had a positive co-relation with pH, Hardness, Total alkalinity, DO, free $CO_2$, and sulphate. It was also observed that Biological Oxygen Demand and Chemical Oxygen demand had a strong inverse relationship with dissolved oxygen.

Murugesan *et al.* (2007) investigated a study on Chittar River in the region of Courtallam, in the state of Tamil Nadu. To study the levels of pollution both physicochemical and biological properties of the water samples were studied. Courtallam Falls of the Chittar River is a place of tourist attraction during the southwest monsoon season. In this season high input of detergents and other anthropogenic activities was observed to contaminate the water.

This study was performed during peak tourist season to assess physico-chemical and biological properties of the river. All physic-chemical parameters except sulphate were found within the permissible limits. However, the Total Coliform and Fecal Coliforms counts exceeded the permissible limits, indicating a poor quality of the river water.

# CHAPTER III

# MATERIALS AND METHODS

All natural waters contain various types of dissolved constituents as well as the heavy metals which are originated from the environment by spontaneous natural process and also from the waste product of human activities. The chemical analyses of fresh water samples include the measurement of pH, Total Dissolved Solids (TDS), Salinity, Sodium (Na), Potassium (K), Calcium (Ca), Carbonate ($CO_3$) and Bicarbonate ($HCO_3$).

## 3.1 Study area

The site of freshwater sampling from different sources of Shitalakhsya and Balu river of Dhaka have been shown in Figure 1. The detailed information regarding fresh water sampling has been reported in Tables (1&2).

## 3.2 Collection of freshwater samples

Freshwater samples were collected to study the extent of heavy metal contaminations of the Shitalakhsya and Balu river, Dhaka. To obtain a general information regarding sampling (exactly number of places) point freshwater samples were collected randomly from selected rivers. In each river, 20 samples were collected from different point of selected rivers.

| Table 1. Detailed information regarding freshwater sampling | | | | |
|---|---|---|---|---|
| **SL. No.** | **Sample ID** | **River Name** | **Location** | **Date** |
| 1. | $S_1$ | Shitalakshya | Narayanganj Bandar Noughat | 22.07.2016 |
| 2. | $S_2$ | Shitalakshya | Narayanganj Bandar Noughat | 22.07.2016 |
| 3. | $S_3$ | Shitalakshya | Narayanganj Bandar Noughat | 22.07.2016 |
| 4. | $S_4$ | Shitalakshya | Narayanganj Bandar Noughat | 22.07.2016 |
| 5. | $S_5$ | Shitalakshya | Narayanganj Ferri Terminal Ghat | 22.07.2016 |
| 6. | $S_6$ | Shitalakshya | Narayanganj Ferri Terminal Ghat | 22.07.2016 |
| 7. | $S_7$ | Shitalakshya | Narayanganj Ferri Terminal Ghat | 22.07.2016 |
| 8. | $S_8$ | Shitalakshya | Narayanganj Ferri Terminal Ghat | 22.07.2016 |
| 9. | $S_9$ | Shitalakshya | Madanganj Ghat | 22.07.2016 |
| 10. | $S_{10}$ | Shitalakshya | Madanganj Ghat | 22.07.2016 |
| 11. | $S_{11}$ | Shitalakshya | Madanganj Ghat | 22.07.2016 |
| 12. | $S_{12}$ | Shitalakshya | Madanganj Ghat | 22.07.2016 |
| 13. | $S_{13}$ | Shitalakshya | Nabiganj Ghat | 22.07.2016 |
| 14. | $S_{14}$ | Shitalakshya | Nabiganj Ghat | 22.07.2016 |
| 15. | $S_{15}$ | Shitalakshya | Nabiganj Ghat | 22.07.2016 |
| 16. | $S_{16}$ | Shitalakshya | Nabiganj Ghat | 22.07.2016 |
| 17. | $S_{17}$ | Shitalakshya | Godra Ghat | 22.07.2016 |
| 18. | $S_{18}$ | Shitalakshya | Godra Ghat | 22.07.2016 |
| 19. | $S_{19}$ | Shitalakshya | Godra Ghat | 22.07.2016 |
| 20. | $S_{20}$ | Shitalakshya | Godra Ghat | 22.07.2016 |

| Table 2. Detailed information regarding freshwater sampling | | | | |
|---|---|---|---|---|
| **SL. No.** | **Sample ID** | **River Name** | **Location** | **Date** |
| 1. | $B_1$ | Balu | Uttar Bazar, Demra | 09.08.2016 |
| 2. | $B_2$ | Balu | Uttar Bazar, Demra | 09.08.2016 |
| 3. | $B_3$ | Balu | Uttar Bazar, Demra | 09.08.2016 |
| 4. | $B_4$ | Balu | Uttar Bazar, Demra | 09.08.2016 |
| 5. | $B_5$ | Balu | Uttar Bazar, Demra | 09.08.2016 |
| 6. | $B_6$ | Balu | Below Demra-Rupganj Bridge | 09.08.2016 |
| 7. | $B_7$ | Balu | Below Demra-Rupganj Bridge | 09.08.2016 |
| 8. | $B_8$ | Balu | Below Demra-Rupganj Bridge | 09.08.2016 |
| 9. | $B_9$ | Balu | Below Demra-Rupganj Bridge | 09.08.2016 |
| 10. | $B_{10}$ | Balu | Below Demra-Rupganj Bridge | 09.08.2016 |
| 11. | $B_{11}$ | Balu | Beside Poschimgaon Dakhinpara | 09.08.2016 |
| 12. | $B_{12}$ | Balu | Beside Poschimgaon Dakhinpara | 09.08.2016 |
| 13. | $B_{13}$ | Balu | Beside Poschimgaon Dakhinpara | 09.08.2016 |
| 14. | $B_{14}$ | Balu | Beside Poschimgaon Dakhinpara | 09.08.2016 |
| 15. | $B_{15}$ | Balu | Beside Poschimgaon Dakhinpara | 09.08.2016 |
| 16. | $B_{16}$ | Balu | Near Kayetpara Bazar | 09.08.2016 |
| 17. | $B_{17}$ | Balu | Near Kayetpara Bazar | 09.08.2016 |
| 18. | $B_{18}$ | Balu | Near Kayetpara Bazar | 09.08.2016 |
| 19. | $B_{19}$ | Balu | Near Kayetpara Bazar | 09.08.2016 |
| 20. | $B_{20}$ | Balu | Near Kayetpara Bazar | 09.08.2016 |

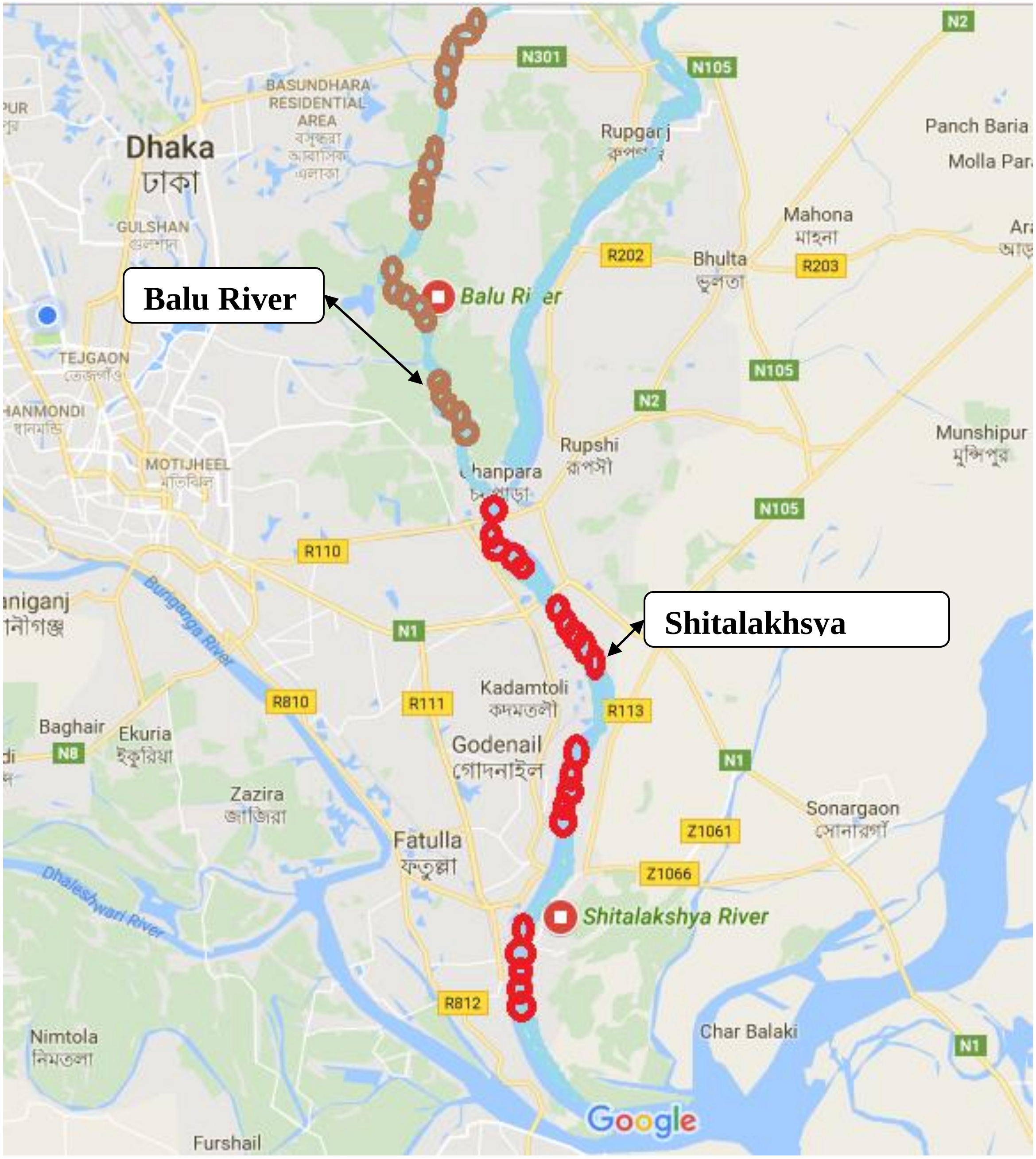


**Figure 1:** Fresh water sampling point of Shitalakhsya and Balu River

## 3.3 Sample Preparation

The fresh water samples were collected in 500 mL previously cleaned plastic bottles. Before, water sampling, all bottles were rinsed again 3 to 4 times with water to be sampled. Freshwater samples were taken from the midstream and few centimeters below the surface. After collection of freshwater of samples, all bottles were sealed immediately to avoid exposure to air or any kings of dust. The water samples after proper making were carried to the departmental laboratory of Agricultural Chemistry, Sher-e-Bangla Agricultural University, Dhaka. After bringing to the laboratory, all samples were kept in clean, cool and dry place. All samples were then filtered with filter paper (Whatman no.42) to remove the unwanted solid and suspended materials before analysis. The samples were analysed as quickly as possible on arrival at the laboratory.

