STUDY ON WATER QUALITY OF CHUNKURI, DHAKI AND VODRA RIVER

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STUDY ON WATER QUALITY OF CHUNKURI, DHAKI AND VODRA RIVER

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CERTIFICATE

*This is to certify that the thesis entitled **"STUDY ON WATER QUALITY OF CHUNKURI, DHAKI AND VODRA RIVER"** submitted to the Department of Agroforestry and Environmental Science, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGROFORESTRY AND ENVIRONMENTAL SCIENCE**, embodies the result of a piece of bonafide research work carried out by **MARIA YESMIN,** Registration No. **13-05348** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dr. Ferzana Islam
Professor
Supervisor

Dated: June, 2020

Dhaka, Bangladesh

DEDICATED

TO

MY

BELOVED

PARENTS

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- Author

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ABSTRACT

Water is known as the most important and major requirement for life and life supporting activities. The usual source of drinking water from streams, rivers, wells are usually not treated. Present study was conducted to assess some physio-chemical properties of water collected from different point of Chunkuri, Dhaki and Vodra rivers of Bangladesh. To reach the goal of our study total 21 samples were collected from the three rivers randomly to analyze the physio-chemical properties: Color, Odor, pH, Total Dissolved Solids (TDS), EC, Turbidity, Chlorine, DO and BOD5. Results from our study showed that most of the parameters did not exceed the maximum permissible limit except Turbidity. Study revealed that pH: 7.99, 8.03 and 7.99; TDS: 270.17, 265 and 326.17 mg l^{-1}; EC: 573.5, 602.17 and 668.17 µscm^{-1}; Turbidity: 16.58, 38.42 and 64.51 NUT; Chlorine: 232.12, 537.93 and 903.14 mg l^{-1}; DO: 7.07, 6.01 and 8.4 mg l^{-1}; BOD5: 3.8, 3.32 and 4.55 mg l^{-1} for Chunkuri, Dhaki and Vodra rivers respectively. The average turbidity of Chunkuri, Dhaki and Vodra rivers were 16.58, 38.42 and 64.51 NTU, where standard Turbidity is 5 NTU but ideal is 1 NTU. Water color were black, ash and light grey with foul odor driven by huge contaminant factors. Proper embankment plantations, riparian management in the watersheds can help to improve the water quality of these rivers.

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ABBREVIATIONS	ELABORATIONS
%	Percentage
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
CV%	Percentage of Coefficient of Variance
et al.	and others
etc.	Etcetera
FAO	Food And Agriculture Organization of United Nations
LSD	Least Significant Difference
etc.	Etcetera
ppm	Parts per million
SAU	Sher-e- Bangla Agricultural University
EC	Electrical conductivity
TDS	Total Dissolve Solid
Cl^{-1}	Chlorine
DO	Dissolve Oxygen
BOD5	Biological Oxygen Demand
NS	Non significant
SRDI	Soil Resources Development Institute
USDA	United Nations Department of Agriculture
pH	Negative logarithm of hydrogen ion concentration
µs cm^{-1}	Microsimen per centimeter
mol kg^{-1}	Mol per kg
NTU	Nephelometric Turbidity Unit

CHAPTER 1
INTRODUCTION

Water is the most essential and prime necessity of life. It is an essential requirement for the life supporting activities. Surface water generally available in Rivers, Lakes, Ponds and Dams is used for drinking, irrigation and power supply etc. The usual source of drinking water is from streams, rivers, wells which are usually not treated (Agbair, 2009).Quality of water generally refers to the component of water, which is to be present at the optimum level for suitable growth of plants and animals. Aquatic organisms need a healthy environment to live and have adequate nutrients for their growth. The productivity depends on the physical-chemical characteristics of the water BOD5. The maximum productivity obtained when the physio-chemical parameters are at optimum level (Kamal, 2007).

Among the essential requisite water is known as the primary pre-requisite for supporting all biological life, industrial, municipal, agricultural and household activities. Unfortunately, the sources of useable water are becoming polluted day by day due to natural and human activities. Pollution of surface water (river, lakes and ponds), ground water and seawater is a threat to human and animal lives. Although water is generally considered a recyclable resource, proper management is needed to protect the resource as it is highly vulnerable to pollution due to increased growth of industries, urbanization and anthropogenic activities due to overpopulation (Ouyang, 2006). Therefore it is necessary to determine the water quality and evaluate its impacts and provide measures to mitigate the problems (Mishra *et al.* 2009). Researches on the water quality aspects are of paramount significance in developing fresh water quality. Water quality plays an important role in decision making process for pollution control. Therefore, water quality is paramount factor in ecosystem productivity (Huet, 1986). Aquatics organisms need a healthy environment to live and have adequate nutrients for their growth. The productivity depends on the physio-chemical characteristics of the water BOD5. The maximum productivity obtained when the physical and chemical parameters are at the optimum level. Information is not available on the water quality of Chunkuri, Vodra, Dhaki river but this river plays an important role for fisheries. The aim of the present investigation was to determine the physio- chemical parameters of the water.

