ASSESSMENT OF PHYSICO-CHEMICAL PROPERTIES OF SOME LAKES AND PONDS WATER OF DHAKA METROPOLITAN CITY

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CERTIFICATE

This is to certify that the thesis entitled, **"ASSESSMENT OF PHYSICO-CHEMICAL PROPERTIES OF SOME LAKES AND PONDS WATER OF DHAKA, METROPOLITAN CITY"** 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 **MD. ZILLUR RAHMAN** bearing **Registration No. 09-03470** 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: 18.05.2017
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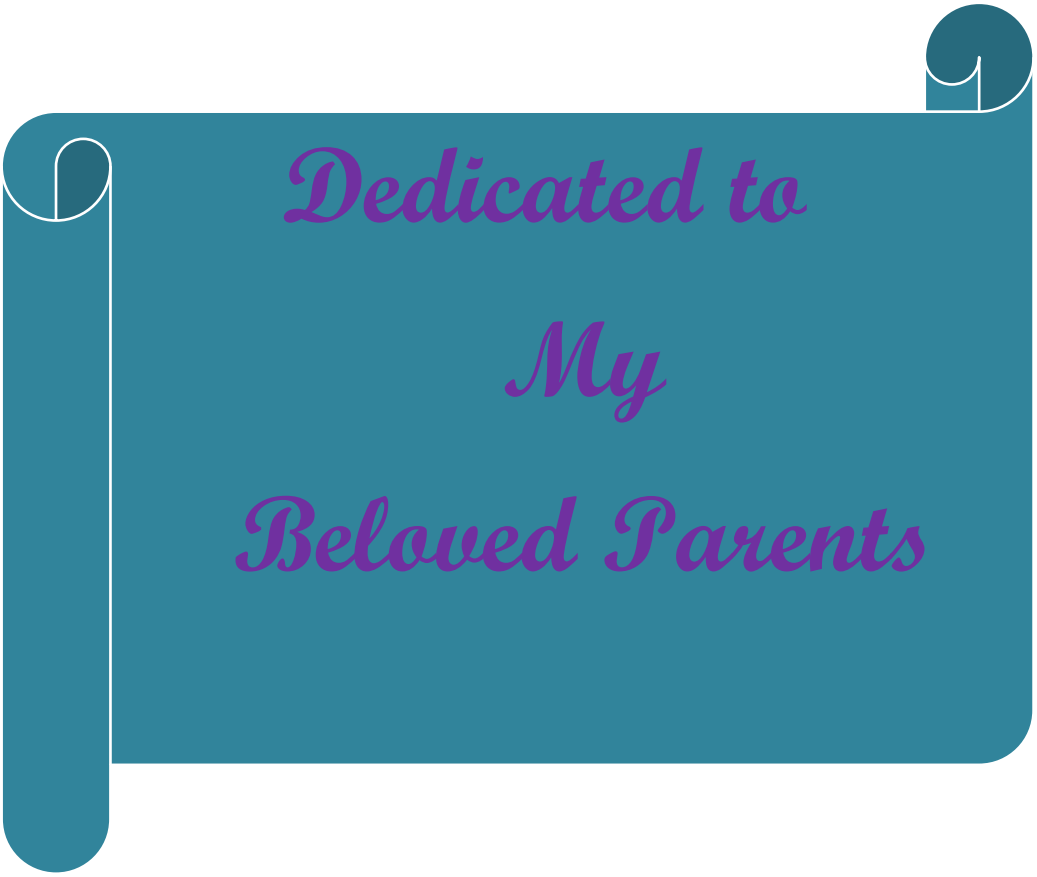
Dedicated to
My
Beloved Parents

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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

ABSTRACT

This study was carried out to determine some physico-chemical properties of different lakes and pond of metropolitan city, namely Curzon Hall, Dhanmondi, Hatirjheel and Sher-e-Bangla Agriculutral University campus, Dhaka. Ten samples were collected from the each pond and lakes 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 odor of lakes water was slightly bad and the color was light grey to slightly black. The results of the present study shows that except pH, K and HCO_3, other measured parameters did not exceed the maximum permissible limit. The pH exceeded (8.22) the standard limit (>8) for other three lakes except Hatirjheel lake. The K content exceeded the acceptable limit (<5mg/L) except SAU campus pond. And Bicarbonate was found within ranges of 244 to 400mg/L for all the pond and lakes, whereas the standard limit of Bicarbonate is 1.50mg/L. From the statistical point of view, most of time, pH and Bicarbonate showed negative correlation with other parameters. So, it can be concluded that without proper analysis of the water quality of different lakes and pond of Dhaka city should not use for drinking purposes, agricultural productions, fisheries, livestocks, recreational activities and various industrial uses.

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CHAPTER I

INTRODUCTION

Water plays an important role in assimilation or carrying of the municipal and industrial waste waters and run off from agricultural land. Recently water pollution has become a dreadfully severe and visible form of environmental contamination as water bodies are used arbitrarily as dumps (Francis, 1994). The pollution from industrial effluents, urban and agricultural waste in some rivers and water bodies has reached alarming levels in Bangladesh (Alam *et al.*, 2007). Heavy metals are natural compounded elements occurring in the environment and different in concentrations along the earth crust. Dissimilar to organic polymerized toxins it can be degraded slowly by biological or chemical processes (Anand and Kala, 2015).

A large number of ponds, lakes and water bodies in different parts of Dhaka are in a dismal state. Many of these ponds have been replaced by box culverts leading to primary drainage congestion. These water bodies, which could serve to refresh the city environment, are in fact polluting the environment by acting as dumping grounds for domestic and industrial wastes, breeding grounds for mosquitoes and by spreading diseases. The effects of the encroachment and flling up of khals, lakes and wetlands, both by public and private agencies become devastating during floods. These practices of encroachment and pollution, unless stopped forthwith, will lead to a situation when the city will not be livable anymore. It is strongly proposed that 40% wetlands including the reserved ponds/lakes be declared by the Ministry of Environment and Forest as ecologically critical area (ECA) through official gazette notification without much delay. Of 40%, a minimum of 12% of the drainage catchment area equivalent to about 20 km^2

can be made available as reserved ponds or lakes and developed as water parks and the rest 28% protected as natural wetlands for the retention of storm water. So a continuous monitoring of water quality is very essential to determine the state of pollution.

Although metals are natural constituents of our earth and they are present in all environments, their concentrations are drastically altered by man-made actions. The natural distributions of metals have been distressed in terrestrial and aquatic environment due to industrialization and urbanization in last few decades (Banerjee, 2003). Heavy metals are natural trace components of the aquatic environment, but their levels have increased due to domestic, industrial, mining and agricultural activities (Leland *et al.*, 1978; Mance, 1987; Kalay and Canli, 2000). Sources of these elements in soils mainly include natural occurrence derived from parent materials and anthropogenic activities. Anthropogenic inputs are associated with industrialization and agricultural activates deposition such as atmospheric deposition, waste disposal and waste incineration, emissions from traffic, fertilizer application and long-term application of wastewater in agricultural land. Heavy metals are nonbiodegradable, they can be necessary or beneficial to plants at certain levels but can be toxic when they exceed the specific thresholds level (Qishlaqi and Farid, 2007).

These toxic heavy metals when released in aquatic environment may enter into the food chain through biomagnifications which may cause various health problems in humans and animals. Pollution by heavy metals is still a serious problem due to their toxicity and ability to accumulate in the biota (Islam and Tanaka, 2004). From an environmental point of view, coastal zones can be considered as the geographic space of interaction between

terrestrial and marine ecosystems that is of great importance for the survival of a large variety of plants, animals and marine species (Castro *et al.*, 1999).

Dhaka is one of the most densely populated cities in the world, surrounded by number of rivers such as; the Buriganga, Turag, Shitalakhya, Balu, Bongshi, Karnatali etc. (GOB, 1997). But, most of them are biologically dead or about to die (Karn and Harada, 2001; Bangladesh River System, 2004). The surface water of ponds and lakes along these peripheral rivers of Dhaka city is also known to be highly polluted due to municipal waste waters that are discharged into these rivers (Kamal *et al*., 1999; Karn and Harada, 2001). Both organic and inorganic waste effluents adversely interact with the river and lake system and deteriorating the water quality of these water. For this reason, water causes the adverse effect on surrounding land and aquatic ecosystem as well as subsequent impact on the livelihood of the local community (Rahman *et al*., 2012; Meghla *et al*., 2013).

The concerns over surface water quality are gradually emerging due to the disposed location of industrial units and the adverse effects on surrounding land and aquatic environment, as well as subsequent impacts on the livelihood system of the local community (Islam *et al.*, 2011).

Dhaka Export Processing Zone (DEPZ) which is situated under Manikgonj district being the 2nd EPZ of Bangladesh has started its operation in 1993 and at present houses 92 industrial units which are categorically the leading pollution creators. These industrial units in number are as follows: cap/accessories/garments (42); textile/knitting (22); plastic goods (6); footwear/leather goods (4); metal products (2); electronic goods (2); paper products (1); chemical and fertilizer (1) and miscellaneous (11) (Mahbub *et al.*, 2014). Every industrial unit is supposed to have Effluent Treatment Plant (ETP) to treat the respective wastewater they generate. However, so far only

a few industries have installed such plants. Even then most of the installed ETPs operate occasionally only to be qualified to international buyers and to get clearance certificate from Department of Environment (DoE) (Mortula and Rahman, 2002). Most of the industries discharge their effluents containing heavy metals without any prior treatment through open drain and contaminates water, soil and vegetables of the adjacent areas. Pollution from the DEPZ has already affected the wetland and some of the streams ruining aquatic habitats and natural fisheries. Recently, it has been reported that the surface water body connected to DEPZ effluent disposal sites have been steadily contaminated with a huge number of heavy and toxic metals (Mahfuz *et al.*, 2004).

This information is important to communicate to the general people and the Government in order to develop policies for the conservation of the precious fresh water resources (Ali *et al*., 2000). Moreover, assessment of water quality of any region is an important aspect of developmental activities, as rivers are used for water supply to domestic, industrial, agricultural purposes (Jackher and Rawat, 2003).