## 3.4 Analytical methods of fresh water samples

The major chemical constituents or salient features of fresh waters related to water toxicity were considered for analysis as follows:

### 3.4.1 Physical characteristics

i. Color

ii. Odor

### 3.4.2 Chemical characteristics

i. pH

ii. Total Dissolved Solids (TDS)

iii. Salinity

#### 3.4.2.1 Ionic Constituents

i. Sodium (Na)

ii. Potassium (K)

iii. Calcium (Ca)

iv. Carbonate ($CO_3$) and

v. Bicarbonate ($HCO_3$)

All chemical analyses were performed at the departmental laboratory of Sher-e-Bangla Agricultural University, Dhaka-1207

**Physical characteristics**

**Color**

Color is a qualitative characteristic of waste water. With the help of its general condition, the waste water contamination can be assumed. If the color is dark grey or black, the waste water is typically septic, having undergone extensive bacterial decomposition under anaerobic conditions. The color of the sample was compared with the glass comparator and colorless distilled water. The color was determined by the instruction of Ohio Lake Management Society (2003).

**Odor**

The determination of odor has become increasingly important, as the odor may give a hint about the presence of various organic unwanted components in the waste water samples. Odor is measured by successive dilutions of the sample with odor-free water until the odor is no longer detectable. The odor was determined by the instruction of Natural Resources and Environment Board (2001).

### pH

The pH is considered to be the most important waste water parameter. The pH value of freshwater samples was determined electrometrically by taking 100 mL of sample in 200 mL beaker and immersing the electrode of the pH meter into the water as stated by APHA (1995).

### Total Dissolved Solids (TDS)

The suspended and dissolved solids in waste water are considered as total solids. Solids that are able to settle can be removed by sedimentation. The unit of solids that are able to settle is milligrams per liter (ppm). Usually, about 60% of the suspended solids in an industrial wastewater have solids that are able to settle. The TDS value of freshwater samples was determined electrometrically by taking 100 mL of sample in 200 mL beaker and immersing the electrode of TDS meter (Model CONSORT C 933).

### Salinity

The water samples were prepared by removing sediments and wastes materials for the determination of salinity. The value of salinity of freshwater samples was determined electrometrically by taking 100 mL of sample in 200 mL beaker and immersing the electrode of EC meter (Model CONSORT C 933).

**Calcium (Ca)**

Calcium (Ca) was determined from the fresh water separately with the help of Flame Photometer (Model Jenway PFP7) using appropriate filters (Calcium filter). About 100mL of filtered sample was taken in a 250mL beaker and then aspirated in a natural gas flame of light emitted by Calcium at 589 nm which were directly proportional to the concentration of these ions present in water sample, respectively.


**Figure** 2 : pH meter (A),  EC meter (B)

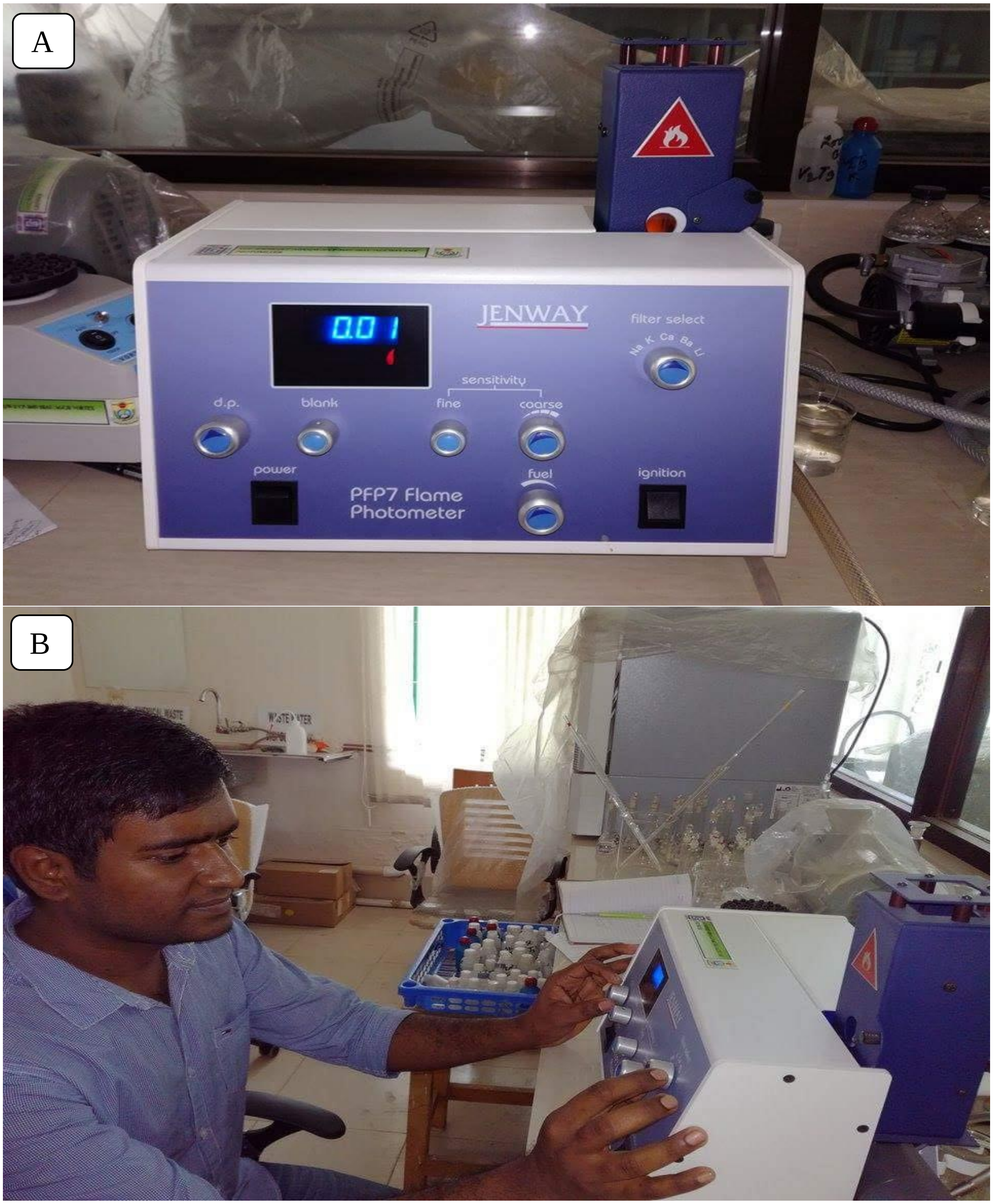


**Figure 3**: Flame Photometer (A), Handling of Flame Photometer (B)

**Potassium (K) and Sodium (Na)**

Potassium (K) and Sodium (Na) were determined from the fresh water separately with the help of Flame Photometer (Model Jenway PFP7) using appropriate filters (Potassium filter and Sodium filter). About 100 mL of filtered sample was taken in a 250 mL beaker and then aspirated in a natural gas flame of light emitted by sodium at 589 nm and potassium at 768 nm wavelength which were directly proportional to the concentration of these ions present in water sample, respectively.

**Carbonate ($CO_3$) and Bicarbonate ($HCO_3$)**

Carbonate ($CO_3$) and Bicarbonate ($HCO_3$) contents of water samples were determined by acidimetric method of titration using phenolphathalein and methyl orange indicators (Tandon, 1995 and Singh *et al.*, 1999). Exactly 10 ml of water sample was taken in a porcelain dish by addition of 5 drops of phenolphthalein indicator. If pink colour indicated the presence of carbonate, then it was titrated with 0.05N sulphuric acid ($H_2SO_4$) until the solution became colorless. After the addition of 2 to 3 drops of methyl orange indicator, it was titrated with 0.05N $H_2SO_4$ till the color changed from yellow to rosy red.

**Statistical Analysis**

Statistical Analysis of data generated out of the chemical analysis of freshwater samples were done by using MS excel 2007 software and establish the association among the parameters. And comparison was also calculated with the help of scientific calculator (CASIO super FX-991).

# CHAPTER IV

# RESULT AND DISCUSSION

In the experimental samples, the major physical and ionic constituents such as Color, Odor, pH, Total Dissolved Solids (TDS), Salinity, Sodium (Na), Potassium (K), Calcium (Ca), Carbonate ($CO_3$) and Bicarbonate ($HCO_3$) were observed. The obtained analytical results have been represented in Tables (4&5). The salient features of the experimental findings presented in this chapter and discussed under appropriate headings and support the relevant available research findings wherever applicable.

## 4.1 Physical characteristics

The color and odor of the samples ensure that the collected samples were contaminated. The presence of various inorganic and organic pollutants were the causes of color and odor of the rivers water. The results of various physical tests were given below and discuss about them briefly.

### 4.1.1 Color

Colorless water is considered pure though it may be unsafe for human health. Generally, colored water imparts adverse effect on human health and aquatic environment (Table 3). As pure water doesn’t possess any kind of color, water colors may provide evidence that there is some form of contamination. All kind of particles, organic matter, algae, sediments, dissolved minerals or any other artificial chemicals are harmful to human and aquatic health. Colored water may stain textile that can cause permanent damage.

Impacts of colored water on industrial boilers, equipments and tools could be high consumption of energy because of the insulation caused by minerals present in water hence reduces efficiency and life of the equipment. During the collection of fresh water samples color varied from river to river. The water samples color were black, ash and also light grey in Balu and Shitalakshya river.

### 4.1.2 Odor

Severe pollution has reduced the Shitalakhsya and Balu river into a 'dumping drain' of toxic refuse, threatening millions of people living on its banks with serious health hazards and a loss of their livelihoods (Table 3). That the river is dying is clearly evident from its stench. The highly toxic waters release a 'gas' that starts irritating the nostrils and throat as soon as humans breathe it. Its foul odors can be smelled from as far away as half a kilometer. The rapid increasing number of industries are involved to emit their waste material into the rivers and these rotten waste materials causes the bad or foul odor in the river water. During the investigation, the collected freshwater samples were found with bad smells and also in some case severe foul odor. Specially, the odor of Shitalakshya river was severely foul odor than the Balu river. Because the garment factory wastes are generally cloth pieces, and are recyclable, but the factories with dying functions cause liquid chemical waste of hazardous nature. The tanneries produce liquid wastes and seriously pollute the adjoining rivers. These also have solid waste which is partly recycled.