Water pollution caused by chemical substances such as minerals and heavy metals affects tropical rain forest and river ecology. Usually, the presence of an odor 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 odor causing metabolic and decay products. Different levels of pH may also affect the rate of chemical reactions leading to the production of odor. 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 surrounded by several rivers and is often called the land of rivers. Rivers are considered as a blessing of this country. According to U.S. Library of Congress, the rivers of Bangladesh flow at about 140,000 cubic meters per second during the annual monsoon period while during the dry period, they diminish to 7,000 cubic meters per second. The release of the waste water without proper treatment from the surrounding industries and municipalities, agricultural run-off and dumping of the wastage on the bank of the river leads to the increased pollution of the river water (Meghla, 2013). Rivers are the most important natural resource for human development but it is being polluted by in discriminate disposal of sewage, industrial waste which affects its physio-chemical and microbiological quality (Koshy and Nayar, 1999). The potential cause of degradation of river water quality due to various point and nonpoint sources is harmful (Kova *et al.* 1996, Carpenter *et al.* 1998). Increasing problem of deterioration of river water quality it is necessary to monitoring of water quality to evaluate the production capacity. Prevention of river pollution requires effective monitoring of physio-chemical and microbial parameters (Bonde *et al.* 1977).

Various factors like temperature, turbidity, nutrients, hardness, alkalinity, dissolved Oxygen play an important role for the growth of plants and animals in the water BOD5, on the other hand biological Oxygen demand, chemical Oxygen demand indicate the pollution level of the water BOD5. In natural aquatic system, various chemical parameters occur in low concentration. This concentration increases as a result of rapid growth of population, increased urbanization, expansion of industrial activities, exploitation of natural resources, extension of irrigation and lack of environmental regulations (Mehedi *et al.* 1999). A number of published data shows that there are some relationships among the water quality parameters (Qaddr *et al.* 1991). The total mass of dissolved constituents is referred to as the total dissolved solids (TDS) concentration. 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 $500mgL^{-1}$ is not recommended for use as drinking water (EPA secondary drinking water guidelines). Water with TDS above 1,500 to 2,600 mgL^{-1} (EC greater than 2.25 to 4mmho/cm) is generally considered problematic for irrigation use on crops with low or medium salt tolerance (Harter, 2003). 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). Water is the most valuable and vital resource for sustenance of life and also for any developmental activity (Kumar *et al*. 2010). Bangladesh is a low lying flat country with big inland water BOD5, including some of the biggest rivers in theworld and is extremely vulnerable because of its geographical characteristics (Matin and Kamal, 2010).

It is hoped that our findings will not only provide valuable information about major and minor water qualities of Chunkuri, Vodra and Dhaki river but also present a scientific perspective of the effects of water quality so that further regulatory and scientific attention can be drawn to these kind of related issues. Hence the present designed study will contribute to the existing pool of knowledge in general, and to bridge some of the remaining gaps in regard to the present status of surface water quality of the studied Chunkuri, Vodra, Dhaki river water quality. It thus intends to documents the present findings of our research work and explore how and where private and public benefits potentially align. Based on these the exploratory study aims to address the following research objectives:

1. To study the physical water qualities of Chunkuri, Vodra and Dhaki river.
2. To know the present status of chemical properties of these three river water.
3. To determine the suitability of water for drinking, agricultural purpose and other uses.

CHAPTER 2

REVIEW OF LITERATURE

The aim of this chapter is to review the past research works that are related to the present study. Few studies on surface water quality of river have been conducted in abroad but a very few research had been conducted on the surface water qualities on the rivers of Bangladesh. Once the groundwater is contaminated, its quality cannot be restored back easily and to device ways and means to protect it. However, the review of some related studies on water qualities of rivers have been furnished below under the following sections:

2.1 Physical properties of river water

2.1.1 Color

Flura *et al.* (2016) accomplished a research to assess the physio-chemical and biological parameters of Meghna River water in three spots during the period of January, 2014 to December, 2014. Nineteen (ten were physical and nine were chemical) physio-chemical parameters of water Such as Water color. The findings of physio- chemical and biologicalparameters of water indicate water quality of Meghna river are safe for aquatic lives, but the continuous sewage disposal may create problems in the future.

Miah *et al.* (2015) studied 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 were identified.

Kesalkar *et al.* (2012) conducted the Physio-chemical characteristics of waste water from Paper Industry and presented the characteristics of waste water 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 color. These samples wereexamined and compared with the effluent discharge of Indian standards.

Dinrifo *et al.* (2010) revealed the Physio- chemical properties of Rain Water Collected from Some Industrial Areas of Lagos State Nigeria. This study had been carried out to determine the physio-chemical properties of rainwater from 4 different industrial sites in Lagos State Nigeria and the rainwater samples were taken to the laboratory and analyzed. The result assayed on the rainwater samples indicated that average values of color (7.0, 9.0, 6.7 and 5.0 Hazen units) respectively.

2.1.2 Odor

Flura *et al.* (2016) accomplished a research to assess the physio-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) physio-chemical parameters of water Such as Odor of water. The findings of physio-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.