In a nutshell, this research will provide a clear idea about the present water quality and physico-chemical parameters of ponds and lakes of Dhaka Metropolitan city. Keeping in mind the present research work was conducted for the assessments of Physico-Chemical properties of waters in different ponds of Dhaka city with the following objectives –

1. To elucidate the Physical properties of waters in different ponds and lakes of Dhaka metropolitan city.

2. To analyze the chemical constituents of ponds and lakes waters.

CHAPTER II

REVIEW OF LITERATURE

Sikder *et al.* (2016) carried out 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, NO_2 and SO_2 concentration and the concentration range for CO: 2425-7635 μg/m 3, 82-652 μg/m 3 for NO_2, 151.93-553.56 μg/m 3 for PM10 and 395-510 μg/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(μScm-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), respectively.

Flura *et al.* (2016) conducted 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 physicochemical 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) conducted an experiment in 2014 to assess the physic-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) studied involves assessment of water quality of Kshipra river by use of control chart, water quality index (WQI), physic chemical and microbiological analysis. Analysis of 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. WQI values ranged from284.0-1112.34 and show all study site to be under pollution stress. Results of the present investigation showed that water quality of the river is 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 water of Kshipra river is found to be of D class and river is observed to be under great pollution stress. Immediate remedial measures are recommended to control pollution and improve water quality of the river which is important for proper management and conservation of this holy river.

Mohiuddin *et al.* (2015) conducted research to assess the level of Cr, Pb, Cd, Ni, Zn, Cu, Fe and Mn contamination in the sediment samples of the Buriganga river, at the Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh. Total 14 sediment samples were collected from different areas of upstream of the Buriganga river. The mean concentrations of total Cr, Pb, Cd, Ni, Fe, Cu, Zn and Mn in the sediment samples were 173.4, 31.4, 1.5, 153.3, 481.8, 344.2, 12989 and 4036 μg g^{-1}, respectively. The range of pH and EC of sediment were 5.87-8.21 and 230-707 μS cm^{-1}, respectively. The mean value of organic matter in sediment

samples was 13.4%. Heavy metal concentrations in sediment were compared with geochemical background and standard values, previous report on the Buriganga river and other rivers in Bangladesh. The average concentration of Cr, Pb and Ni in sediments of the Buriganga river is almost twice of the geochemical background *i.e.* average worldwide shale standard and continental upper crust value, Cd and Zn is about five times and Cu content is about ten times higher than the geochemical background values. Average concentration of Cr, Cu and Ni exceeded the severe effect level (SEL) values, where as Pb, Cd and Zn exceeded toxicity reference values (TRV). However, the concentration of heavy metal in the sediment samples of the Buriganga river for the year 2009 of the same river reported by corresponding author was relatively higher than this study average. The average Enrichment factors (EFc) for Zn, Cu, Mn and Cd reflects extremely contaminated pollution level which implies that these metals originated from point source of pollution and very severely enriched in river sediments. The pollution load index (PLI) of sediments of the studied region varied from 1.61-7.51. The geoaccumulation index (I_{geo}) for Cu of five locations was greater than 3.0, which exhibited strongly polluted sediment quality. The I_{geo} for Mn in 11 locations and Zn in 12 sites were greater than 1.0, indicated moderately polluted sediment quality. Heavy metal pollution intensity in the Buriganga river water and sediments signaled alarming condition for city dwellers and aquatic ecosystem of the river.

Islam and Azam (2015) investigated the seasonal variation in physicochemical 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, Water Quality Index (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 is 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), Acidity (87.90±5.62mg/L), alkalinity (37.67±06.19mg/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.

Gulzar and Nanda (2015) studied to determine the physico-chemical properties (moisture content, reducing sugars, proline content, electrical conductivity, ash content, pH, titrable acidity, HMF, water activity, total soluble solids and total solids), enzymatic activity (diastase and invertase), colour characteristics (mmpfund, ABS450 and CIE L* a* b*) and mineral content (Cu, Mn, Fe, Zn, Pb and Cd) of three different varieties of honeys from Kashmir valley of India (acacia honey, pine honeydew and multifl oral honey). Of the honey samples analysed, only pine honeydew were grouped in dark category of honey (L* 50) and possessed both red and yellow components. All the physico-chemical properties and enzymatic activity indicated that all the three analysed varieties of honey met the criteria set by the International Honey Commission and revised codex standards for honey. The source of honey had a significant effect.

Mobin *et al.* (2014) stated the assessment of water quality parameters including pH, DO, BOD, temperature, TDS, EC, transparency, hardness, and alkalinity of the Turag River in Tongi, Gazipur, Bangladesh. The physicochemical parameters of water were investigated for 3 points in the Turag River through experimental methods. The river water was black in color and the odor was bad which indicate that the water is polluted and dangerous for aquatic ecosystem and human health. The temperature of water was within an average value of 28 to 39^{o}C which indicates standard temperature (20 to 30^{o}C) for aquatic medium. The average value of pH was 6.83, which indicates that the value was within the standard limits (6.5 to 8.0) for aquatic organisms. The values of DO water were within the range of 0.6 to 3.9 ppm with an average value of 2.25 ppm indicating low DO value from standard level (4.0 to 6.0 ppm for domestic and 5.0 ppm for fish

culture). The values of BOD were within the average value of 1.15 ppm indicating lower condition compared to standard value of BOD (6.0 ppm for fish culture and 10.0 ppm for irrigation). The average value of TDS was 340.86 ppm which indicates low TDS condition. The EC values were ranged from 35 to150 μS/cm with an average value of 56.30 μS/cm which indicates lower condition than the standard value. The average value of transparency was 28.39 cm. The average value of hardness was 106.79 ppm which indicates near to the standard level. The average alkalinity was 237.66 ppm indicating very lower condition than the standard limit (2000 ppm for irrigation).

Behera *et al.* (2014) studied on Physico-Chemical Properties of Water Sample Collected from Mangrove Ecosystem of Mahanadi River Delta, Odisha, India and investigated the physicochemical parameters of water samples which were compared with the water quality standard of 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.

Meghla *et al.* (2013) performed on the assessment of Physicochemical Properties of water from the Turag River in Dhaka City, Bangladesh. The inspection demonstrated the present scenario of the water quality of the River Turag which has been highly polluted due to dumping of untreated waste of corporation and industrial directly. The contents of total phosphorus (P), nitrogen (N), hardness and alkalinity in the river water unevenly exceeded than the permissible limit of the standard values (EQS, 1997) in all seasons. Though the levels of pH, total dissolved solid (TDS), electric conductivity (EC), and cadmium (Cd) were highly outpace the standard level in both post and pre monsoon season but in monsoon they were under the permissible limit in the Turag River. The lowest concentration of dissolved oxygen (DO) and higher concentration of biological oxygen demand (BOD) were observed that severely harmed the aquatic organisms and destroyed their habitat in the river. Temperature, the contents of sodium (Na), potassium (K) and copper (Cu) were within the standard level in all seasons. The comparative study showed that the water quality of the Turag River was highly degraded due to the presence of significant amount of pollutants discharged from Dhaka city. This deterioration not only affects the aquatic organisms but also worse affects the entire ecosystem as well as the local people who depend on river water for their daily activities.

Gupta *et al.* (2013) studied on assessment of Physicochemical Properties of Yamuna River in Agra City and 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, and 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.

Mokaddes *et al.* (2013) conducted to evaluate level of water pollution and its influence on heavy metal contaminations of lake water of Dhaka metropolitan city. The chemical analysis of water samples included pH, EC, As, Cu, Mn, 'ln. Pb and Cd. The concentrations of heavy metal of lake water were recorded as: in case of pH = 6.95, in case of EC = 22.44 (µscm-1), in case of Cu = 0.018 ppm, in case of Zn = 0.274 ppm, in case of Mn = 0.084 ppm, in case of As = 0.002 ppb, in case of Pb = 0.002 ppm and in case of Cd = 0.044 ppm. The pH value of lakes water range from 5.34 to 7.68, an indication of slightly acidic to alkaline in nature. The average EC value for lakes water ranged from 17.61 to 34.61 µScm^{-1} where EC value varied from 14.24 to 33.48 µScm-1 in the lake water.

Patil et al. (2012) stated the people on globe are under tremendous threat due to undesired changes in the physical, chemical and biological characteristics of air, water and soil. Due to increased human population, industrialization, use of fertilizers and man-made activity water is highly polluted with different harmful contaminants. Natural water contaminates due to weathering of rocks and leaching of soils, mining processing etc. It is necessary that the quality of drinking water should be checked at regular time interval, because due to use of contaminated drinking water, human population suffers from varied of water borne diseases. The availability of good quality water is an indispensable feature for preventing diseases and

improving quality of life. It is necessary to know details about different physico-chemical parameters such as color, temperature, acidity, hardness, pH, sulphate, chloride, DO, BOD, COD, alkalinity used for testing of water quality. Heavy metals such as Pb, Cr, Fe, Hg etc. are of special concern because they produce water or chronic poisoning in aquatic animals. Some water analysis reports with physic-chemical parameters have been given for the exploring parameter study. Guidelines of different physic-chemical parameters also have been given for comparing the value of real water sample.

Sharma *et al.* (2012) performed an evaluation of the physicochemical parameters of the Narmada River, Madhya Pradesh. The study covered a period of 12 months commencing August 2009. In order to draw water samples, three different sampling stations along the course of the River were selected. The various parameters considered were pH, temperature, transparency, D.O, BOD, chlorides, phosphates, nitrate, alkalinity, sulphates and total hardness. Phosphates, nitrate, alkalinity, sulphates were found to be high in September and October whereas pH, temperature, chlorides and total hardness were high in summer. The overall values of the parameters were within the WHO limits.