**Table 3:** The water color and odor of Shitalakhsya and Balu River

| Parameters | Shitalakhsya River | | Balu River | |
|---|---|---|---|---|
| | Color | Odor | Color | Odor |
| Sample 1 | Blackish | Bad | Light grey | Slightly bad |
| Sample 2 | Blackish | Bad | Light grey | Slightly bad |
| Sample 3 | Blackish | Bad | Light grey | Slightly bad |
| Sample 4 | Blackish | Bad | Light grey | Slightly bad |
| Sample 5 | Blackish | Bad | Light grey | Slightly bad |
| Sample 6 | Blackish | Bad | Ash | Slightly bad |
| Sample 7 | Blackish | Bad | Ash | Slightly bad |
| Sample 8 | Blackish | Bad | Ash | Slightly bad |
| Sample 9 | Ash | Slightly bad | Ash | Slightly bad |
| Sample 10 | Ash | Slightly bad | Ash | Slightly bad |
| Sample 11 | Ash | Slightly bad | Blackish | Bad |
| Sample 12 | Ash | Slightly bad | Blackish | Bad |
| Sample 13 | Ash | Slightly bad | Blackish | Bad |
| Sample 14 | Ash | Slightly bad | Blackish | Bad |
| Sample 15 | Ash | Slightly bad | Blackish | Bad |
| Sample 16 | Ash | Slightly bad | Blackish | Bad |
| Sample 17 | Light grey | Slightly bad | Blackish | Bad |
| Sample 18 | Light grey | Slightly bad | Blackish | Bad |
| Sample 19 | Light grey | Slightly bad | Blackish | Bad |
| Sample 20 | Light grey | Slightly bad | Blackish | Bad |

| Table 4: Parameter and concentration of fresh water in Shitalakshya river | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Sample** | pH | TDS (mg/L) | Salinity (dS/m) | Carbonate (mg/L) | Bi-carbonate (mg/L) | Calcium (mg/L) | Potassium (mg/L) | Sodium (mg/L) |
| $S_1$ | 6.48 | 77.4 | 0.11 | Trace | 61.05 | 5.1 | 3.6 | 8.16 |
| $S_2$ | 7.21 | 74.7 | 0.11 | Trace | 61.05 | 5.1 | 2.9 | 7.8 |
| $S_3$ | 7.27 | 74 | 0.11 | Trace | 61.05 | 5.1 | 2.9 | 7.8 |
| $S_4$ | 6.67 | 74.6 | 0.11 | Trace | 61.05 | 5.1 | 3.35 | 7.76 |
| $S_5$ | 6.78 | 72.7 | 0.11 | Trace | 61.05 | 5.1 | 3.1 | 7.48 |
| $S_6$ | 7 | 74.2 | 0.09 | Trace | 61 | 4.9 | 3.2 | 7.8 |
| $S_7$ | 6.78 | 76.2 | 0.09 | Trace | 61 | 4.9 | 2.9 | 7.28 |
| $S_8$ | 7.25 | 71.4 | 0.09 | Trace | 61 | 4.9 | 3.05 | 7.2 |
| $S_9$ | 7.15 | 71.7 | 0.09 | Trace | 61 | 4.9 | 3.05 | 8.16 |
| $S_{10}$ | 6.79 | 75 | 0.09 | Trace | 61 | 4.9 | 3.05 | 8.08 |
| $S_{11}$ | 6.37 | 74.2 | 0.1 | Trace | 60.95 | 5 | 3.3 | 8.04 |
| $S_{12}$ | 6.88 | 73.5 | 0.1 | Trace | 60.95 | 5 | 3.2 | 11.24 |
| $S_{13}$ | 6.45 | 84.4 | 0.1 | Trace | 60.95 | 5 | 2.8 | 7.88 |
| $S_{14}$ | 6.98 | 72.99 | 0.1 | Trace | 60.95 | 5 | 2.88 | 8.16 |
| $S_{15}$ | 7.02 | 76.3 | 0.1 | Trace | 60.95 | 5 | 3.2 | 7.78 |
| $S_{16}$ | 7.02 | 72.1 | 0.101 | Trace | 61 | 5.12 | 2.57 | 7.82 |
| $S_{17}$ | 7.25 | 75.7 | 0.101 | Trace | 91.5 | 5.12 | 2.75 | 7.76 |
| $S_{18}$ | 7.01 | 75.3 | 0.101 | Trace | 91.5 | 5.12 | 3.3 | 8.16 |
| $S_{19}$ | 7.18 | 74.9 | 0.101 | Trace | 61 | 5.12 | 3.2 | 7.96 |
| $S_{20}$ | 6.82 | 74.2 | 0.101 | Trace | 61 | 5.12 | 3.3 | 8.04 |
| Min. | 6.37 | 71.4 | 0.09 | Trace | 61 | 4.9 | 2.57 | 7.2 |
| Max. | 7.27 | 84.4 | 0.11 | Trace | 91.5 | 5.12 | 3.6 | 11.24 |
| Avg. | 6.91 | 75.1 | 0.1 | Trace | 65.12 | 5.01 | 3.08 | 8.13 |
| SD | 0.274353 | 2.751393 | 1.42383E-17 | Trace | 9.387702 | 0 | 0.244282 | 0.80668 |
| CV (%) | 0.039709 | 0.036657 | 1.42383E-16 | Trace | 0.144074 | 0 | 0.079301 | 0.099256 |

| Table 5: Parameter and concentration of fresh water in Balu river | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Sample** | pH | TDS (mg/L) | Salinity (dS/m) | Carbonate (mg/L) | Bi-carbonate (mg/L) | Calcium (mg/L) | Potassium (mg/L) | Sodium (mg/L) |
| $B_1$ | 7.16 | 105 | 0.1 | Trace | 91.5 | 7.1 | 3.6 | 10 |
| $B_2$ | 7.07 | 106 | 0.1 | Trace | 61 | 7.1 | 3.5 | 8.16 |
| $B_3$ | 7.1 | 101.4 | 0.1 | Trace | 91.5 | 7.1 | 4.4 | 9.92 |
| $B_4$ | 6.98 | 102.4 | 0.1 | Trace | 61 | 7.1 | 4.4 | 9.84 |
| $B_5$ | 7.1 | 103 | 0.1 | Trace | 91.5 | 7.1 | 4.4 | 9.8 |
| $B_6$ | 7.06 | 105 | 0.11 | Trace | 91.5 | 7.02 | 4.4 | 9.92 |
| $B_7$ | 7.09 | 99.1 | 0.11 | Trace | 61 | 7.02 | 4.3 | 9.8 |
| $B_8$ | 6.95 | 105 | 0.11 | Trace | 91.5 | 7.02 | 4.3 | 9.52 |
| $B_9$ | 7.16 | 100.8 | 0.11 | Trace | 91.5 | 7.02 | 3.85 | 9.16 |
| $B_{10}$ | 7.15 | 99.8 | 0.11 | Trace | 91.5 | 7.02 | 4.4 | 9.75 |
| $B_{11}$ | 7.09 | 102 | 0.09 | Trace | 61 | 7.01 | 3.6 | 8.08 |
| $B_{12}$ | 7.12 | 100.9 | 0.09 | Trace | 91.5 | 7.01 | 4.4 | 9.24 |
| $B_{13}$ | 7.07 | 99.7 | 0.09 | Trace | 91.5 | 7.01 | 3.65 | 8.08 |
| $B_{14}$ | 7.14 | 100.6 | 0.09 | Trace | 61 | 7.01 | 3.65 | 9.24 |
| $B_{15}$ | 7.01 | 102 | 0.09 | Trace | 91.5 | 5.2 | 3.6 | 9.8 |
| $B_{16}$ | 6.95 | 101.1 | 0.1 | Trace | 91.5 | 7.01 | 4.3 | 9.84 |
| $B_{17}$ | 7.18 | 102 | 0.1 | Trace | 91.5 | 5.08 | 3.65 | 9.64 |
| $B_{18}$ | 7.12 | 97.2 | 0.1 | Trace | 91.5 | 7.08 | 3.6 | 8.28 |
| $B_{19}$ | 7.32 | 100.4 | 0.1 | Trace | 91.5 | 7.01 | 4.05 | 8.28 |
| $B_{20}$ | 7.42 | 104 | 0.1 | Trace | 91.5 | 7.04 | 4.05 | 9.76 |
| Min. | 6.95 | 97.2 | 0.09 | Trace | 61 | 5.2 | 3.5 | 8.08 |
| Max. | 7.42 | 106 | 0.11 | Trace | 91.5 | 7.10 | 4.4 | 10 |
| Average | 7.12 | 101.85 | 0.1 | Trace | 83.18 | 6.85 | 4 | 9.28 |
| SD | 0.112 | 2.268 | 1.42383E -17 | Trace | 22.724 | 0.616 | 0.364 | 0.709 |
| CV (%) | 0.016 | 0.022 | 1.42383E -16 | Trace | 0.298 | 0.092 | 0.091 | 0.076 |

## 4.2 Chemical characteristics

### 4.2.1 pH

The pH of the water entering the distribution system must be controlled to minimize the corrosion of water mains and pipes in household water systems. Failure to do so can result in the contamination of drinking water and in adverse effects on its taste, odor, and appearance. The minimum and maximum pH value of Shitalakhsya was recorded as 6.37 and 7.27. The average values of pH of Shitalakshya 6.91. On the other hand, minimum and maximum pH value of Balu river were recorded 6.95 and 7.42 respectively. The acceptable range of pH for irrigation water quality is from 6.0 to 8.5 (Ayers and Westcot, 1985). Even the optimal range of pH for sustainable aquatic life is 6.5-8 (ECR, 1997).

The pH value (6.37-7.27) of the present study is less than the previous study (7.5 to 8.4) that was performed by Islam *et al.* (2007) in Shitalakshya River (Islam *et al.*, 2010)**.** Therefore the pH of the Shitalakshya River water is not so problematic for aquatic growth, the optimum ranges of pH for aquatic life is 6.8 to 9.0 (Trivedi and Raj, 1992). The pH value fluctuated the ranges 6.7 to 7.35 and 6.8 to 7.20 from March 2012 to May 2012 during the study period (Smitha *et al.*, 2013).

The result showed that, the pH values are within the permissible limit in Shitalakshya and Balu rivers. According to the water quality standard for aquaculture, the recommended pH value ranges from 6.5 to 8.0 (Meade, 1989). On the basis of their comments, it can be concluded that the water samples in both rivers were not problematic for irrigating agricultural crops and any other activities rather than use of drinking water.

### 4.2.2 Total Dissolved Solids (TDS)

The TDS of all collected water samples from 40 locations under the two rivers were within the ranges of 71.4 to 84.4 mg/L in Shitalakhsya and 97.2 to 106 mg/L for Balu river. The average TDS values of Shitalakhsya and Balu river were 75.1 and 101.85 mg/L, respectively. The highest TDS value 84.4mg/L was observed in Shitalakshya river from the area of Nabiganj Ghat (sample no.13), but the lowest TDS value of 71.4 mg/L (sample no.8). Whereas, the highest TDS value of 106 mg/L was observed in Balu river from the Narayanganj Bandar Noughat area (sample no.2), but the lowest TDS value was 97.2 mg/L (sample no.18). From the result, it was found that TDS values were higher in Balu than Shitalakhsya rivers of water.