Miah *et al.* (2015) studied 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 Odor were identified.

2.2 Chemical properties of river water

2.2.1 pH

Nahar *et al*. (2016) conducted a study to assess the physio-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 pH were examined. From this study it was observed that the parameters exceeded the permissible limits.

Sikder *et al.* (2016) leading 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 pH in water samples were found to range from 7.5-7.9.

Akter *et al.* (2014) carried out the water quality in Dhaka Export Processing Zone (DEPZ) area was studied on the basis of some physio-chemical parameters and heavy metal concentrations. The range of pH for all of the samples was found from 7.1 to 8.17. For pH the ranges were within the limits but there was an increasing trend of the values was observed in every case which is highly alarming.

Behera *et al.* (2014) studied on the Physio-chemical properties of water sample collected from Mangrove ecosystem of Mahanadi River Delta, Odisha, India. This present study, investigated the physio-chemical 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: pH (6.05-8.6). Most of the study sites indicated the pollution status of this estuarine water.

Gupta *et al.* (2013) studied to find out the physio-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 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 pH. pH showed that the River water of Yamuna is alkaline in nature.

Kesalkar *et al*. (2012) conducted the Physio-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. These samples were examined and compared with the effluent discharge of Indian standards. The raw waste water consisted of pH of 6.8-7.1. After the treatment pH varies 7.1 -7.3 respectively. The Result showed that pH was in the permissible limit.

Yadav *et al.* (2011) studied on Kosi River in 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 characteristics and physio-chemical parameters of water were examined, these included pH. 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.

Dinrifo *et al.* (2010) revealed the Physio- chemical properties of Rain Water Collected from Some Industrial Areas of Lagos State Nigeria. This study had been carried out to determine the physio-chemical properties of rainwater from 4 different industrial sites in Lagos State Nigeria and the rainwater samples were taken to the laboratory and analyzed. 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.

Sadashivaia *et al.* (2008) carried out the hydrochemistry of groundwater in the Jaipur city to assess the quality of groundwater for determining its suitability for drinking and agricultural purposes. Groundwater samples were collected from eleven stations of Jaipur city during monsoon season and were analyzed for physio-chemical parameters such as pH. Comparison of the concentration of the chemical constituents with WHO (world health organization) drinking water standards of 1983, the status of groundwater is better for drinking purposes. The parameters like pH are within permissible limit as per WHO.

2.2.2 Total Dissolved Solids (TDS)

Majumder *et al.* (2018) investigate the physio-chemical parameters of the Jhenai River during the period from February-April 2018. The water samples were collected from three different sampling stations for analyzing the physio-chemical parameters such as total dissolved solids in water. The result of the study showed that the TDS were varied from 524-582 mgL^{-1}, respectively, indicated high ionic concentration in the river water. The result of the study concluded that the water can be used for various purposes as well as for aquatic organisms.

Sikder *et al.* (2016) investigated that 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 TDS concentration in water samples were found to range from 810-850 (mgL^{-1}).

Behera *et al.* (2014) studied on the Physio-chemical properties of water sample collected from Mangrove ecosystem of Mahanadi River Delta, Odisha, India. This present study, investigated the physio-chemical parameters of water samples which were compared withthe water quality standard of Bureau of Indian Standard (BIS) and pollution control boardof the state. These variations of different parameters investigated as follows: TDS (4510– 11900 mgL^{-1}). Most of the study sites indicated the pollution status of this estuarine water.

Gupta *et al.* (2013) studied to find out the physio-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 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. Total Dissolved Solids was found above the permissible limits of WHO.

Kumar (2013) conducted experimental work on Physio-Chemical Properties of Ground Water of U.P., (India). The study deals with evaluation of granite mines situated in jhansi (Goramachia) for their status about physio-chemical contamination of ground water. Six different sites are selected for sample testing collected from mines and urban area. Three samples have been taken at various distances on the site. This location is 10Km above from Jhansi city. The physio-chemical parameters such as TDS have been tested. It has been found that parameters are not in limit when compared with WHO standards.

Kesalkar *et al*. (2012) conducted the Physio-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. These samples were examined and compared with the effluent discharge of Indian standards. The raw waste water consisted of Total Dissolved Solids ranges from 1043-1293 mg/l. After the treatment, Total dissolved solids ranges from 807-984 mg/L. The Result showed that the TDS were in the permissible limits.

Ugwu and Wakawa (2012) showed the impact of growing population in the city of Abuja in Nigeria by studying the seasonal physio-chemical 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 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.

Singh *et al*. (2010) showed the physio-chemical properties of water samples from Manipur river system, India. An Assessment of physio-chemical 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 Maxima of TDS 870 mgL^{-1} were recorded during rainy season. The results were indicated that most of the physical and chemical parameters from Manipur river system were within the limits of WHO for drinking.

Semwal and Akolkar (2006) studied water quality assessment of rivers in Uttaranchal, in view of their religious importance and ecological sustainability. The physio-chemical water quality in most of the rivers of Uttaranchal remained unchanged except of total dissolved solids, which ranged from 90.23 to 121.33 mgL^{-1}

2.2.3 Electrical conductivity (EC)

Flura *et al.* (2016) accomplished a research to assess the physio-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) physio-chemical parameters of water Such as Electrical Conductivity. The findings of physio-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.