Shrivastava *et al.* (2012) carried out a research on the sewage disposal into the Mancha River in Betul City, Madhya Pradesh. The water samples were collected from nine different sampling points, which had sewage inlets nearby. This exercise was conducted in early summer (in March 2009), in the rainy season (in July 2009) and after rainy season (in November 2009). They studied water quality for physicochemical parameters like D.O, COD,

BOD, chlorides, nitrates etc. On comparing the data obtained with the amounts prescribed by the WHO, it was found that all the parameters exceeded the prescribed limits.

Shanthi *et al.* (2012) studied on the Physico-chemical analysis of ground water near municipal solid waste dumping sites in Coimbatore city. This paper assessed the physical and chemical parameters of groundwater in Coimbatore city. These groundwater samples were collected near the municipal solid waste dumping area during the rainy seasons 2011. These samples were studied for various physicochemical properties. A comparative study on ground water i.e. bore well and hand pump water were carried out by taking certain vital parameters such as pH, TS, TSS, TDS, TA, COD, Nitrate, Cl-, F- etc. In this present study it was founded that the maximum parameters were not at the level of pollution except few parameters like nitrate, TDS, TSS, TS and TH in ground water. Hence both the type of ground water satisfy the requirement for the use in. Therefore, the best accepted option was to avoid the possibility of polluting the groundwater resources.

Gupta *et al.* (2011) investigated a Physico-chemical analysis pertaining to the Chambal River System in Kota city, Rajasthan. The period covered was summer seasons from 2007 to 2009. The pH values, total hardness, alkalinity, chlorides, sulphates and TDS levels were observed to be satisfactory, implying that the pollution was within limits. The presence of iron, ammonia and comparatively lower value of dissolved oxygen indicate the river is polluted to some extent. Overall the river was moderately

polluted and only highly polluted at the points of influx of sewage and domestic wastes.

Chetia *et al.* (2011) carried out a study to review the pollution levels in Brahmaputra river system at Golaghat (Assam), India. The analysis of Arsenic (As) in the under ground water was carried out for this purpose. Samples were collected from different depths of the tube wells in the area. An aggregate of 22 samples were collected in this manner. Along with total Arsenic, an examination of concentration levels of Iron, Manganese, Calcium, Sodium, Potassium, and Magnesium was carried out. Physicochemical parameters like pH, total hardness, and DO were also studied out. Most of the samples were found to be contaminated by As and Fe beyond permissible limits and the Gamariguri block was found to be affected the worst.

Santhi *et al.* (2011) observed the water quality in Kodumudiaru dam in Tirunelveli District. Various physiochemical parameters, such as, pH, Electrical conductivity, total hardness, total alkalinity and presence of metals, such as Ca, Mg etc. were analyzed for the purpose of the study. Equipments like pH meter and Conductivity Bridge were used. The results revealed that the various parameters, referred to above, were within permissible limits and hence the dam water was safe for drinking, agriculture etc.

Yadav (2010) conducted a research to examine its suitability for drinking, irrigation and industrial purpose. The presence of problematic salts contains in groundwater due to local pollutants and affected the groundwater quality adversely. The estimated values were compared with drinking water quality standards prescribed by B.I.S. It was found that drinking water is severely polluted with hardness causing salts. This study reveals that people dependent on water sources of the study area are prone to health hazards of contaminated water and quality managements to hardness urgently needed

Malviya *et al.* (2010) performed a chemical assessment of Narmada River water at Hoshangabad city and Nemawar. The samples were collected for about a year at six different sampling sites, four sampling sites were selected in Hoshangabad, one sampling site in Handia village (Harda) and one sampling site in Nemawar village (Dewas). The parameters that were assessed are DO, BOD, COD, turbidity and total hardness. Some of the sites were found to be highly polluted as compared to others.

Rajamanickan *et al.* (2010) carried out a review of water of Amravati river basin, Karor. The objective was to determine how pollution levels were affected by effluents released by textile dyeing units on ground water quality of the river. It was observed that the pollution levels had enhanced as a result of increasing discharge of pollutants into the river. Comparison of the sample data with the standards prescribed by WHO, revealed that various physiochemical parameters, such as, TDS, TA, TH, Ca, Cl, SO4 were in excess of the prescribed limits. It was concluded that a visible effect on the pollution levels of water had been caused due to the discharge of industrial wastes.

Samuel *et al.* (2010) conducted a study on water quality of Noyall River, Tamilnadu. Several textile dye units discharged their effluents into the river. The study was carried outto find the correlation between the effluents discharged and the pollution levels in the riverwater. High levels of Total Dissolved Solids (TDS) and Cl were observed from dataobtained from investigation of sample results.Heavy metals were also found in dam sediments.

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 2005in 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.

Geetha *et al.* (2008) performed a research to assess the underground water contamination and the effect of textile effluents on Noyyal River basin in and around Tiruppur Town. Twenty six sampling locations were selected at random and the ground water samples were collected mostly from tube wells at Noyyal River basin in and around Tiruppur area. The samples were analyzed for major physical and chemical water quality parameters like pH, alkalinity, electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), Ca, Mg, Na, K, Cl- & SO4 2-. It was found that the underground water quality was contaminated at few sampling sites due to the industrial discharge of the effluents on to the river or land from the Tiruppur town. The sampling sites namely Orathupalayam, Karuvapalayam, Kulathupalayam, Uttukuli and Kodumanalpudur showed high deviations in total alkalinity, total hardness, Ca, Mg and chloride concentrations. Hence our study concludes that the underground water quality study in this region shows a constant variation in different parameters in different periods (before and after monsoon). So it is highly important to take periodical monitoring of the underground water quality in this region for our future sustainability.

Alam *et al.* (2007) described in a study to review the increasing levels of pollution in Surma River, Bangladesh. In order to assess the quality of Water, the process of sample collection was done in both rainy season and in summer. An aggregate of 167 samples were taken out. These samples were then tested for different types of parameters viz.–physical, physicochemical, and bacteriological. A fixed distance of 250 metres was kept for each of the sampling point. It was observed that the effluents of paper mills and cement factory have deteriorated the water quality which is shown by high value of BOD and Coliform count in dry season. The study concluded that for drinking purposes the water is not of an adequate quality in the absence of any purification; but for other recreational activities like swimming, industrial use etc. the 'River Water' was still of an adequate quality.

Bhandari *et al.* (2007) studied the physiochemical characterics of Kosi River system, in North India. Samples were collected in all three seasons of the year during 2004-05. It was observed that, except in a few cases, the selected parameters were within the prescribed limits set by WHO. Only two parameters, BOD and Turbidity showed higher valuescompared to limits. Higher values of Mg and Ca may be attributed to the mining of Dolomite and soil erosion.

Kumar *et al.* (2006) assessed the quality of water of the Tunga River, Karnataka. They conducted hydro-chemical analysis to measure the seasonal variation in different variables of surface water of Tunga River by sampling at different stations during March to February 2005. A high level of

saturation of D.O. was revealed. Additionally it was also observed that concentration levels of nitrate, phosphate, sodium and potassium in river waters were lower than such levels in sub terrain waters of the the region. In case of all parameters, the computed values were found to be within the range specified by Authorities such as World Health Organization(WHO). Hence, the surface water of Tunga river water is fit for domestic use but a check needs to be maintained to prevent contamination in future.

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 freshwater 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 different places of metropolitan city of Dhaka (Curzon Hall Area, Dhanmondi Lake, Hatirjheel Lake, SAU Campus Pond) have been shown in Figure (1 & 2). The detailed information regarding freshwater sampling has been reported in Table 1.

3.2 Collection of freshwater samples

The freshwater samples were collected to assess the extent of physic chemical properties of different lakes and ponds (Curzon Hall Area, Dhanmondi Lake, Hatirjheel Lake, SAU Campus Pond) of metropolitan city, Dhaka. To obtain a general information regarding sampling, exactly Number of places) point freshwater samples were collected randomly from selected rivers. In each lakes and ponds, 20 samples were collected from each selected lakes of metropolitan city.