A similar observation was reported by Meghla *et al.* (2013) for the assessment of physic-chemical properties of water from Turag River in Dhaka City, Bangladesh. The average TDS (342 mg/L) was observed in 2006 and highest TDS (812 mg/L) was found in 2010 of Turag river (Banu *et al.*, 2013). The TDS values obtained from this work ranged from 19.91 to 24.25 mg/L with a mean value of 22.11± 2.41 mg/L (Eze and Ogbaran, 2010). And TDS of the waste water samples contained 567 to 956 mg/L from the Kushtia industrial zone (Rafiquel *et al.*, 2016). The standard of TDS for domestic water supplies is 500 mg/L by USPH (De, 2005).

The acceptable standard of TDS for drinking water is 1000 mg/L, industrial water is 1500 mg/L, livestock is 5000 mg/L, and irrigation is 2000 mg/L (ADB, 1994). According to Freeze and Cherry (1979), all the water samples containing TDS less then 1000 mg/L were graded as freshwater in quality. Therefore, these waters might safely be used for irrigation and also were suitable for crop production in respect of TDS. On the basis of water quality standard for aquaculture as cited in Appendices 2, 3 and 4. No other samples were found as unsuitable for aquaculture and livestock consumption, because the collected surface water containing less than 1000 mg/L TDS.

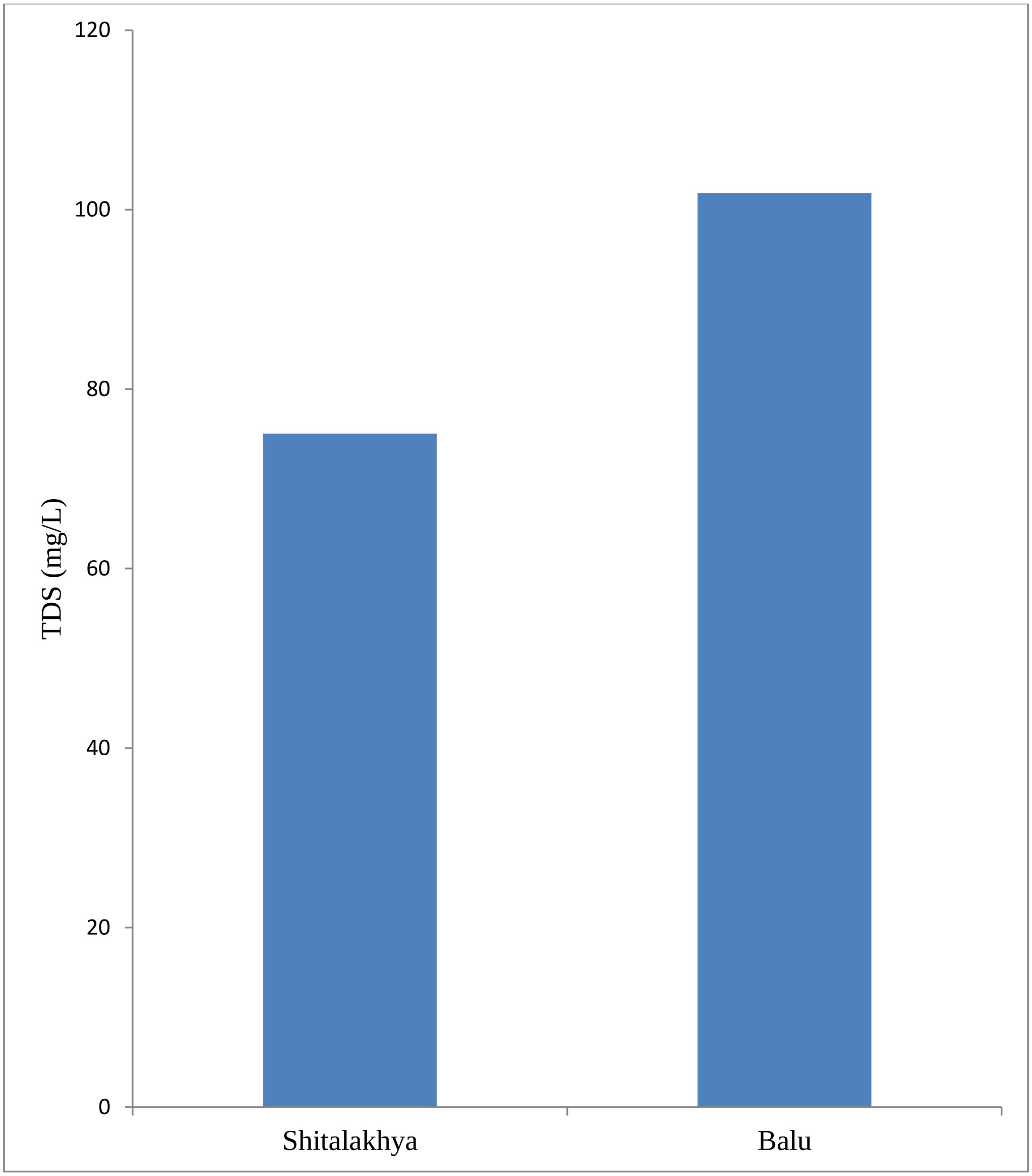


**Figure 4.** Comparison of TDS (mg/L) value of water of Shitalakshya and Balu River

### 4.2.3 Salinity

Now-a-days, the estimated salt intake from drinking water in this population exceeded recommended limits. The problem of saline intrusion into drinking water has multiple causes and is likely to be exacerbated by climate change induced sea-level rise. In coastal area of Bangladesh, natural drinking water sources, such as rivers and ground water are threatened by saltwater intrusion from the Bay of Bengal. The lowest and the highest value of salinity were 0.09 dS/m and 0.11 dS/m recorded from both of the rivers. The average salinity was recorded 0.1 dS/m from both Shitalakshya and Balu river. No samples contained more than 0.11 dS/m in the rivers. SRDI (1997) reported that, soil salinity levels south of Khulna and Bagerhat towns ranged between 8 to 15 dS/m during the low flow season. The salinity of water indicates the presence of ionic substances that may come from the reaction of metals and acids containing in water. The lowest salinity value of the surface water was 0.08 mg/L and the highest value observed was 0.52 mg/L from Kushtia industrial zone. From the result it was observed that the EC value increased with increasing TDS and salinity (Rahman *et al.*, 2012).

According to them, it can be concluded that water of Shitalakhsya and Balu river might safely be used for irrigation and also were suitable for crop production in respect of salinity (Appendix 5).

## 4.3 Ionic Constituents

### 4.3.1 Sodium (Na)

The concentration of Na in fresh water samples of the study area varied from 7.2 to 11.24 mg\L with an average value of 8.13 mg/L (Table 4) in Shitalakhsya river. Where in Balu river, the minimum and the maximum concentration of Sodiun (Na) were 8.08 and 10 mg/L with a mean value of 9.28 mg/L (Table 5). In the study, it is showed that, the highest concentration of Na was observed as 10mg/L in Balu river (Sample no.1) and lowest was found 7.2 mg/L in Shitalakhsya river (Sample no. 8) In each case, the concentration of soudium (Na) was higher in Balu river than Shitalakshya river. Maximum concentration of Sodium (28.320 mg/L) was found in rainy season and minimum (6.720 mg/L) in summer season from Ganga river (Joshi *et al.*, 2009). The maximum and minimum concentration of Na (57.19 mg/L and 97.89mg/L) were recorded form Tongi in Bangladesh (Bidyut *et al.*, 2014). Sodium concentration of water samples varied from 10 to 20 mg/L from the sampling point Kamlapur and the lowest was found at Barokhada and Jugia (Nahar *et al.*, 2016)

Irrigation water containing less than 40 mg/L Na was suitable for raising crop plants (Ayers and Westcot, 1985). According to the Appendices 3 and 4, the upper limit for the livestock use of drinking water and aquaculture for 300 mg/L and 75 mg/L, respectively. There were no samples which contained such concentration of Sodium. From this result, it can be concluded that the water of Shitalakshya and Balu rivers are safe for the consumption of livestock, agricultural production as well as for the aquaculture.