Sikder *et al.* (2016) leading 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 EC concentration in water samples were found to range from 1850-1900 (μScm-1).

Agbaire *et al.* (2015) studied some physio-chemical 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: conductivity (15.88±1.96μScm^{-1}). These results were largely within the WHO, SON and FEPA limits for drinking water.

Ugwu and Wakawa (2012) showed the impact of growing population in the city of Abuja in Nigeria by studying the seasonal physio-chemical characteristics of the Usma River. The study revealed that all parameters measured were within the permissible level. The values for Electrical conductivity showed that the discharges of domestic and industrial wastes in the river water as a result of human activities were responsible for the increasedlevels of pollution.

Singh *et al*. (2010) showed the physio-chemical properties of water samples from Manipur river system, India. An Assessment of physio-chemical 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 Maxima of conductivity 467 μScm^{-1} recorded during rainy season. The results were indicated that most of the physical and chemical parameters from monipur river system were within the limits of WHO for drinking.

Ullah *et al*. (2009) carried out the assessment of groundwater contamination in an industrial city, Sialkot, Pakistan. The groundwater water samples were collected from 25 localities during October-November 2005 in the industrial city of Pakistan. The physio-chemical parameters like Electric Conductivity (EC). The Analysis showed that Zone 1 was highly contaminated with high level of EC.

2.2.4 Turbidity

Tanjung *et al.* (2019) studied the quality of the water to determine the water pollution index based on the physio-chemical parameters in Mimika waters, Indonesia. The sampling of water quality was carried out in October 2016 at six stations. Then, the results were compared with the standard of sea water quality for biota marine based on the Decree of the Minister of Environment No. 51 year 2004. This study showed that the physio-chemical parameters of the waters, such as water turbidity are still appropriate to the biota marine in all study stations.

Oboh and Agbala (2017) studied the water quality of the Siluko River, Nigeria was investigated from March to August 2015 to determine its suitability for drinking and usage for domestic purposes. Water samples collected from three stations were tested for thirteen physio-chemical parameters such as turbidity using standard analytical procedures. All other parameters, with the exception of turbidity were within the permissible limits recommended by the Nigerian Standard for Drinking Water Quality (NSDWQ) and World Health Organization (WHO).

Bhasin *et al*. (2016) studied the various parameters like turbidity was performed. Water Quality Index (WQI) values ranged from 284.0-1112.34 and show all study site to be under pollution stress. Results of the present investigation showed that water quality of the river was more deteriorated during summer followed by monsoon and winter season. Immediate remedial measures are recommended to control pollution and improve water quality of the river.

Agbaire *et al.* (2015) studied some physio-chemical 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: Turbidity (9.23±1.63NTU). These results were largely within the WHO, SON and FEPA limits for drinking water.

Gupta *et al.* (2013) studied to find out the physio-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 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 Turbidity. Turbidity was found above the permissible limits of WHO.

Kumar (2013) conducted experimental work on Physio-Chemical Properties of Ground Water of U.P (India). The study deals with evaluation of granite mines situated in jhansi (Goramachia) for their status about physio-chemical contamination of ground water. Six different sites are selected for sample testing collected from mines and urban area. Three samples have been taken at various distances on the site. This location is 10Km above from Jhansi city. The physio-chemical parameters such as turbidity have been tested. It has been found that parameters are not in limit when compared with WHO standards.

Yadav *et al.* (2011) studied on Kosi River in 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 charactérics and physio-chemical parameters of water were examined, these included turbidity. 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.

Dinrifo *et al.* (2010) revealed the Physio-chemical properties of Rain Water Collected from Some Industrial Areas of Lagos State Nigeria. This study had been carried out to determine the physio-chemical properties of rainwater from 4 different industrial sites in Lagos State Nigeria and the rainwater samples were taken to the laboratory and analyzed. The result assayed on the rainwater samples indicated that average values of turbidity (0.2, 0.25, 0.18 and 0.16 NTU).

Ullah *et al*. (2009) carried out the assessment of groundwater contamination in an industrial city, Sialkot, Pakistan. The groundwater water samples were collected from 25 localities during October-November 2005 in the industrial city of Pakistan. The physio-chemical parameters like Turbidity were recorded. These results were compared with standard guidelines from WHO and Pakistan Standard Quality Control Authority

(PSQCA) for groundwater quality. The Analysis showed that Zone 1 was highly contaminated with high level of turbidity. 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).

2.2.5 Chlorides

Bhasin *et al*. (2016) studied the various parameters like chloride was performed. Water Quality Index (WQI) values ranged from 284.0-1112.34 and show all study site to be under pollution stress. Results of the present investigation showed that water quality of the river was more deteriorated during summer followed by monsoon and winter season.

Nahar *et al*. (2016) conducted a study in 2014 to assess the physio-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, Thana para and Ghosh para at 1 km 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 Chloride were examined. From this study it was observed that the parameters exceeded the permissible limits.