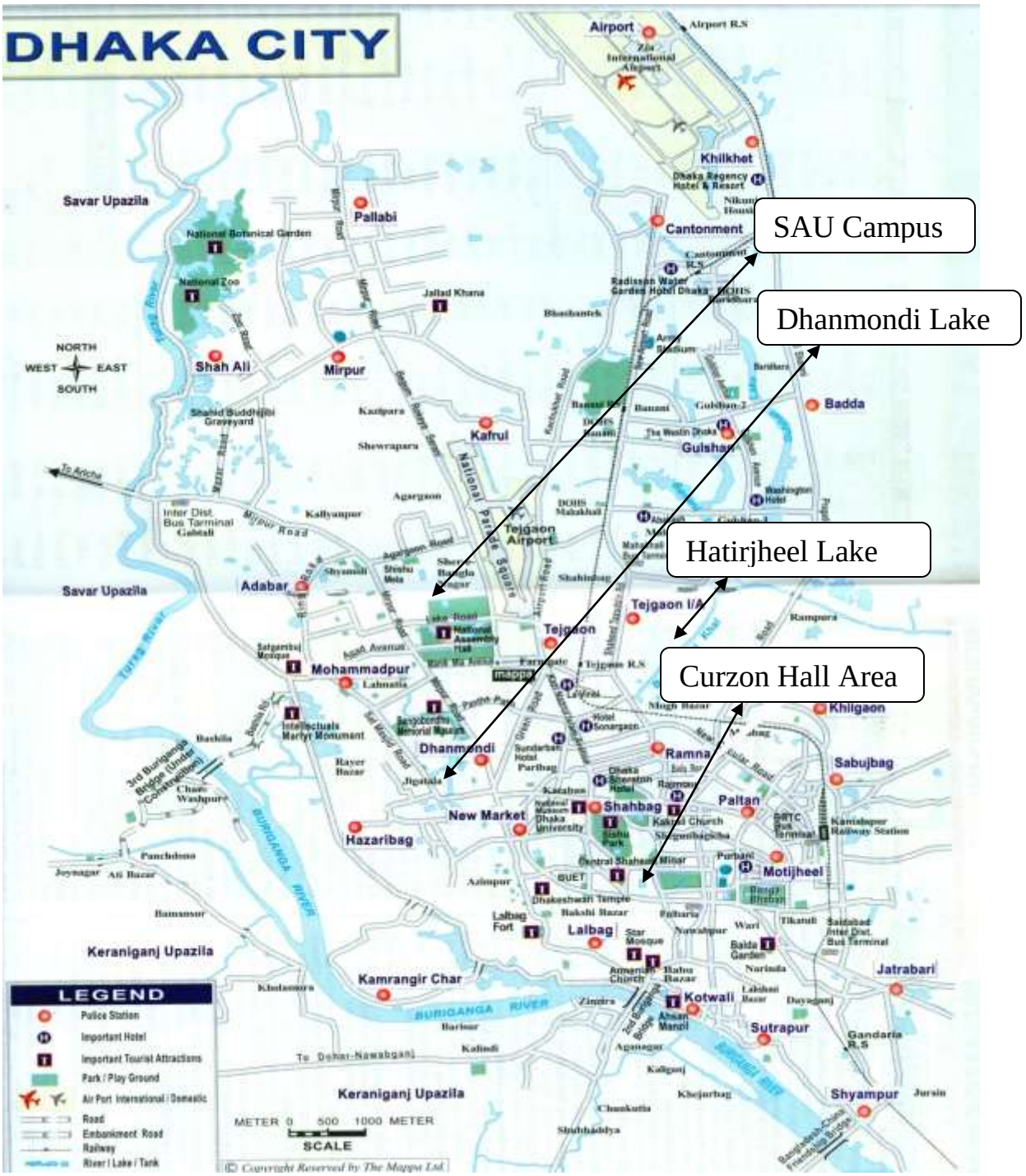

Fig. 1: Sampling point of different places of Dhaka.

3.3 Sample Preparation

The freshwater 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 analyzed 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 freshwaters 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 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 wastewater 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 (Model) 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 100mL of sample in 200mL beaker and immersing the electrode of Flame Photometer (Model Jenway PFP7).

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.

Fig. 2: pH meter (A), EC meter.

Fig.3: Flame Photometer

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 100mL of filtered sample was taken in a 250mL beaker and then aspirated in a natural gas flame of light emitted by sodium at 589 nm and potassium at 768 nm 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 samples was taken in a porcelain dish by addition of 5 drops of phenolphthalein indicator. If Pink color 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 and establish the association among the parameters statistical analysis was performed by using the software MS Excel 2007. 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 pH, total dissolved solids (TDS), salinity, sodium (Na), potassium (K), calcium (Ca), carbonate (CO_3) and bicarbonate (HCO_3). The obtained analytical results have been represented in Tables. 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 clearly indicated that the samples collected were contaminated. The results of various physical tests are given below and discuss about them briefly.

4.1.1 Color

The color of the most of the samples was slightly black, light grey, which enhances the probability of presence of various inorganic and organic pollutants. The water color of Dhanmondi lake was slightly black due to the presence of organic and inorganic waste materials. On the other hand, the color of other three lakes and pond were more or less light grey.

4.1.2 Odor

The odor of the samples ensure that the contamination of different waste materials into the water. Most of the samples posses unpleasant odor, which proves the presence of various inorganic and organic pollutants, waste materials decompositions and so on.

Table 1: The water color and odor of Dhanmondi Lake and Hatirjheel Lake.

Parameters	Dhanmondi Lake		Hatirjheel Lake	
	Colour	Odor	Colour	Odor
Sample 1	Slightly Black	Slightly unpleasant	Light grey	Unpleasant
Sample 2	Slightly Black	Slightly unpleasant	Light grey	Unpleasant
Sample 3	Slightly Black	Slightly unpleasant	Light grey	Unpleasant
Sample 4	Slightly Black	Slightly unpleasant	Light grey	Unpleasant
Sample 5	Slightly Black	Slightly unpleasant	Light grey	Unpleasant
Sample 6	Slightly Black	Slightly unpleasant	Light grey	Unpleasant
Sample 7	Slightly Black	Slightly unpleasant	Light grey	Unpleasant
Sample 8	Slightly Black	Slightly unpleasant	Light grey	Unpleasant
Sample 9	Slightly Black	Slightly unpleasant	Light grey	Unpleasant
Sample 10	Slightly Black	Slightly unpleasant	Light grey	Unpleasant

Table 2: The water color and odor of Curzon Hall pond and SAU Campus Pond.

Parameters	Curzon Hall Lake		SAU Campus Pond	
	Colour	Odor	Colour	Odor
Sample 1	Light grey	Slightly unpleasant	Light grey	Normal
Sample 2	Light grey	Slightly unpleasant	Light grey	Normal
Sample 3	Light grey	Slightly unpleasant	Light grey	Normal
Sample 4	Light grey	Slightly unpleasant	Light grey	Normal
Sample 5	Light grey	Slightly unpleasant	Light grey	Normal
Sample 6	Light grey	Slightly unpleasant	Light grey	Normal
Sample 7	Light grey	Slightly unpleasant	Light grey	Normal
Sample 8	Light grey	Slightly unpleasant	Light grey	Normal
Sample 9	Light grey	Slightly unpleasant	Light grey	Normal
Sample 10	Light grey	Slightly unpleasant	Light grey	Normal

Table 3: Parameters and concentrations of different chemical constituents of surface water of Dhanmondi Lake

Sample no.	pH	TDS (mg/ L)	Salinity (dS/m)	Carbonate (mg/L)	Bi-carbonate (mg/L)	Calcium (mg/L)	Potassium (mg/L)	Sodium (mg/L)
Sample 1	7.97	147	0.1	0	400	10	2.95	18.96
Sample 2	8.02	141	0.1	0	400	10	2.9	18.8
Sample 3	8	147	0.1	0	400	10	3.09	19.42
Sample 4	8.02	143	0.1	0	300	10	3.1	18.92
Sample 5	8.07	142	0.1	0	400	10	4.7	18.08
Sample 6	8	145	0.1	0	300	12	5.55	19.12
Sample 7	8.03	151	0.1	0	400	12	5	19.48
Sample 8	8.08	140	0.1	0	400	10	4.6	19.8
Sample 9	8.09	142	0.1	0	400	12	4.7	18.88
Sample 10	8.07	145	0.1	0	400	12	5.02	19.32
Max.	8.09	151	0.1	0	400	12	5.55	19.8
Min.	7.97	140	0.1	0	300	10	2.9	18.08
Average	8.03	144.5	0.1	0	375	10.83	4.17	19.06
SD	0.04	3.37	4.01	0	42.16	1.03	1.03	0.47
CV	0.50	2.33	4.061E-17	0	0.112437	0.09533	0.245948	0.02481

Table 4: Parameters and concentrations of different chemical constituents of surface water of Hatirjheel Lake

Sample no.	pH	TDS (mg/L)	Salinity (dS/m)	Carbonate (mg/L)	Bi-carbonate (mg/L)	Calcium (mg/L)	Potassium (mg/L)	Sodium (mg/L)
Sample 1	7.82	313	0.3	0	244	5	7.3	28.84
Sample 2	7.69	315	0.3	0	305	7	7	29.08
Sample 3	7.82	315	0.3	0	274.5	5	6.75	28.78
Sample 4	7.93	312	0.3	0	274.5	5	6.7	28.96
Sample 5	7.72	319	0.3	0	274.5	7	7.1	29.6
Sample 6	7.86	319	0.3	0	305	5	6.6	28.92
Sample 7	7.77	320	0.3	0	274.5	7	6.8	29.08
Sample 8	7.78	340	0.3	0	305	7	6.75	29.28
Sample 9	7.76	339	0.3	0	274.5	5	6.55	29.28
Sample 10	7.8	331	0.3	0	274.5	7	6.85	29.52
Max.	7.93	340	0.3	0	305	7	7.3	29.6
Min.	7.69	312	0.3	0	244	5	6.55	28.78
Average	7.78	322.92	0.3	0	279.58	6	6.85	29.14
SD	0.07	10.51	5.85	0	19.29	1.05	0.23	0.28
CV	0.88	3.25	195.05	0	6.90	17.57	3.38	0.96

Table 5: Parameters and concentrations of different chemical constituents of surface water of Curzon Hall pond

Sample no.	pH	TDS (mg/L)	Salinity (dS/m)	Carbonate (mg/L)	Bi-carbonate (mg/L)	Calcium (mg/L)	Potassium (mg/L)	Sodium (mg/L)
Sample 1	8.02	117	0.1	0	122	2	4.25	18.84
Sample 2	7.97	121	0.1	0	122	5	6.45	18.88
Sample 3	7.94	123	0.1	0	152.2	5	6.6	17.84
Sample 4	7.92	123	0.1	0	122	5	4.45	19.32
Sample 5	7.91	124	0.1	0	122	5	6.7	18.64
Sample 6	7.95	121	0.1	0	127	5	6.35	19.52
Sample 7	7.86	123	0.1	0	122	5	4.55	18.68
Sample 8	7.88	121	0.1	0	122.5	5	6.45	17.48
Sample 9	7.87	147	0.1	0	122	2	4.3	18.6
Sample 10	7.86	123	0.1	0	122	2	4.35	18.52
Max.	8.02	147	0.1	0	152.2	5	6.7	19.52
Min.	7.86	117	0.1	0	122	2	4.25	17.48
Average	7.92	125.58	0.1	0	127.49	4	5.45	18.61
SD	0.052873	8.219895	1.46285E-17	0	9.485902	1.449138	1.12927	0.608912
CV	0.006674	0.065454	1.46285E-16	0	0.074404	0.362284	0.207205	0.03272

Table 6: Parameters and concentrations of different chemical constituents surface water of SAU Pond