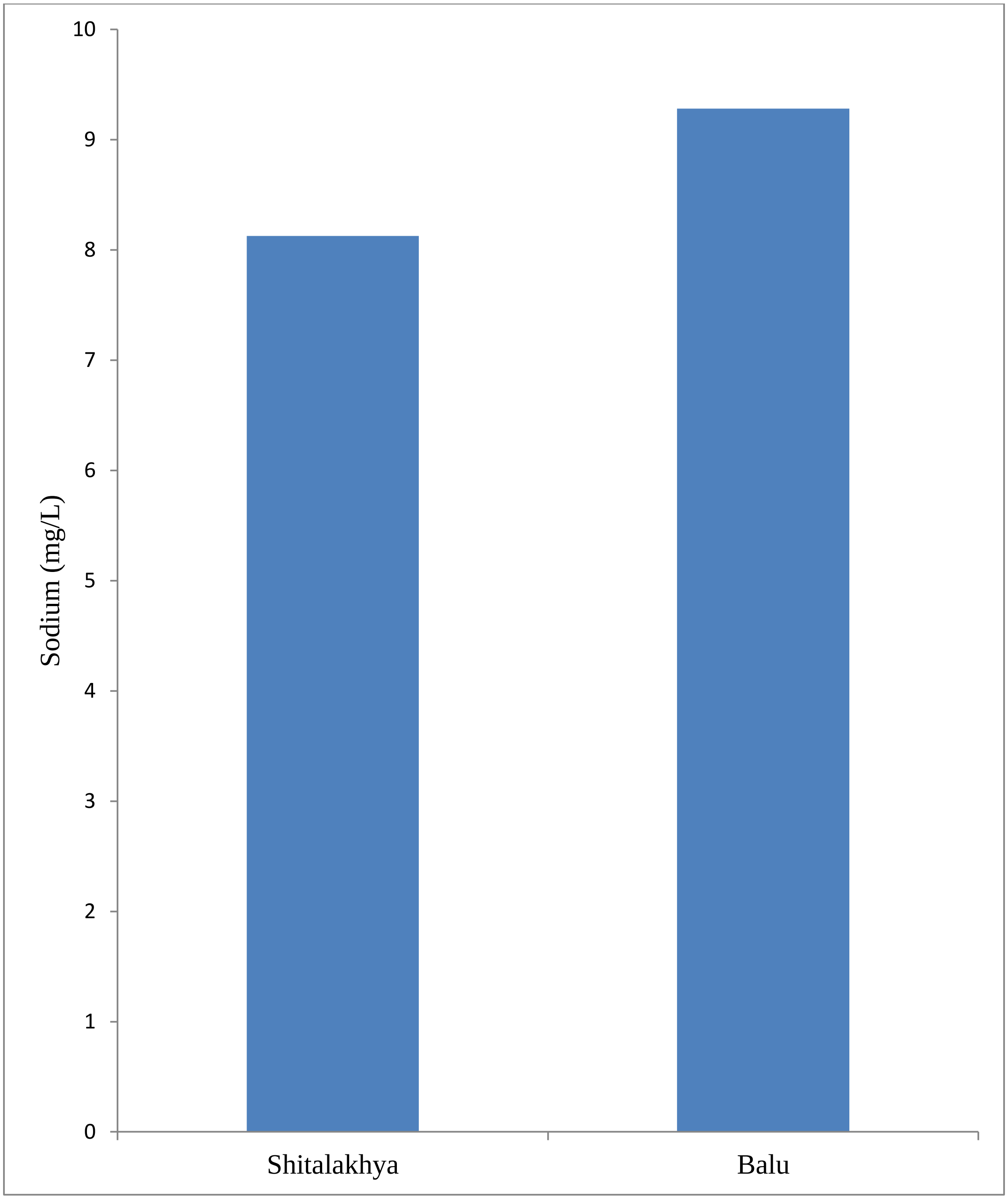


**Figure 5.** Comparison of Sodium (mg/L) value of water of Shitalakshya and Balu River

### 4.3.2 Potassium (K)

The concentration of Potassium (K) in the collected water samples in Shitalakshya river which was varies from 2.57 to 3.6 mg/L with the mean values of 3.08 mg/L. In case of Balu river, the lowest value observed 3.50 mg/L and the highest values were found 4.4 mg/L with the mean value of 4 mg/L. From the mean value of K content in Balu river was greater than the Shitalakshya river because of heavy of dilution of minerals and heavy metals from the different tanneries and garments waste materials. The highest K content (3.6 mg/L) was found from Narayanganj Bandar Noughat (Samples no. 1) whereas, the highest K content (4.4 mg/L) in maximum cases of Balu river from different locations. Similarly, maximum concentration of potassium 3.425 mg/L was found in rainy season and minimum (1.216 mg/L) in summer season (Joshi *et al.*, 2009). The K content ranged from 18.19 to 44.91 mg/L in Tongi area of Bangladesh (Bidyut *et al.*, 2014). Potassium concentration of water of the study area ranged from 3.409 to 5.114 mg/L. The highest concentration (5.114 mg/L) was found at the sampling point Kamlapur and the lowest was found at Barokhada and Jugia (Nahar *et al.*, 2016)

The acceptable content of K for aquaculture is less than 5.0 mg/L (Meade, 1989) as shown in Appendix 3&4. And the upper limit for the livestock use of water is 20 mg/L. From the above information, all the samples were found within this range. So, it can be concluded that the use of water for the livestock, aquaculture and for the agricultural production is suitable.

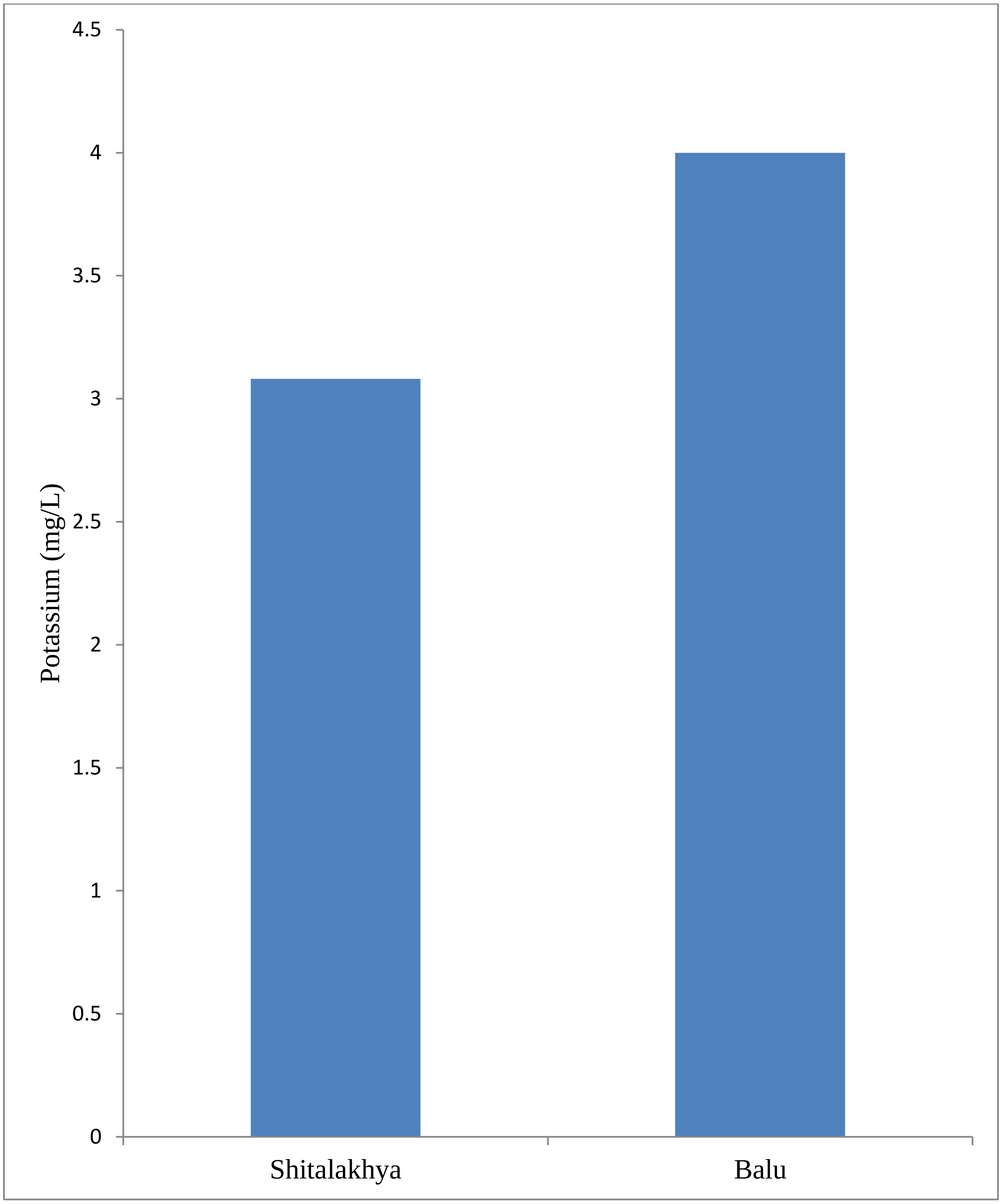


**Figure 6.** Comparison of of Potassium (mg/L) value of water of Shitalakshya and Balu River

### 4.3.3 Calcium (Ca)

The concentration of Ca in fresh water samples of the study area were 4.9 to 5.12 mg\L with an average value of 5.01 mg/L (Table 4) in the Shitalakhsya river. On the other hand, the lowest concentration of Ca was 5.20 mg/L and highest was 7.10 mg/L with the mean value of 6.85 mg/L in Balu river (Table 5). From the result, the concentration of Ca was higher in Balu river as compared to the Shitalakshya river due to heavy dilution by rain water and effluents from different industries. This value is very low when compared with the WHO values 200 mg/L and 25–100 mg/L values for optimum productivity of fish (Bhatnagar and Devi, 2013.). It would therefore be necessary to have some calcium supplement since calcium is necessary for bone and scale formation. Calcium content of water samples ranged between 22.9 mg/L to 49.2 mg/L (Waghmare and Kulkarni, 2013). Singh *et al.* (2010) reported calcium concentration range between 6.01-17.63 mg/L from Manipur river system.

A water samples collection survey was conducted by Islam *et al.* (2010) and found the similar result. Irrigation water containing less than 20 mg/L Ca was suitable for raising crop plants (Ayers and Westcot, 1985). In the study area, all the collected water samples were suitable based on the estimated Ca content. Considering fresh water quality for aquaculture, the detected amount of Ca was suitable where acceptable limit of Ca for this aspect ranges from 4 to 160mg/L (Meade, 1989) as mentioned in Appendix 4.