Kumar and Kumar (2013) conducted experimental work on Physio-Chemical Properties of Ground Water of U.P. (India). The study deals with evaluation of granite mines situated in jhansi (Goramachia) for their status about physio-chemical contamination of ground water. Six different sites are selected for sample testing collected from mines and urban area. Three samples have been taken at various distances on the site. This location is 10Km above from Jhansi city. The physic-chemical parameters such as Cl^- (chloride) have been tested. It has been found that parameters are not in limit when compared with WHO standards.

Kotadiya *et al.* (2013) leading 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 physio-chemical characteristics like Chloride.

Yadav *et al.* (2011) studied on Kosi River in 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 characteristics and physio-chemical parameters of water were examined, these included chloride. 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.

Dinrifo *et al.* (2010) revealed the Physio-chemical properties of Rain Water Collected from Some Industrial Areas of Lagos State Nigeria. This study had been carried out to determine the physio-chemical properties of rain water from 4 different industrial sites in Lagos State Nigeria and the rain water samples were taken to the laboratory and analyzed. The rain water samples indicated that average values of chloride (15.133, 14.3 and 11.1 mgL^{-1}).

Singh *et al*. (2010) showed the physio-chemical properties of water samples from Manipur river system, India. An Assessment of physio-chemical 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 maximum of Chloride 42.63 mgL^{-1} observed during the summer from the rivers indicating degradation of water quality during these seasons. The results were indicated that most of the physical and chemical parameters from Manipur river system were within the limits of WHO for drinking.

Ullah *et al*. (2009) carried out the assessment of groundwater contamination in an industrial city, Sialkot, Pakistan. The groundwater water samples were collected from 25 localities during October-November 2005 in the industrial city of Pakistan. The physio-chemical parameters like Chloride (Cl^{-1}) were recorded. These results were compared with standard guidelines from WHO and Pakistan Standard Quality Control Authority (PSQCA) for groundwater quality. The Analysis showed thatZone1 were highly contaminated with high level of Cl^{-1} concentrations were above the permissible levels of both WHO and PSQCA.

Sadashivaia *et al* (2008) carried out the hydrochemistry of groundwater in the Jaipur city to assess the quality of groundwater for determining its suitability for drinking and agricultural purposes. Groundwater samples were collected from eleven stations of Jaipur city during monsoon season and were analyzed for physio-chemical parameters like chloride. Comparison of the concentration of the chemical constituents with WHO (worldhealth organization) drinking water standards of 1983, the status of groundwater is better for drinking purposes. The parameters like chloride are within permissible limit as per WHO.

2.2.6 Dissolved oxygen (DO)

Adarsh *et al.* (2019) carried out the assessment of quality of lakes in Mysore; result shows that lakes are polluted due to the disposal of sewage or through the industrial effluents. Due to rapid increase in population, exponential industrialization and urbanization, etc. several water bodies, in and around Mysuru exposed to various forms of environmental degradations. This leads to aggregations of phytoplankton, macro algae and occasionally colorless heterotrophic protists can discolor the water giving rise to foam. Due to this, there is reduction in DO (Dissolved Oxygen) level which ultimately disturbs the ecological balance of the lake and finally leads to eutrophication in water bodies.

Behera *et al.* (2014) studied on the Physio-chemical properties of water sample collected from Mangrove ecosystem of Mahanadi River Delta, Odisha, India. This present study, investigated the physio-chemical parameters of water samples which were compared withthe 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 mgL^{-1}). Most of the study sites indicated the pollution status of this estuarine water.

Tyagi *et al*. (2013) stated that Water quality index (WQI) is valuable and unique rating to depict the overall water quality status in a single term that is helpful for the selection of appropriate treatment technique to meet the concerned issues. However, WQI depicts the composite influence of different water quality parameters and communicates water quality information to the public and legislative decision makers. In spite of absence of a globally accepted composite index of water quality, some countries have used and are using aggregated water quality data in the development of water quality indices. Attempts have been made to review the WQI criteria for the appropriateness of drinking water sources. Besides, the present article also highlights and draws attention towards the development of a new and globally accepted "Water Quality Index" in a simplified format, which may be used at large and could represent the reliable picture of water quality. Initially, WQI selecting 10 most commonly used water quality variables like dissolved oxygen (DO).

Mahananda *et al.* (2010) revealed the physio-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 Attempts were taken to study and analyze the physical and chemical characteristics of parameters of water like Dissolved oxygen. 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.

Singh *et al*. (2010) showed the physio-chemical properties of water samples from Manipur river system, India. An Assessment of physio-chemical 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 values of DO were below the minimum permissible limit (4.43 mgL^{-1}) during summer season. The results were indicated that most of the physical and chemical parameters from Manipur river system were within the limits of WHO for drinking.

Kamal *et al*. (2007) studied on Mouri River at Khulna, in Bangladesh. For the purposes of the study physio-chemical properties of water were anlaysed. They collected water samples from six different sites regularly over the interval January-March 2002.