Sample no.	pH	TDS (mg/L)	Salinity (dS/m)	Carbonate (mg/L)	Bi-carbonate (mg/L)	Calcium (mg/L)	Potassium (mg/L)	Sodium (mg/L)
Sample 1	8.22	113	0.1	0	91.5	5	3.2	19.88
Sample 2	8.17	115	0.1	0	91.5	2	2.8	18.44
Sample 3	8.17	97.8	0.1	0	122	2	4.1	18.44
Sample 4	8.12	111	0.1	0	122	2	3.3	18.52
Sample 5	8	148	0.1	0	122	2	3.6	18.56
Sample 6	8.11	112	0.1	0	122	5	4.3	19
Sample 7	8.07	114	0.1	0	122	5	1.8	19.48
Sample 8	8.05	112	0.1	0	91.5	5	1.9	19.78
Sample 9	8.05	111	0.1	0	122	2	2.8	18.76
Sample 10	8.05	110	0.1	0	91.5	2	3.6	20.08
Max.	8.22	148	0.1	0	122	5	4.3	20.08
Min.	8	97.8	0.1	0	91.5	2	1.8	18.44
Average	8.103	115.8	0.1	0	109.2917	3.25	3.125	19.12
SD	0.069194	12.74099	1.46285E-17	0	15.75013	1.549193	0.835597	0.64979
CV	0.00854	0.110026	1.46285E-16	0	0.144111	0.476675	0.267391	0.033982

4.2 Chemical characteristics

4.2.1 pH

The average pH values of Dhanmondi lake and Curzon Hall lake were 8.03 and 7.92, respectively. The maximum pH value of Dhanmondi lake was recorded 8.09 whereas the minimum pH value was 7.97. On the other hand, the maximum and minimum pH values of Curzon Hall lake were recorded 8.2 and 7.86, respectively. Moreover, the average pH values of Hatirjheel lake and SAU Campus Pond were 7.78 and 8.10, respectively. The maximum pH value of Hatirjheel lake was recorded 7.93 whereas the minimum pH value was 7.69. On the other hand, the maximum and minimum pH values of SAU Campus Pond were recorded 8.22 and 8.0, respectively. The maximum pH of 8.485 and the minimum was pH of 4.187 was reported from Kushtia industrial zone (Rafiquel *et al.*, 2016). The pH values of collected water sample ranges from 6.62 to 7.46, which is slightly acidic to slightly alkaline in nature and it increased with increasing distance towards the Tejgaon Khal to Shitalakhya River (Zamal *et al.*, 2016)

The acceptable range of pH for irrigation water quality is from 6.0 to 8.5 (Ayers and Westcot, 1985). According to the water quality standard for aquaculture, the recommended pH value ranges from 6.5 to 8.0 (Meade, 1989).

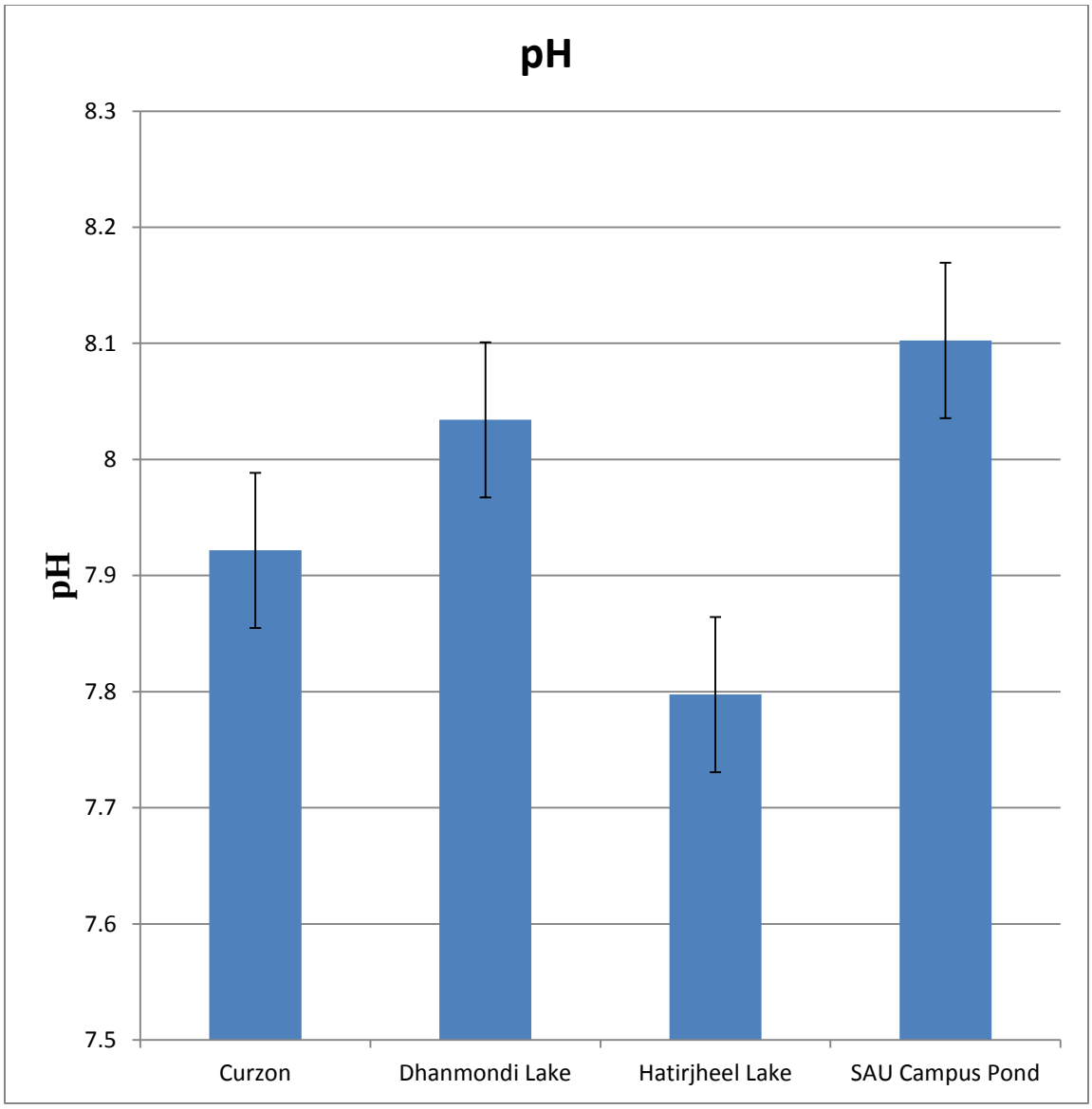

Fig. 4. Comparison of water pH value of different ponds and lakes of Dhaka.

4.2.2 Total Dissolved Solids (TDS)

Total dissolved solids are composed mainly of carbonates, bicarbonates, chlorides, phosphates and nitrates of calcium, magnesium, sodium, potassium and manganese, organic matter, salt and other particles (Mahananda, 2010). The average TDS values of Hatirjheel lake and SAU campus pond were 322.92 and 115.8mg/L, respectively. The highest TDS value of 340mg/L was observed in Hatirjheel lake (sample no.8), but the lowest TDS value of 312mg/L (sample no.4). Whereas, the highest TDS value of SAU Campus Pond was 148 mg/L and the lowest TDS value of 97.8mg/L. In case of Dhanmondi lake, the highest TDS value (151mg/L) and the lowest TDS value (140mg/L) were found. But in Curzon Hall lake, the highest TDS value (147mg/L) and the lowest TDS value (117mg/L) were recorded. The average TDS (342mg/L) was observed in 2006 and highest TDS (812mg/L) was found in 2010 of Turag river (Banu *et al.*, 2013). And the TDS of the wastewater samples contained 567 to 956 mg/L from the Kushtia industrial zone (Rafiq *et al.*, 2016). It has been reported that farmers use artificial animal feeds to supplement pond, nutrients which has been reported to increase total dissolved solids (Ehigbonare *et al.*, 2006).

According to Freeze and Cherry (1979), all the water samples containing TDS les 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 1000mg/L TDS.

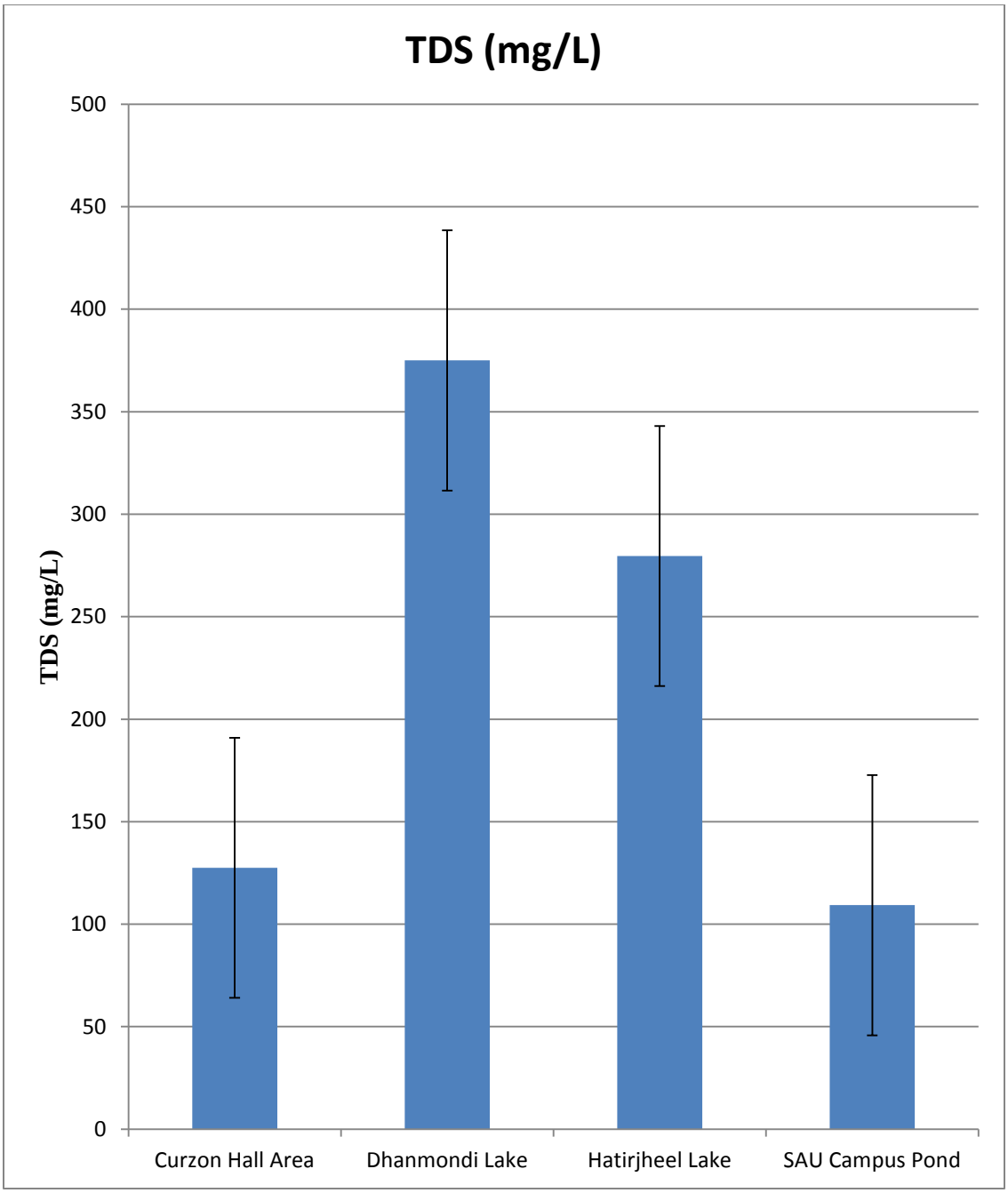

Fig. 5. Comparison of water TDS (mg/L) contents of different lakes and ponds of Dhaka.