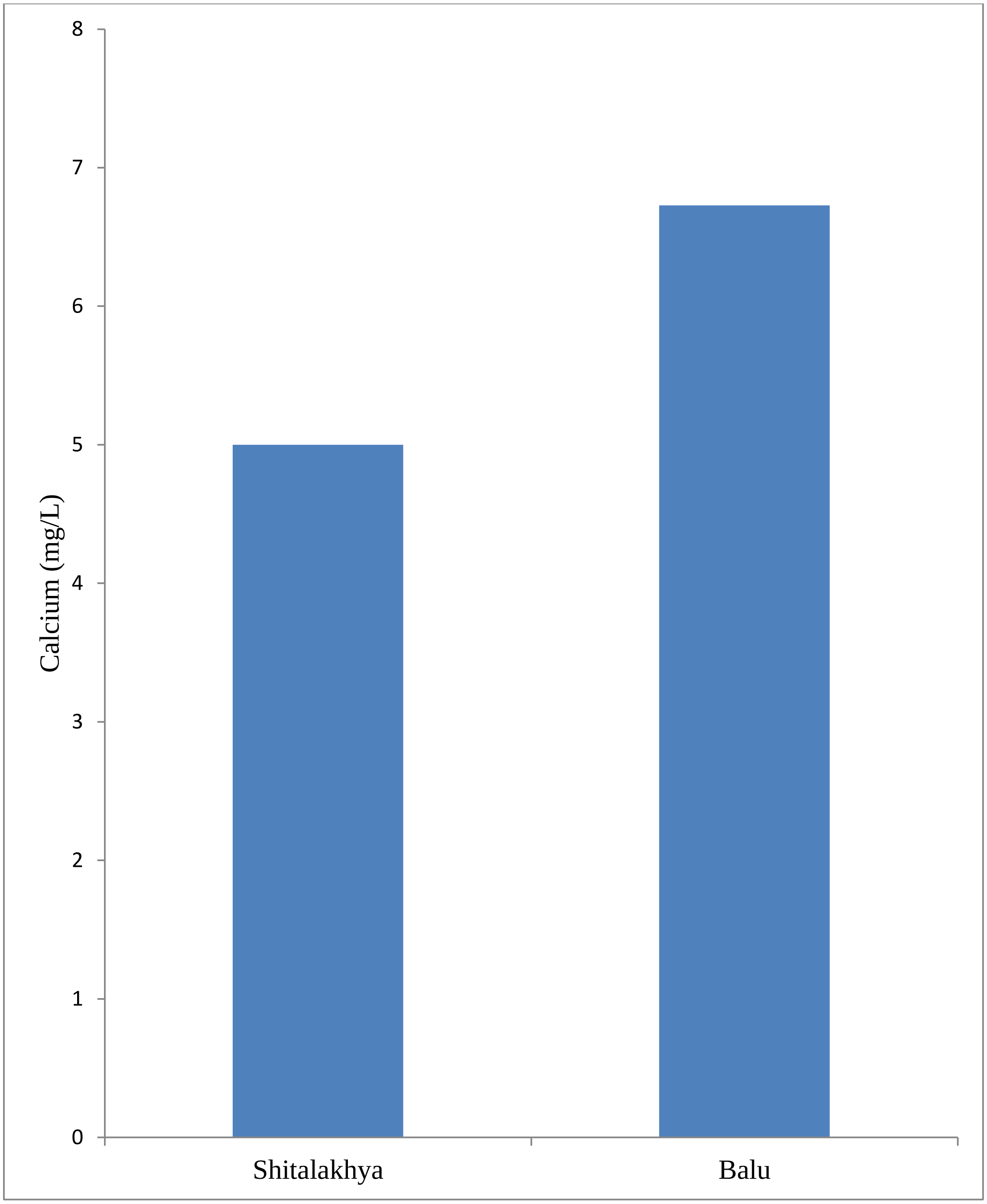


**Figure 7.** Comparison of Calcium (mg/L) value of water of Shitalakshya and Balu River

### 4.3.4 Carbonate ($CO_3^{2-}$)

All the water samples did not contain any trace amount of $CO_3^{2-}$ for both Shitalakshya and Balu river. The detected concentration of all the water samples was found in very trace amounts which indicated that all the water samples were free from carbonate. So, the detected concentration of $CO_3^{2-}$ had no any remarkable influence based on the effect of river as well as the environment even for the usage of agricultural purposes.

### 4.3.5 Bicarbonate ($HCO_3^-$)

The concentration of $HCO_3^-$ in the collected water samples fluctuated between 61 to 91.5mg/L with the mean value of 65.12 mg/L in respect of Shitalakhsya river. On the other hand, the minimum and maximum values of $HCO_3^-$ were 61 to 91.5mg/L with the mean value of 83.18 mg/L in Balu river.

The maximum recommended concentration of $HCO_3^-$ in irrigation is 0.10 mg/L (Ayers and Westcot, 1985). According to the findings, Shitalakhsya and Balu rivers are highly unsuitable and it would be considered as problematic for aquaculture, agricultural production and livestock usage.

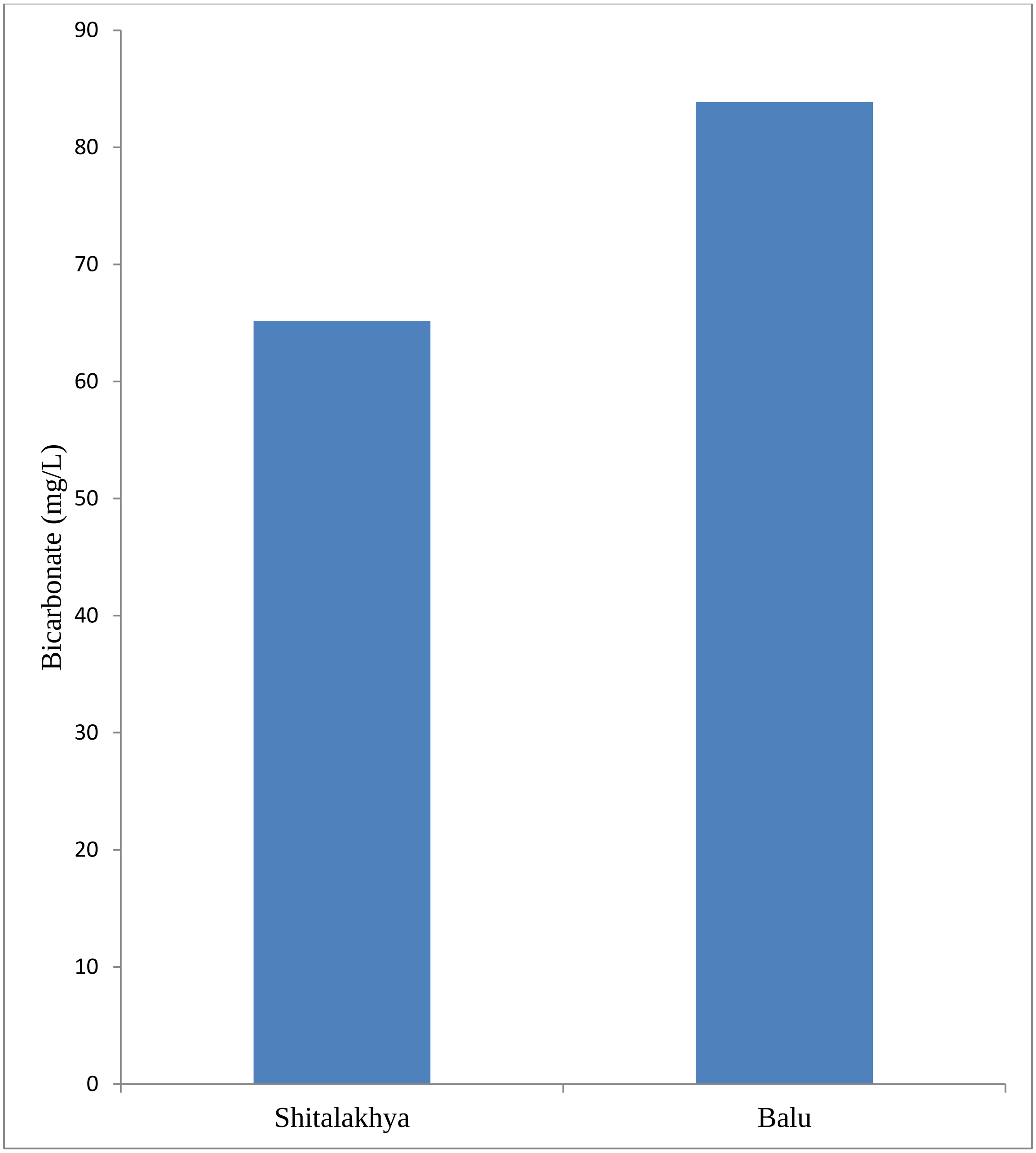


**Figure 8.** Comparison of Bicarbonate (mg/L) value of water of Shitalakshya and Balu River

### 4.4 Correlation matrix of Shitalakshya and Balu River

The correlation matrix presented in Tables 6 & 7 showed both positive and negative significant correlations among the different physico-chemical parameters. In tannery effluents and adjacent river among the parameters. In case of Shitalakshya river, the pH and TDS values showed the positive correlation with Bicarbonate (r=0.264; r=0.090). Even Potassium (K) showed the positive correlation with Sodium (r=0.210), whereas a negative significant correlation existed between Bi-carbonate and Potassiou (r=-0.006).

In case of Balu river, a significant positive correlation existed between Potassium (K) and Calcium (Ca), with Sodium and Potassium (r=0.561785; r=0.357233), respectively. TDS values also showed the positive correlation with Sodium and Potassium (r=0.263903; r=0.011992). And pH values were found the positive correlation with Bi-carbonate and Calcium (r=0.216994; r=0.051999).

**Table 6:** Correlation matrix among the parameters in Shitalakshya River

| Parameters | pH | TDS (mg/L) | Bi-carbonate (mg/L) | Calcium (mg/L) | Potassium (mg/L) | Sodium (mg/L) |
|---|---|---|---|---|---|---|
| pH | 1 | | | | | |
| TDS | -0.49822 | 1 | | | | |
| Bi-carbonate | 0.26426 | 0.090178 | 1 | | | |
| Calcium | 0.07 | 0.061 | 0.334 | 1 | | |
| Potassium | -0.4064 | -0.00634 | -0.006 | 0.063 | 1 | |
| Sodium | -0.10047 | -0.06138 | -0.061 | 0.040 | 0.210 | 1 |

**Table 7:** Correlation matrix among the parameters in Balu River

| Parameters | pH | TDS (mg/L) | Bi-carbonate (mg/L) | Calcium (mg/L) | Potassium (mg/L) | Sodium (mg/L |
|---|---|---|---|---|---|---|
| pH | 1 | | | | | |
| TDS(mg/L) | -0.07509 | 1 | | | | |
| Bi-carbonate | 0.21699 | -0.31103 | 1 | | | |
| Calcium | 0.05199 | -0.0196 | -0.18248 | 1 | | |
| Potassium | -0.15618 | 0.01199 | -0.11468 | 0.35723 | 1 | |
| Sodium | -0.12601 | 0.26390 | -0.04043 | -0.19991 | 0.56178 | 1 |

# CHAPTER V

## SUMMARY AND CONCLUSION

The investigation was conducted at the Agricultural Chemistry laboratory at Sher-e-Bangla Agricultural University to assess the physico-chemical parameters as well as to know the major and minor minerals content in Shitalakshya and Balu rivers of Bangladesh. For this purpose, 20 samples were collected from different locations in each river to analyze the physico-chemical parameters like TDS, Salinity, pH, Sodium (Na), Potassium (K), Calcium (Ca), Carbonate ($CO_3^{2-}$) and Bicarbonate ($HCO_3^-$).

The pH values of Shitalakshya and Balu river ranged from 6.37 to 7.42 and most of the pH values were belonged around below the range of 7.5. The highest and lowest value of pH were not far from each value of two rivers. In case of Total Dissolve Solid (TDS), the highest concentration was 106 mg/L in Balu river whereas the lowest value was 71.4 mg/L in Shitalakshya river. The maximum concentration of salt was 0.11 dS/m in both of the rivers. The selected rivers were free from Carbonate during investigation. But in case of Bicarbonate, the highest and lowest value of $HCO_3^-$ were 91.5 mg/L and 61 mg/L observed in both of the rivers. The Calcium (Ca) concentration varied from 5.2 mg/L to 7.1 mg/L and the highest (7.1 mg/L) concentration of Ca was observed in Balu river. Whereas, the Ca content was found with the ranges of 4.9 mg/L to 5.12 mg/L in the samples of the Shitalakshya river. In case of Sodium (Na), the range varied from 7.2 mg/L to 11.24 mg/L and the maximum (11.24mg/L) of Na concentration with the lowest (7.2 mg/L) was observed in Shitalakhsya river. In case of potassium the highest (4.4 mg/L) K content was found in Balu river and the lowest (3.5 mg/L) was observed in Shitalakshya river.