The physio-chemical parameters like DO were studied. A statistical analysis done on sample data revealed that temperature of the water had a positive co-relation with DO. It was alsoobserved that Biological Oxygen Demand and Chemical Oxygen demand had a strong inverse relationship with dissolved oxygen.

Kumar *et al.* (2005) conducted the physio-chemical parameters in water of river Gomti were assessed to know about the water quality in its catchment area. Total of fifteen sampling sites were selected between Guaghat upstream and Gomti Barrage. Parameters like Dissolved oxygen (DO) were determined. Changes in water quality of River Gomti due to variations in quantity of parameters were found.

2.2.7 Biological dissolved oxygen (BOD5)

Tanjung *et al.* (2019) studied the quality of the water to determine the water pollution index based on the physio-chemical parameters in Mimika waters, Indonesia. The sampling of water quality was carried out in October 2016 at six stations (Moga, Puriri, Inaoga, Keakwa, Atukaand, Pomako waters).Then, the results were compared with the standard of sea water quality for biota marine based on the Decree of the Minister of Environment No. 51 year 2004. This study showed that the physio-chemical parameters of the waters, such as BOD5 are still appropriate to the biota marine in all study stations.

Egun *et al.* (2018) investigated the water quality of the Okhuaihe River, Nigeria to determine its suitability for drinking and other domestic purposes. Water samples collected from three stations were tested for fifteen physio-chemical parameters using standard analytical procedures. Biological oxygen demand was significantly different across the three stations. All parameters were within the permissible limits recommended by the Nigerian Standard for Drinking Water Quality (NSDWQ) and World Health Organization (WHO). Water Quality Index (WQI) values ranged from 9.17 to 10.40, indicating excellent water quality. Although the quality of the water from the Okhuaihe River is suitable for drinking and domestic usage, regular monitoring of human activities along the water front and control of effluents discharged into the river is recommended to sustain and improve water quality.

Bhasin *et al*. (2016) studied the various parameters like biological oxygen demand (BOD5) 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.

Majumder *et al.* (2018) conducted to investigate the physio-chemical parameters of the Jhenai River during the period from February-April 2018. The water samples were collected from three different sampling stations for analyzing the physio-chemical parameters such as biochemical oxygen demand in water. The contents of BOD5 of all stations were ranged from 1.1-1.4 mgL^{-1} revealed that organic waste pollution. The result of the study concluded that the water can be used for various purposes as well as for aquatic organisms.

Kesalkar *et al*. (2012) conducted the Physio-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. These samples were examined and compared with the effluent discharge of Indian standards. The raw waste water consisted of BOD5 varies from 268 - 387 mg/L. After the treatment BOD5 ranges from 176-282 respectively. The Result showed that the BOD5 does not meet the permissible standards after treatment.

Yadav *et al.* (2011) studied on Kosi River in 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 characteristics and physio-chemical parameters of water were examined, these included Biological Oxygen Demand (BOD5). 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.

Kamal *et al*. (2007) studied on Mouri River at Khulna, in Bangladesh. For the purposes of the study physio-chemical properties of water were analyzed. They collected water samples from six different sites regularly over the interval January-March 2002.

The physio-chemical parameters like BOD5 were studied. It was also observed that Biological Oxygen Demand and Chemical Oxygen demand had a strong inverse relationship with dissolved oxygen.

CHAPTER 3

MATERIALS AND METHODS

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), EC, Turbidity, CL, DO, BOD5.

3.1 Study area

The site of freshwater sampling from different sources of Chunkuri, Dhaki and Vodra river of Khulna have been shown in Figure 1. The detailed information regarding fresh water sampling has been reported in Tables (1, 2, 3, 4). The experimental site of Dacop situated at $22^{0}509'$ to $22^{0}592'$N Latitude and $89^{0}491'$ to $89^{0}562'$E Longitude.

3.2 Collection of freshwater samples

Freshwater samples were collected to study the extent of heavy metal contaminations of the Chunkuri, Vodra and Dhaki river, Khulna. To obtain a general information regarding sampling (exactly number of places) point freshwater samples were collected randomly from selected rivers 1km, 2km, 3km away from the river junction. In each river, 18 samples were collected from different point of selected rivers.

Plate 1: Collection of freshwater samples

Table 1. Detailed information regarding freshwater sample

SL.No.	Sample ID	Location	River Name	Date
1.	KCF11	Krishtanpara	Chunkuri	19.11.19
2.	KCF12	Krishtanpara	Chunkuri	19.11.19
3.	KCF13	Krishtanpara	Chunkuri	19.11.19
4.	KCF21	Krishtanpara	Chunkuri	19.11.19
5.	KCF22	Krishtanpara	Chunkuri	19.11.19
6.	KCF23	Krishtanpara	Chunkuri	19.11.19
7.	KCF31	Krishtanpara	Chunkuri	19.11.19
8.	KCF32	Krishtanpara	Chunkuri	19.11.19
9.	KCF33	Krishtanpara	Chunkuri	19.11.19
10.	KCE11	Krishtanpara	Chunkuri	20.11.19
11.	KCE12	Krishtanpara	Chunkuri	20.11.19
12.	KCE13	Krishtanpara	Chunkuri	20.11.19
13.	KCE21	Krishtanpara	Chunkuri	20.11.19
14.	KCE22	Krishtanpara	Chunkuri	20.11.19
15.	KCE23	Krishtanpara	Chunkuri	20.11.19
16.	KCE31	Krishtanpara	Chunkuri	20.11.19
17.	KCE32	Krishtanpara	Chunkuri	20.11.19
18.	KCE33	Krishtanpara	Chunkuri	20.11.19