4.2.3 Salinity

Although scientists do not know with certainty the full extent of the effects of climate change, there is a growing concern that one of the first and most critical impacts will be on the world's freshwater resources. During investigation, the concentration of salt in Hatirjheel lake was found 0.3dS/m, whereas the concentration of salt was 0.1dS/m in Dhanmondi lake, Curzon Hall Lake, and also in SAU Campus pond. In this survey, it was concluded that Hatirjheel lake contained more amount of salt than any other lakes and pond. The salinity of water indicates the presence of ionic substances that may come from the reaction of metals and acids containing in water. Rahman *et al.* (2016) observed the highest salinity value of the surface water (0.52 mg/L) and the lowest value observed (0.08 mg/L). EC has good relation with TDS and salinity

According to their comments, it can be concluded that the lakes and pond of metropolitan Dhaka city's water 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 freshwater samples of the study area varied from 28.78 to 29.6mg\L with an average value of 29.14mg/L (Table) in Hatirjheel lake. Whereas in SAU Campus Pond, the maximum and the minimum concentration of Na were 20.8 and 18.44 mg/L with a mean value of 19.12mg/L (Table). Moreover, the maximum and the minimum concentration of Na were 19.8 and 18.08 mg/L in Dhanmondi lake. But in Curzon hall lake, the maximum and the minimum concentration of Na were 19.52 and 17.48 mg/L with the mean value of 18.61mg/L. Sodium concentration of water samples varied from 10 to 20 mg/L from the point Kamlapur and the lowest was found at Barokhada and Jugia (Nahar *et al.*, 2016)**.** The maximum and minimum concentration of Na 57.19 and 97.89mg/L were recorded form Tongi in Bangladesh (Bidyut *et al.*, 2014).

Irrigation water containing less than 40 mg/L Na was suitable for raising crop plants (Ayers and Westcot, 1985). The acceptable content of Na in water samples for aquaculture is 75.00 mg/L (Meade, 1989). All rivers water under test contained less than 75.00 mg/ L Na. 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 is concluded that the waters of different lakes and pond of Dhaka city are safe for the consumption of livestock, agricultural production as well as for the aquaculture.

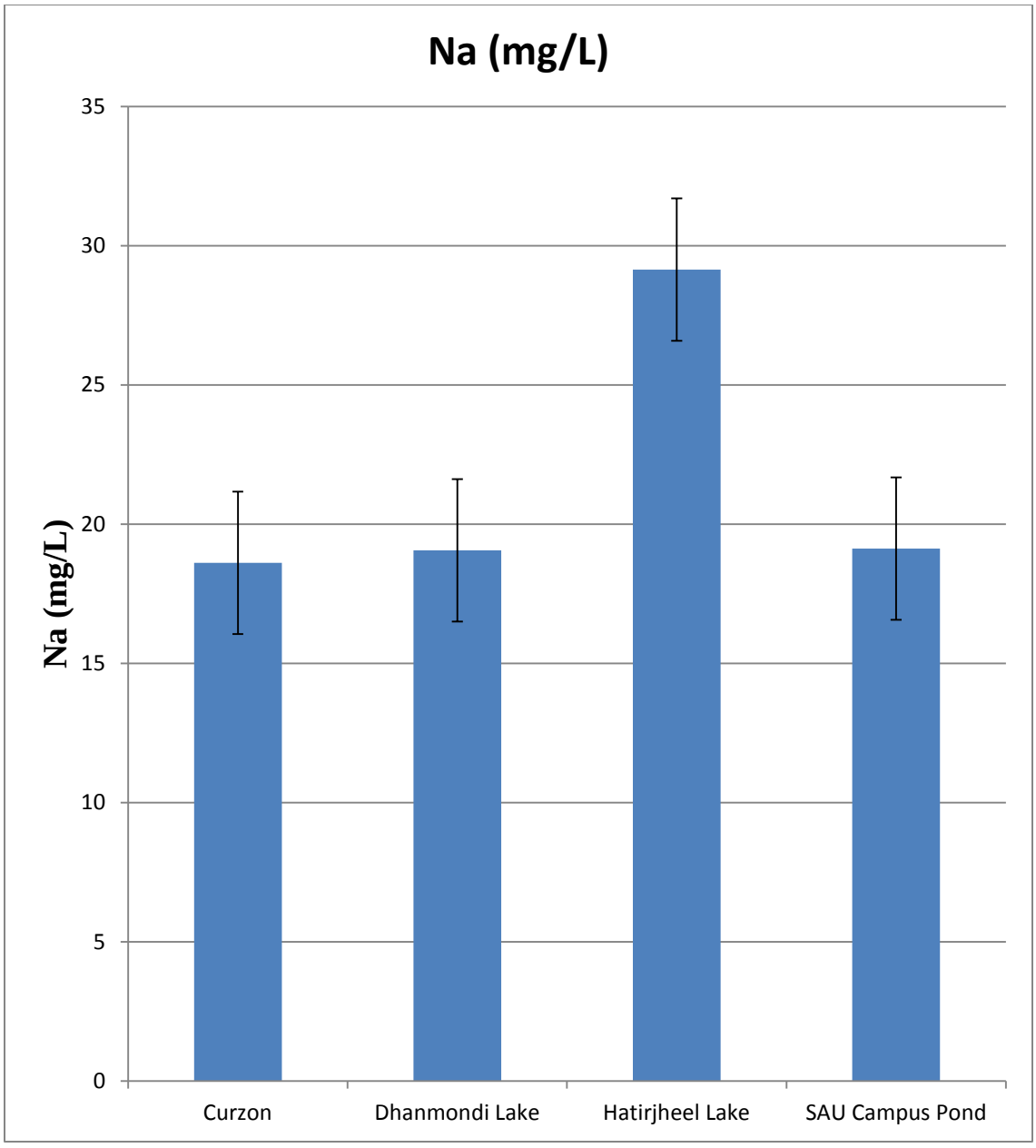

Fig. 6. Comparison of water sodium (mg/L) contents of different lakes and ponds of Dhaka.

4.3.2 Potassium (K)

The concentration of potassium (K) in the collected water samples in Dhanmondi lake varied from 2.9 to 5.55 mg/L with the mean value of 4.17mg/L. But, the highest value observed 6.7mg/L and the lowest value was found 4.25 mg/L which were significantly higher than Dhanmondi lake. Even the K content ranged from1.8 to 4.3mg/L in SAU Campus Pond. From the mean value of K content in Hatirjheel lake was greater (6.85mg/L) which was higher than other three lakes. This might be due to run off of K 'Bearing fertilizer from the adjacent crop field, garments industries, leaching domestic effluents and decomposition of organic matter, which contaminated the river water (Tapas *et al.* 2000). The result from this worked revealed that potassium in those water samples ranged between 10.03 to 14.51 mg/L with a mean of 11.74 ± 2.01 mg/L. (Agbaire *et al.*, 2015) from the ponds of Abraka in Nigeria. Similarly, Potassium concentration of water of the study area ranged 3.409 to 5.114 mg/L as Table 03. 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 concentration of river water of K content was also observed by Gupta (1999) and Zaman *et al.* (2001).

The acceptable content of K for aquaculture is less than 5.0 mg/L (Meade, 1989) as shown in Appendix 4. And the upper limit for the livestock use of water is 20 mg/L. Based on this limit, no samples were found unsuitable for the livestock and aquaculture.