However, the rivers of Bangladesh are polluted by many ways such as waste materials, organic matter decomposition, inorganic substances, garments waste materials, tanneries and so on. The adverse effects of such interventions have been deleterious to the aquatic environment. They have destroyed the fish and aquatic vegetables that thrive into the rivers. They have also blocked the natural flow of water. Our lack of knowledge about environmental management and indifferent attitude towards protection of the environment have turned these beautiful water body into a sink of pollution, receiving numerous unauthorized sewage outlets, surface run-off, urban drainage discharges and even solid waste from various sources. These practices have caused enormous harm to the rivers environment and its subsequent degradation in many ways. In order to assist the natural processes of surface water recharge, maintenance of aquatic life and ecological balance and for turning the rivers and surrounding areas into recreational places, planned development of the rivers is very much essential. Saving the rivers from the pollution should be a priority concerns for the sake of environment. Awareness program is necessary to stop unauthorized activities that seriously lead to pollution of the rivers and surrounding environment.

## RECOMMENDATION

- As we do not able to determine many other quality parameters especially heavy metals due to lack of lab facilities, so further analysis of different heavy metals should be done.
- The assessment of heavy metals should be done at regular interval and as well as season wise in future.

# REFERENCES

ADB (Asian Development Bank) (1994). Training manual for environmental monitoring. USA: Engineer. Sci. Inc., 2-16.

Agbaire, P. O., Akporido, Samuel O. and Emoyan O.O. (2015). Determination of Some Physicochemical Parameters of Water From Artificial Concrete Fish Ponds In Abraka And Its Environs, Delta State, Nigeria. *Int. J. of Plant, Animal and Environ. Sci.* **5**(3):70-76.

Agricultural Waste Management Field Handbook, page 1 to 17.University of Missouri. USA.

Akter, M., Sikder, T. and Atique Ullah, A. K. M. (2014). Water Quality Assessment of an Industrial Zone Polluted Aquatic Body in Dhaka, Bangladesh. *American J. of Environ. Protection*, **3**(5): 232-237.

Anonymous (2017). Learn about salinity and water quality: Reporting the concentrations of ions and molecules. http://www.salinitymanagement.org/Salinity%20Management%20Guide/ls/ls_3c.html. Visited on 24 August, 2017.

APHA (1995). Standard methods for the examination of water and wastewater. 19th edn. American Public Health Association, Washington, DC.

Ayers, R.S. and Westcot, D.W. (1985). Water Quality for Agriculture. FAO Irrigation and Drainage Paper.**29** (Rev. I):1-144

Banu, Z., Chowdhury, M.S.A., Hossain, M.D., Nakagami, K. (2013). Contamination and Ecological Risk Assessment of Heavy Metal in the Sediment of Turag River, Bangladesh: An Index Analysis Approach. *J. of Water Res. and Protection,* **5**:239-248.

Barth, J.A.C., Steidle, D., Kuntz, D., Goacht, T., Mouvet, C., Von, W.T., Lobe, I., Langenhoff, A., Albrechtsen, H.J., Janniche, G.S., Morasch, B., Hunkeler D. and Grathwohl, P. (2007). Deposition, persistence and turnover of pollutants: First results from the EU project Aqua Terra for selected river basins and aquifers. Sci. Total Environ. 376:40-50.

Behera, B.C., Mishra, R.R., Patra, J.K., Dutta, S.K. and Thatoi, H.N. (2014). Physico Chemical Properties of Water Sample Collected From Mangrove Ecosystem of Mahanadi River Delta, Odisha, India. *American J. of Marine Sci.*, **2**(1):19-24.

Bharambe, P.R., Rodge, R.P. and Ambegaonkar, P. R. (1992). Depth and quality of underground water as affected by canal irrigation. *J Indian Soc. Soil Sci.* **40**(2): 344-347.

Bhasin, S., Arvind, N., Shukla, Shrivastava, S. and Mishra, U. (2016). Control Chart Model for Assessment of Water Quality of a Tropical River- Kshipra Ujjain, India. *Saudi J. Life Sci.,* **1**(1):51-64

Bhatnagar, A. and Devi, P. (2013). Water Quality Guidance for the Management of Pond Fish Culture. *Intl J. Environ. Sci.,* **3** (6):1980 – 1993.

Bidyut, B., Mia, M.Y. and Zakir, H.M. (2014). Water Quality Evaluation of Tongi Area in Bangladesh: An Impact of Industrialization. *J. Chem. Bio. Phy. Sci.*, **4**(2):1735-1752.

British Geological Survey (1999). Groundwater studies for Arsenic Contamination of Bangladesh, http://phys 4, Harvard. Edu/~wilson/arsenic-frames.html (Online).

British Geological Survey (1999). Groundwater studies for Arsenic Contamination of Bangladesh, http://phys 4, Harvard. Edu/~wilson/arsenic-frames.html (0nline). Kumar, G. N. P.; Srinivas, P.; Chandra, K.G. and Sujatha, P. 2010. Delineation of groundwater potential zones using Remote sensing and GIS techniques: A Case Study of Kurmapalli Vagu Basin in Andhra Pradesh, India. *Int. J. of Water Res. and Environ. Eng.*, 2(3):70-78.

Dara, S.S. (2007). A Textbook of Environmental Chemistry and Pollution Control. 7th ed. S. Chand and Company Ltd., Ram Nagar, New Delhi, India, pp.44-75.

De, A.K. (2005). Environmental chemistry. 5thed. New Age international (P) Ltd., Daryagang, New Delhi, India, 187.

Deepali, K.K. and Gangwar, K.K. (2010). Metals Concentration in Textile and Tannery Effluents, Associated Soils and Ground Water. New York Science Journal. pp. 82-89 (ISSN: 1554-0200).

Dinrifo, R.R.,Babatunde, S.O.E., Bankole, Y.O. and Demu, Q.A (2010). Physico- Chemical Properties of Rain Water Collected from Some

Industrial Areas of Lagos State Nigeria. *European J. of Sci. Res.*, **41**(3):383-390.

DPHE/BGS/DFID (Department for International Development), UK, (2000). Groundwater studies of Arsenic in Bangladesh, Final report, Dhaka. pp. 1-5.

ECR (Environment Conservation Rules) (1997). Government of the People's Republic of Bangladesh, Ministry of Environment and Forest, Bangladesh. *Dhaka Univ. J. Sci.,* **57**(1):29-32.

Ershad, K. (2009). A River in Distress. *A weekly Publication of Daily Star.* **13**(617): 8-15.

ESB (Environmental Studies Board) 1972. National Academy of Sciences. National Academy of Engineering and Agricultural Waste Management Field Handbook, page 1 to 17.University of Missouri. USA.

Eze, V.C. and Ogbaran I.O. (2010). Microbiological and Physicochemical Characterizes of fish pond water in Ughelli Delta State, Nigeria. *Intl. J. Current Res.*, **8**:82 –87.

Flura, M.A.A., Akhery, N., Tanu, M.B. Khan, M.H. (2016). Physico-chemical and biological properties of water from the river Meghna, Bangladesh. *Int. J. of Fisheries and Aquatic Studies*, **4**(2): 161-165

Freeze, R.A. and Cherry, J.A. (1979). Groundwater. Prentice-Hall, Inc. Englewood Cliffs, New Jersey.

Gupta, N., Yadav, K. K., Kumar, V. and Singh, D. (2013). Assessment of Physicochemical Properties of Yamuna River in Agra City. *Int. J. of Chem. Tech. Res*., **5**(1): 528-531.

Harter , T. (2003).Groundwater Quality and Groundwater Pollution. Division of Agriculture and Natural Resources. Farm Water Quality Planning. University of California. USA

Hema, P. and Pandey, S. (2008). Physico-chemical characterisation of textile chemical sludge generated from various cetps in india. Journal of Environmental Research and Development. **2**(3):329-339.

Islam , S.M.D. and Azam, G. (2015). Seasonal variation of physicochemical and toxic properties in three major rivers; Shitalakhya, Buriganga and Turag around Dhaka city, Bangladesh. *J. of Biodiversity and Environ. Sci.* **7** (3):120-131

Islam, M. H., Rahman, M. M. and Ashraf, F. U. (2010). Assessment of water quality and impact of effluents from fertilizer factories to the Shitalakhsya River. *Int. J. of Water Res. and Environ. Eng.* **2**(8): 208-221.

Islam, M.Z., Azim, M.A., Islam, R., Quraishi, S.B. (2008). Seasonal variation of heavy metals in water samples from the Sitalakhya river. *J. Bangladesh Acad. Sci.,* **32**(1):13-22.

Islam, R., Foisal, J.A., Hasanuzzaman, Rahman, M., Lisa, L.A. and Paul, D.K. (2016). Pollution assessment and heavy metal determination by AAS in waste water collected from Kushtia industrial zone in Bangladesh. *African J. Environ. Sci. Tech.,* **10**(1):9-17

Joshi, D.M., Kumar, A. and Agrawal, N. (2009). Studies on Physicochemical Parameters to Assess the Water Quality of River Ganga for Drinking Purpose in Haridwar District. *Rasayan J. of Chemistry*. **2**(1):195-203

Kamal, D., Khan A. N., Rahman, M.A. and Ahamed, F. (2007). Study on the Physico-chemical properties of water of Mouri river, Khulna, Bangladesh, *Pakistan J. Biol. Sci*., **10**(5):710-717

Kesalkar, V.P., Isha, P.K and Sudame, A.M. (2012). Physico-chemical characteristics of wastewater from Paper Industry. *Int. J. of Eng. Res.*, **2**(4):137-143.

Khan, M. A. I.; Hossain, A. M.; Huda, M. E.; Islam M. S. and Elahi, S. F. (2007). Physico- chemical and biological aspects of monsoon waters of Ashulia for economic and aesthetic applications: preliminary studies. *Bangladesh J. of Sci. and Indus. Res.,* **42**(4): 377- 396.

Kotadiya, N.G., Acharya, C.A., Radadia, B.B. and Solanki, H.A. (2013). Determination of Water Quality Index and suitability of a rural freshwater body in Ghuma village, District Ahmedabad, Gujarat. Life Sciences Leaflets. **2**:68-67.

Mahananda, M.R., Mohanty, B.P. and Behera, N.R. (2010). Physico-chemical analysis of surface and ground water of bargarh district, Orissa, india- Mahananda and al Physico-chemical Analysis of Ground & Surface Water, pp. 284 -295.

Mahbub, A., Tanvir, H.M. and Afrin, L.T. (2014). An evaluation of environmental and social impact due to industrial activities- A case study of Bangshi river around Dhaka Export Processing Zone (DEPZ), Bangladesh. *Int. Res. J. of Environmental Sci.,* **3**(2): 103-111.

Matin, M. A. and Kamal, R. (2010). Impact of climate change on river system. *In* The International Symposium on Environmental Degradation and Sustainable Development (ISEDSD), Dhaka, Bangladesh, pp. 61-65.

Meade, J.W. (1985). Allowable ammonia for fish culture, Progressive Fish culture, **47**:135-145.

Meade, J.W. (1989). Aquaculture management. New York. Van Nostr and Reinhold.