Sample ID Meaning: KCF11, 1st letter K=location (Krishtanpara), 2nd letter C= Name of river (Chunkuri), 3rd letter F= Flow time, 4thletter 1= Distance (1km), 5th letter 1=Replication.

Table 2. Detailed information regarding freshwater samples

SL.No.	Sample ID	Location	River Name	Date
19.	KDF11	Kamarkhola	Dhaki	19.11.19
20.	KDF12	Kamarkhola	Dhaki	19.11.19
21.	KDF13	Kamarkhola	Dhaki	19.11.19
22.	KDF21	Kamarkhola	Dhaki	19.11.19
23.	KDF22	Kamarkhola	Dhaki	19.11.19
24.	KDF23	Kamarkhola	Dhaki	19.11.19
25.	KDF31	Kamarkhola	Dhaki	19.11.19
26.	KDF32	Kamarkhola	Dhaki	19.11.19
27.	KDF33	Kamarkhola	Dhaki	19.11.19
28.	KDE11	Kamarkhola	Dhaki	20.11.19
29.	KDE12	Kamarkhola	Dhaki	20.11.19
30.	KDE13	Kamarkhola	Dhaki	20.11.19
31.	KDE21	Kamarkhola	Dhaki	20.11.19
32.	KDE22	Kamarkhola	Dhaki	20.11.19
33.	KDE23	Kamarkhola	Dhaki	20.11.19
34.	KDE31	Kamarkhola	Dhaki	20.11.19
35.	KDE32	Kamarkhola	Dhaki	20.11.19
36.	KDE33	Kamarkhola	Dhaki	20.11.19

Sample ID Meaning: KDF11, 1^{st} letter K=location (Kamarkhola), 2^{nd} letter D= Name of river (Dhaki), 3^{rd} letter F= Flow time, 4^{th} letter 1= Distance (1km), 5^{th} letter 1=Replication.

Table 3. Detailed information regarding freshwater sample

SL.No.	Sample ID	Location	River Name	Date
37.	KVF11	Kamarkhola	Vodra	19.11.19
38.	KVF12	Kamarkhola	Vodra	19.11.19
39.	KVF13	Kamarkhola	Vodra	19.11.19
40.	KVF21	Kamarkhola	Vodra	19.11.19
41.	KVF22	Kamarkhola	Vodra	19.11.19
42.	KVF23	Kamarkhola	Vodra	19.11.19
43.	KVF31	Kamarkhola	Vodra	19.11.19
44.	KVF32	Kamarkhola	Vodra	19.11.19
45.	KVF33	Kamarkhola	Vodra	19.11.19
46.	KVE11	Kamarkhola	Vodra	20.11.19
47.	KVE12	Kamarkhola	Vodra	20.11.19
48.	KVE13	Kamarkhola	Vodra	20.11.19
49.	KVE21	Kamarkhola	Vodra	20.11.19
50.	KVE22	Kamarkhola	Vodra	20.11.19
51.	KVE23	Kamarkhola	Vodra	20.11.19
52.	KVE31	Kamarkhola	Vodra	20.11.19
53.	KVE32	Kamarkhola	Vodra	20.11.19
54.	KVE33	Kamarkhola	Vodra	20.11.19

Sample ID Meaning: KVF11, 1st letter K=location (Kamarkhola), 2nd letter V= Name of river (Vodra), 3rd letter F= Flow time, 4th letter 1=Distance (1km), 5th letter 1=Replication.

Table 4. Detailed information regarding freshwater sample

SL.No.	Sample ID	Location	River Name	Date
55.	KDL1	Kamarkhola	Dhaki	20.11.19
56.	KDL2	Kamarkhola	Dhaki	20.11.19
57.	KDL3	Kamarkhola	Dhaki	20.11.19
58.	KVL1	Kamarkhola	Vodra	20.11.19
59.	KVL2	Kamarkhola	Vodra	20.11.19
60.	KVL3	Kamarkhola	Vodra	20.11.19
61.	KRJ1	Kamarkhola	River Junction	20.11.19
62.	KRJ2	Kamarkhola	River Junction	20.11.19
63.	KRJ3	Kamarkhola	River Junction	20.11.19

Sample ID Meaning: KDL1, 1st letter K=location (Kamarkhola), 2nd letter D= Name of river (Dhaki/Vodra), 3rd letter L=Locality, 4th letter 1= Replication, KRJ=Kamarkhola River Junction (1,2 and 3= Replication).