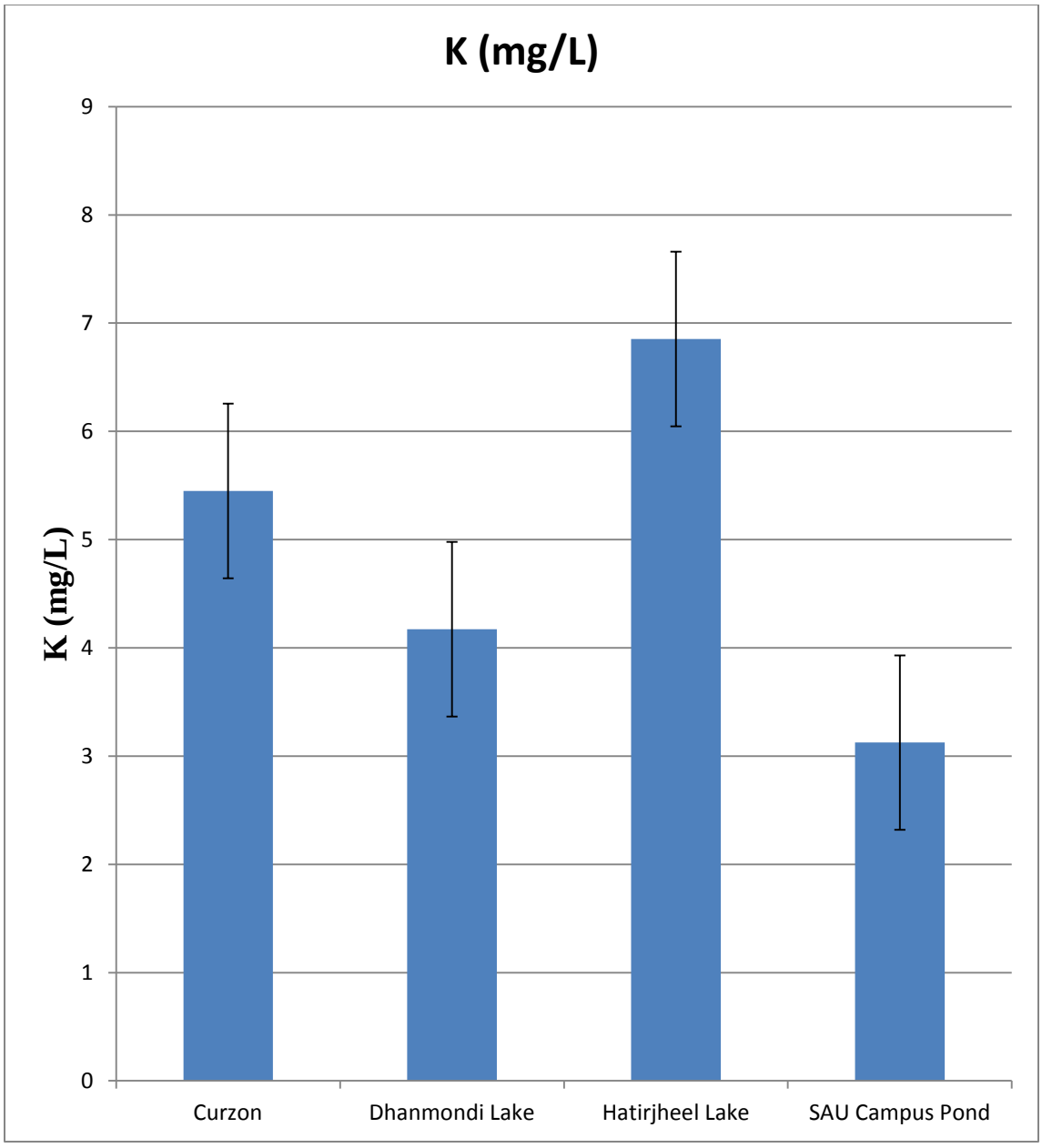

Fig. 7. Comparison of potassium (mg/L) contents of different lakes and ponds of Dhaka.

4.3.3 Calcium (Ca)

The concentration of Calcium (Ca) in the collected water samples in Dhanmondi lake varied from 10 to 12mg/L with the mean value of 10.83mg/L. The Ca content varied from 2 to 5mg/L in Curzon hall area and also in SAU Campus Pond. Even the mean value of Ca content in Hatirjheel lake was greater (6.0 mg/L) which was higher than other two lakes. But, the highest mean value of Ca content which was significantly higher than any other three lakes in Dhaka city. The values ranged from 0.04 to 0.64 mg/L with a mean value of 0.42 ± 0.27 mg/L from the ponds of Abraka in Nigeria (Agbaire *et al.*, 2015). Calcium content of water samples ranged between 22.9 mg/L to 49.2 mg/L from the lendi river of India (Waghmare and Kulkarni, 2013). Bidyut *et al.* (2014 conducted a research survey and found the ranges from 36.07-128.26mg/L content of Ca in the Tongi area of Bangladesh .

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 freshwater 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.

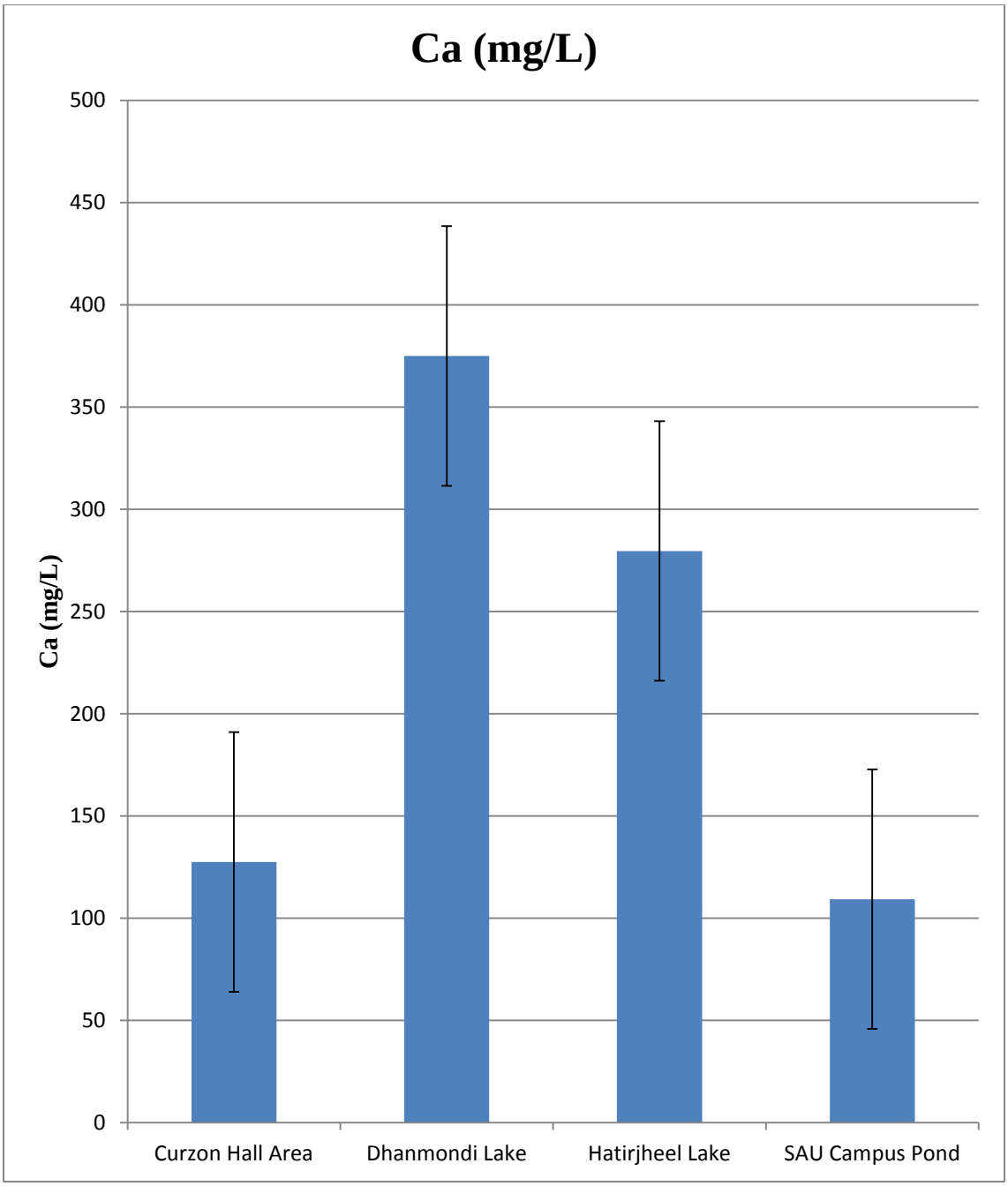

Fig. 8. Comparison of calcium (mg/L) contents of different lakes and ponds of Dhaka.

4.3.4 Carbonate (CO_3)

All the lakes and pond were free from any trace amount of CO_3. There was no record of CO_3 concentration in the selected pond and lakes previously in Dhaka city. The detected concentration of CO_3 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 244 to 305mg/L with the mean value of 279.58mg/L in respect of Hatirjheel lake. On the other hand, the maximum and minimum values of HCO_3 were 91.5 to 122mg/L with the mean value of 109.29mg/L in SAU Campus Pond. Moreover, the maximum and minimum values of HCO_3 were 300 to 400mg/L with the mean value of 375mg/L in Dhanmondi lake, whereas the highest and lowest values of HCO_3 were 122 to 152.2mg/L with the mean value of 127.49mg/L in Curzon hall area.

The maximum recommended concentration of HCO_3 in irrigation is 1.50 mg/L (Ayers and Westcot, 1985). According to the findings, the selected lakes and ponds are highly unsuitable and it would be considered as problematic for aquaculture and livestock usage as well as the environment.