Meghla, N.T.; Islam, M. S.; Ali, Suravi, M. A. and Sultana, N. (2013). Assessment of Physicochemical Properties of Water from the Turag River in Dhaka City, Bangladesh. *Int. J. of Current Microbiology Applied Sci.,* **2**(5):110-122.

Miah, M.Y., Robel, F.N., Bhowmik, S., Bhattacharjee, S., Paul, S. C. and Hossain, M.J. (2015). Assessment of the Coastal Area Water Quality in Noakhali, Bangladesh. *Int. J. of Scientific & Eng. Res.,* **6**(2): 1116-1123

Mishra, A., A. Mukherjee, and Tripathi, B.D. (2009). Seasonal and Temporal Variations in Physico-chemical and Bacterilogical Characteristics of River Ganga in Varanasi. *Int. J. of Environmental Res.,* **3**(3):395-402.

Murugesan, A.G., Perumal, C.M. and Ruby, J. (2007). Physico-chemical and biological study of the river Chittar at Courtallam, Tamil Nadu (India). *J. Environ. Sci. Eng.***, 49**(2):121-6.

Nahar, N., Lanon, M.A.H., Saha, B. and Shaibur, M.R. (2016). Assessment of physico-chemical properties of water of Gorai river at Kushtia town in 2014: a case study. *J. of Sci., Tech. and Environ. Informatics,* **2**(2):51–60.

Natural Resources and Environment Board (2001). Determination of Odour Concentration in Water. Danish Cooperation for Environment and Development.

Ohio Lake Management Society (2003). Citizen Lake Management Society Quality Assurance Project Plan.

Popa, P., Mihaela, T., Mirela, V., Silvia, D., Catalin, T. and Lucian, Georgescu, P. (2012). Study of Physico-Chemical Characteristics of Wastewater in an Urban Agglomeration in Romania. The scientific world journal pp. 1-10.

Rafiquel, I., Jannat, A.F., Hasanuzzaman, M.R., Laisa, A.L. and Dipak, K.P. (2016). Pollution assessment and heavy metal determination by AAS in waste water collected from Kushtia industrial zone in Bangladesh. *African J. Environ. Sci. Technol.,* **10**(1):9-17

Rahman, A. K. M. L., Islam, M., Hossain, M. Z. & Ahsan, M. A. (2012). Study of the seasonal variations in Turag river water quality parameters. *African J. of Pure and Applied Chem.,* **6**(10):144-148

Rajasthan State (2010). India-A greener approach. *E-Journal of Chemistry* **7**(1): 428-432.

Sharma, D. and Kandal, A. (2011). Water quality analysis of River Yamuna using water quality index in the national capital territory, India (2000-2009). *Applied Water Science*. **1**:147.

Shinde, S.E., Pathan, T.S., Raut, K.S. and Sonawane, D.L. (2011), Studies on physico-chemical parameters and correlation coefficient of Harsool-savangi Dam, District Aurangabad, India. *Middle-East J. of Sci. Res.*, **8**(3):544- 554

Siddique, N.A., Islam, M.A., Rahman, M.A. and Alam, M.S. (2009). The Relationship of Arsenic with other metals in drinking water at highly endemic areas in Bangladesh. *Dhaka Univ. J. Sci.,* **57**(1):29-32.

Sikder, M.N.A., Huq, S.M.S., Mamun, M.A.A., Hoque, K.A., Bhuyan, M.S. and Bakar, M.A. (2016). Assessment of physicochemical parameters with its effects on human and aquatic animals giving special preference to effective management of Turag River. *J. of Environmental Sci., Toxicology and Food Tech.,* **10**(3):41-51

Sikder, M.T., Yasuda, M., Syawal, S.M., Saito, T., Tanaka, S. and Kurasaki, M. (2012). Comparative assessment of water quality in the major rivers of Dhaka and West Java. *Int. J. of Environmental Protection*, **2**(4): 8-13.

Singh, M. R., Gupta A. and Beateswari, K. H. (2010). Physico-chemical Properties of Water Samples for Manipur River System India. *J. Appl. Sci. Environ. Manage.,* **14**(4): 85-89

Smitha, Ajay D. and Shivashankar P. August (2013). Physico Chemical Analysis of the Freshwater at River Kapila, Nanjangudu Industrial Area, Mysore, India. *Int. Res. J. of Environ. Sci.,* **2**(8): 59-65.

SRDI, (1997). Land and soil resources Utilization Guide (In Bengali). Thana Nirdeshika Series-Khagrachari SadarThana, Soil Resources Development Institute, Dhaka, Bangladesh.pp-51-61

Tandon, H.L.S. (Ed.) (1995). Method of Analysis of Soils, Plants, Waters and Fertilizers. Fertilizer Development and Consultation Organisation. New Delhi. Pp.84-90.

Thakre, Y.G., Choudhary, M.D. and Raut R.D. (2012). Physicochemical Characterization of Red and Black Soils of Wardha Region. *Int. J. Chem. and Phys. Sci.,* **1**(2): 60-66

Trivedi, P. R. and Raj, G. (1992). Encyclopedia of Environmental Sciences.25: 144.

Ugwu, A.I. and Wakawa, R.J. (2012). A study of seasonal physicochemical parameters in river USMA. *American J. of Environmental Sci*., **8**(5):569-576

Ullah, R., Malik, R.N. and Qadir, A. (2009). Assessment of groundwater contamination in an industrial city, Sialkot, Pakistan. *African J. of Environmental Sci. and Tech.,* **3**(12): 429-446

Waghmare, B. D. And Kulkarni, A. N. (2013). Assessment Of Seasonalvariations In Calcium, Magnesium And Hardness Of Lendi River, District Nanded, Maharashtra, India. *Indian J. L. Sci*., **3**(1):83-85.

Yadav, A.K., Khan, P. and Sharma, S.K. (2010). Water Quality Index Assessment of Groundwater in Todaraisingh Tehsil of Rajasthan State, India - A Greener Approach. *E-Journal of Chem.* **7**(1): 428-432

# APPENDICES

**Appendix 1:** Recommended maximum concentration of different ions in water

| Elements name | Symbol | Concentration for water used (mg/L) |
|---|---|---|
| Calcium | Ca | < 4.0 |
| Potassium | K | 2.0 |
| Phosphorus | P | 2.0 |
| Boron | B | 0.75 |
| Carbonate | $CO_3$ | 1.50 |
| Bicarbonate | $HCO_3$ | 1.50 |

**Source :** Ayers, R.S. and Wescot, D.W. (1985). Water Quality for Agriculture, FAO Irrigation and Drainage Paper 29 (Rev. 1):40-96

**Appendix 2:** Water Classification as per TDS

| Water Clsss | TDS (mg/L) |
|---|---|
| Fresh water | 0-1000 |
| Brackish water | 1000-10000 |
| Saline water | 10000-100000 |
| Brine water | >100000 |

**Source :** Freeze, A.R. and Cherry, J.A. 1979. Groundwater. Prentice Hall Inc. Englewood Cliffs, New Jersey 07632,p. 84

**Appendix 3:** Recommendation limit of toxic constituents in drinking water for livestock use

| Constituents | Symbol | Upper limit (mg/L) |
|---|---|---|
| Boron | B | 5.00 |
| TDS | - | 10000.0 |
| Calcium | Ca | 150 |
| Sodium | Na | 300 |
| Potassium | K | >20 |
| Carbonate | $CO_3$ | 2000 |
| Bicarbonate | $HCO_3$ | 2000 |

**Source:** ESB (Environmental Studies Board) 1972. National Academy of Sciences. National Academy of Engineering, and Agricultural Waste Management Field Handbook, page 1 to 17.University of Missouri. USA.

**Appendix 4:** Water quality standards for aquaculture

| Parameters | Symbol | Concentration (mg/L) |
|---|---|---|
| Calcium | Ca | 4.0-160 |
| Magnesium | Mg | <15.0 |
| Potassium | K | <5.0 |
| Sodium | Na | 75.0 |
| pH | - | 6.5-8.5 |
| Salinity | - | |
| Total Dissolve Solid | TDS | <400.0 |

**Source:** Meade, J.W.1989.Aquaculture Management. New York.Van Nostrand Reinhold.

**Appendix 5:** Effect of salinity of drinking water on livestock and poultry (Water Quality Criteria, 1972).

| **Soluble salt (mg/L)** | **Effect** |
|---|---|
| <1,000 | Low level of salinity; present no serious burden to any class of livestock or poultry |
| 1,000 to 2,999 | Satisfactory for all classes of livestock and poultry; may cause temporary, mild diarrhea in livestock; and water droppings in poultry at higher levels; no effect on health or performance |
| 3,000 to 4,999 | Satisfactory for livestock; may cause temporary diarrhea or be refused by animals no accustomed to it; poor water for poultry causing watery feces and, at high levels, increased mortality and decreased growth (especially in turkeys). |
| 5,000 to 6,999 | Reasonable safety for dairy and beef cattle, sheep, swine, and horses; avoid use for pregnant or lactating animals; not acceptable for poultry, causes decreased growth and production or increased mortality. |
| 7,000 to 10,000 | Unfit for poultry and swine; risk in using for pregnant or lactating cows, horses, sheep, the young of these species, or animals subjected to heavy heat stress or water loss; use should be avoided, although older ruminants, horses, poultry, and swine may subsist for long periods under conditions of low stress. |
| >10,000 | Risks are great; cannot be recommended for use under any conditions. |

**Source:** Agricultural Waste Management Field Handbook, page 1 to 17.University of Missouri. USA.

**Appendix 6:** Reporting the concentrations of ions and molecules (Anonymous, 2017).

| Equivalent weights of selected ions and Equations | |
|---|---|
| **Constituent** | **Equivalent weight** |
| Sodium ($Na^+$) | 23 |
| Calcium ($Ca^{2+}$) | 20 |
| Magnesium ($Mg^{2+}$) | 12 |
| Ammonium ($NH_4^+$) | 18 |
| Potassium ($K^+$) | 39 |
| Bicarbonate ($HCO3^-$) | 61 |
| Carbonate ($CO_3^{2-)}$ | 30 |
| Chloride ($Cl^-$) | 35 |
| Sulfate ($SO4_2$-) | 48 |
| Nitrate ($NO_3^-$) | 62 |
| Phosphate ($H_2PO_4^-$) | 97 |
| ppm = mg solute / $10^6$ milligrams solution = mg/liter<br>= mg solute / kg solution<br>ppb = µg solute / $10^9$ micrograms solution=µg/liter<br>= µg solute / kg solution<br>mg/L = meq/L × equivalent weight<br>meq/L = mg/L ÷ equiv. wt. | |

**Source**: Salinity Management Guide at http://www.salinitymanagement.org/Salinity%20Management%20Guide/ls/ls_3c.html

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| **Author** | CHANDAN SUTRADHAR |
| **Department** | Agricultural Chemistry |
| **University** | Sher-e-Bangla Agricultural University |
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