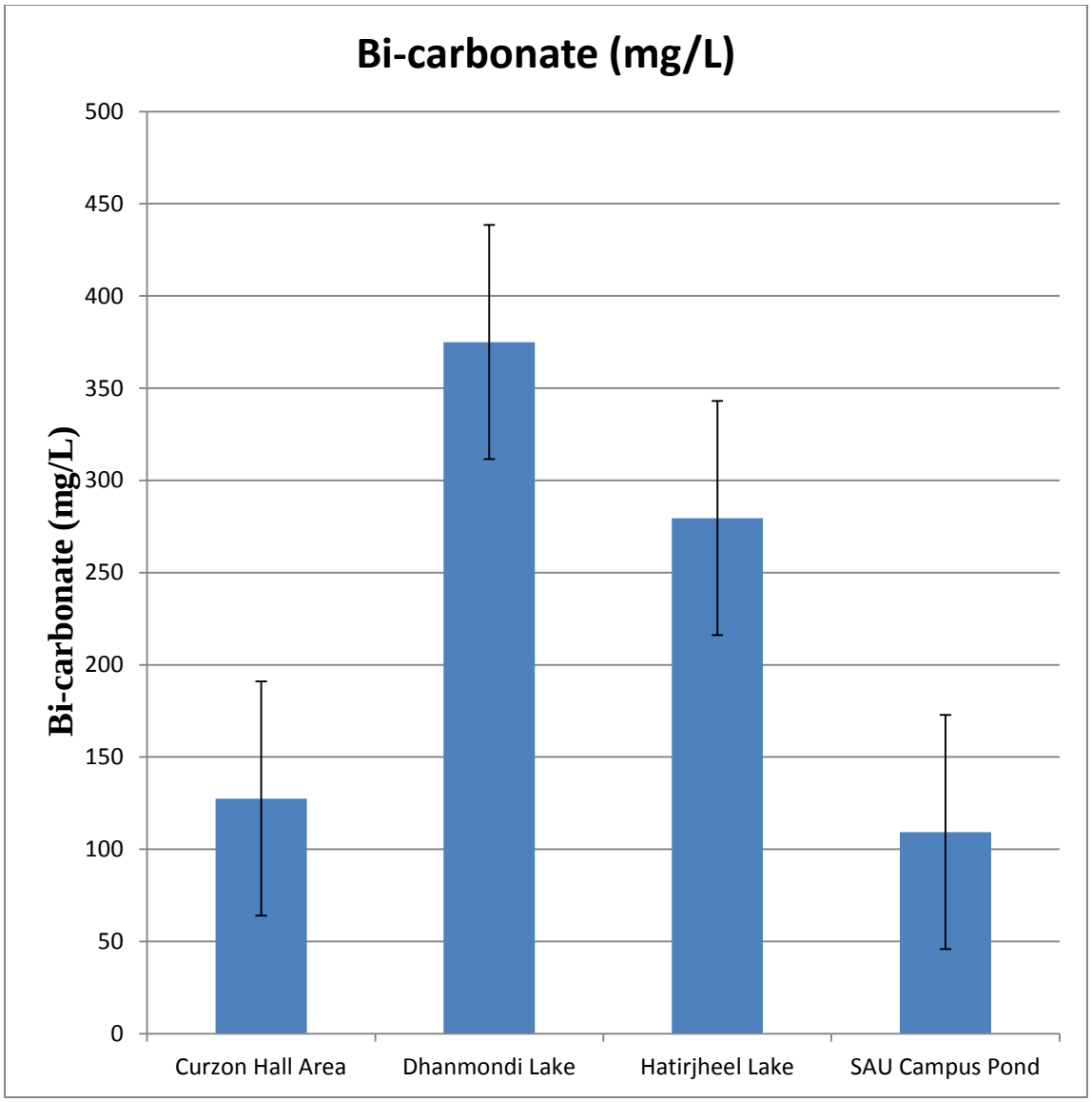

Fig. 9. Comparison of bicarbonate (mg/L) contents of different lakes and ponds of Dhaka.

4.4 Correlation matrix of selected lakes and Pond

4.4.1 Correlation matrix of Hatirjheel Lake and SAU Campus Pond

The correlation matrix presented that in Tables (7&8) both positive and negative significant correlations among the physico-chemical properties. In case of Hatirjheel Lake, TDS, Bicarbonate, Sodium, Calcium and Potassium showed the positive correlation with Bicarbonate (r=0.274143), Sodium(r=0.108161), Calcium(r=0.671607) and Potassium (r=0.272727), accordingly. But a negative significant correlation existed among all the parameters with the pH. Even TDS and Bicarbonate showed the negative correlation with the Potassium (r=-0.44085; r=-0.47727).

SAU Campus Pond, pH also represented the negative correlation with the TDS (r=-0.53159), Bicarbonate (r=-0.26743), Sodium (r=-0.08585). But TDS showed only the positive correlation with Bicarbonate (r=0.126995). A significant positive correlation existed in Sodium with Calcium (r=0.584116).

Table 7: Correlation matrix among the parameters Hatirjheel Lake.

Parameters	pH	TDS (mg/L)	Bicarbonate (mg/L)	Sodium (mg/L)	Calcium (mg/L)	Potassium (mg/L)
pH	1					
TDS	-0.27016	1				
Bicarbonate	-0.20464	0.274143	1			
Sodium	-0.50324	0.574374	0.108161	1		
Calcium	-0.65998	0.2708	0.333333	0.671607	1	
Potassium	-0.34185	-0.44085	-0.47727	0.060712	0.272727	1

Table 8: Correlation matrix among the parameters of SAU Campus Pond.

Parameters	pH	TDS (mg/L)	Bicarbonate (mg/L)	Sodium (mg/L)	Calcium (mg/L)	Potassium (mg/L)
pH	1					
TDS	-0.53159	1				
Bicarbonate	-0.26743	0.126995	1			
Sodium	-0.08585	-0.15307	-0.59736	1		
Calcium	0.143042	-0.11011	-0.16667	0.584116	1	
Potassium	0.222153	-0.01515	0.272949	-0.32857	-0.3502	1

4.4.2 Correlation matrix of Dhanmondi Lake and Curzon Hall pond

The correlation matrix presented that in Tables (9 & 10) both positive and negative significant correlations among the physico-chemical properties. In case of Dhanmondi Lake, the pH showed the positive correlation with Bicarbonate (r=0.326581), Calcium (r=0.266652) and Potassium (r=0.527571), whereas TDS represented the positive correlation with all the parameters. But Bicarbonate showed positive correlation only with the Sodium (r=0.064659). Even Sodium and Calcium also showed positive correlation (r=0.2221; r=0.760412) with Calcium and Potassium, respectively.

Curzon Hall Area, pH also represented the negative correlation only with the TDS (r=-0.47654). But TDS showed the negative correlation with Bicarbonate (r=-0.08181), Sodium (r=-0.04387), Calcium(r=-0.39457), and Potassium(r=-0.29787). But Bicarbonate showed a significant positive correlation with Potassium (r=0.413949). Even Calcium showed more significant positive correlation with Potassium (r=0.699678).

Table 9: Correlation matrix among the parameters of Dhanmondi Lake.

Parameters	pH	TDS (mg/L)	Bicarbonate (mg/L)	Sodium (mg/L)	Calcium (mg/L)	Potassium (mg/L)
pH	1					
TDS	-0.51921	1				
Bicarbonate	-0.326581	0.046944	1			
Sodium	-0.03553	0.297674	0.064659	1		
Calcium	-0.266652	0.370518	0.10206	0.2221	1	
Potassium	-0.527571	-0.07096	-0.08424	0.13071	0.76041	1

Table 10: Correlation matrix of among the parameters Curzon Hall Lake.

Parameters	pH	TDS (mg/L)	Bicarbonate (mg/L)	Sodium (mg/L)	Calcium (mg/L)	Potassium (mg/L)
pH	1					
TDS	-0.47654	1				
Bicarbonate	0.178425	-0.08181	1			
Sodium	0.329382	-0.04387	-0.38578	1		
Calcium	0.017402	-0.39457	0.259705	-0.02418	1	
Potassium	0.19521	-0.29787	0.413949	-0.29512	0.699678	1

CHAPTER V

SUMMARY AND CONCLUSION

The investigation was conducted at the Agricultural Chemistry laboratory at Sher-e-Bangla Agricultural University to assess the physic-chemical parameters as well as to know the heavy metals content in different places of metropolitan city, Dhaka, Bangladesh. For this purpose, 10 samples were collected from different locations in each lake and pond to analyze the physical (TDS, Salinity and pH) and chemical content or ionic constituents like Sodium (Na), Potassium (K), Calcium (Ca), Carbonate (CO_3) and Bicarbonate (HCO_3).

The pH values of different lakes and pond in Dhaka city ranged from 7.69 to 8.22 and most of the pH values were belonged around to the same range. The highest and lowest value of pH was not far from each value. Total Dissolve Solid (TDS), the highest concentration was 340mg/L in Hatirjheel lake whereas the lowest value was 97.8mg/L in SAU Campus Pond. The maximum salinity (0.3dS/m) was observed in Hatirjheel lake and lowest (0.1dS/m) was found in other three lakes and pond. The lakes and pond were free from Carbonate during investigation. But in case of Bicarbonate, the highest (400mg/L) of HCO_3 was observed in Dhanmondi lake whereas the lowest (91.5mg/L) was found in SAU Campus pond. The Calcium (Ca) concentration varied from 2 to 12mg/L in the lakes and pond of Dhaka city. The highest concentration of Ca was observed in Dhanmondi lake. Whereas, the Ca content ranged 2 to 7 in other three lakes and pond water.

The concentration of Sodium (Na) varied from 17.48 to 29.6mg/L in lakes and pond water of Dhaka city. The maximum (29.6mg/L) Na concentration was observed in Hatirjheel lake and the lowest (17.48mg/L) was found in Curzon hall lake. In case of Potassium, the highest (7.3mg/L) K content was found in Hatirjheel alke and the lowest (1.8mg/L) was observed in SAU Campus pond.

However, Wetlands play very important role in the hydrologic cycle. Wetlands can receive, store, and release water in various ways – physically through ground water and surface water run-off, as well as biologically through transpiration by vegetation. Environmental statistics reveals that water bodies should constitute about 10 percent of a city for it to function properly, as the presence of water bodies to ensure reduction of sound and air pollution. Water is a unique resource because it is essential for all life and it constantly cycles between the land and the atmosphere. It has become an important issue for them as it affects not only human uses but also plant and animal life. Lakes are one of the most potential water resources that can meet the increasing demand of water throughout the Dhaka city in dry seasons.

According to the standard and recommended levels of physico-chemical properties of all the lakes and pond were in permissible limit. The result may differ from site to site, depending on the actual natural and anthropogenic conditions. The surface water quality of the different lakes and pond of Dhaka city is a great threat to ecosystem though some parameters may not be in the dangerous level but the condition of the lakes side urbanization and industrialization may cause all kind of water pollution in the near future.

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APPENDICES

Appendix 1: Recommended maximum concentration of different ions in water

Elements name	Symbol	Concentration for water used (mg/L)
Calcium	Ca	<
Potassium	K	2.0
Phosphorus	P	2.0
Boron	B	0.75
Carbonate	CO_3	1.50
Bicarbonate	HCO_3	0.10

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
Carbonate	CO_3	
Bicarbonate	HCO_3	
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.

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