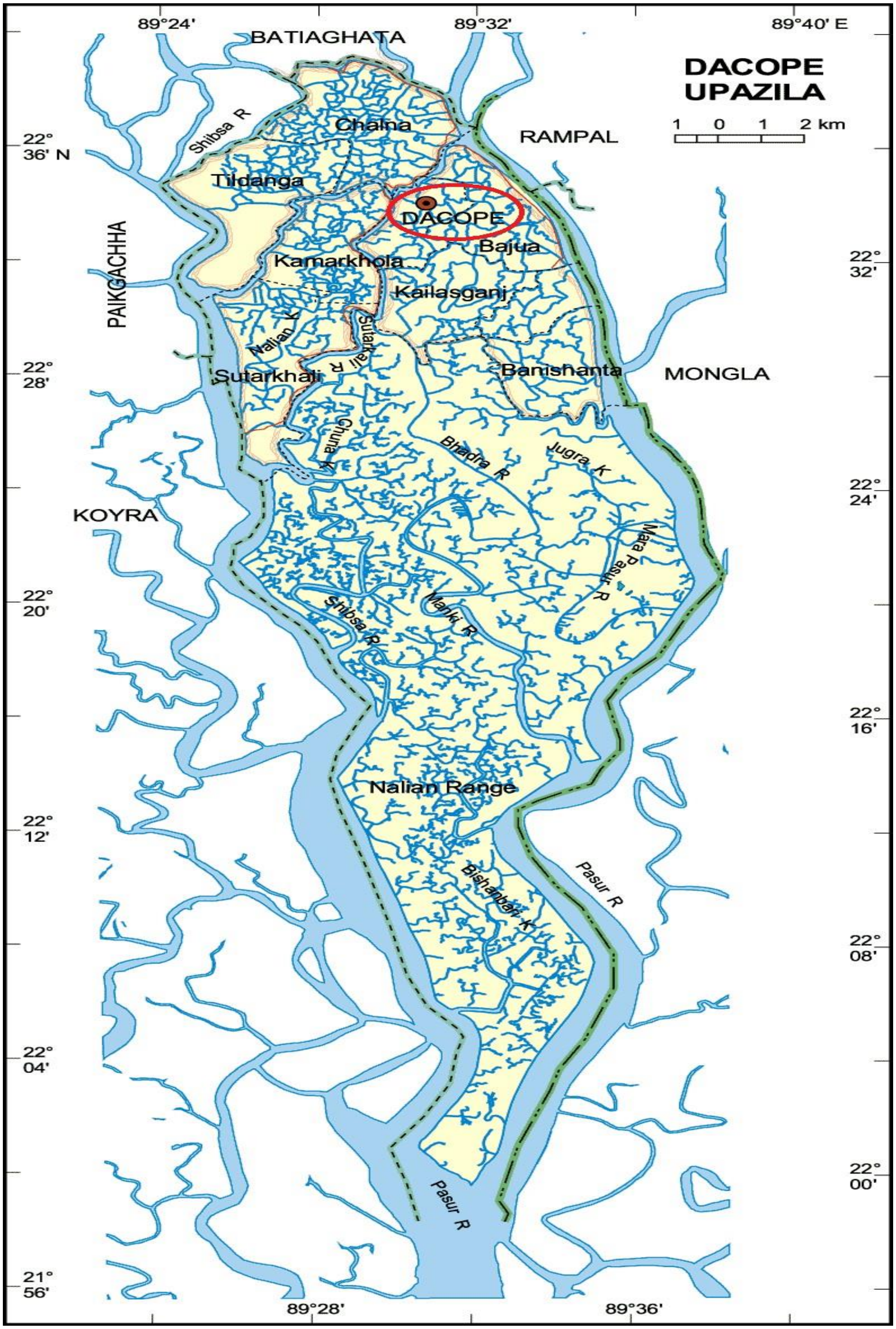

Figure 1: Map showing the study area

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 freshwaters 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, Khulna University. 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 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

1. pH

2. Total Dissolved Solids (TDS)

3. Electrical conductivity (EC)

4. Turbidity

5. CL^{-1}

6. Dissolve Oxygen (DO)

7. Biological Oxygen Demand (BOD5)

All chemical analyses were performed at the departmental laboratory of Khulna University.

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 bacterieral 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).

Chemical characteristics

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).

Figure 2: P^H meter

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).

Electric Conductivity (EC)

Conductivity is the measure of capacity of a substance or solution to conduct electrical current through the water. 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).

Figure 3: EC meter

DISSOLVED OXYGEN (DO) AND BIOLOGICAL OXYGEN DEMAND (BOD5)

Dissolved oxygen content of the water samples was measured by using Winkler's method (modified azide method). The sample was collected in 500 ml bottle and DO was fixed on site by using 1 ml each of Manganous sulphate and Alkaline-iodide-azide. The precipitate formed was dissolved in laboratory by using sulphuric acid and titrated with sodium thiosulphate using starch as an indicator. The end point of titration was blue to straw pale color. The water organisms that dissolve oxygen are relatively varied and depending on type, stage and activity. The DO and BOD5 parameters are important to determine the quality of waters. DO shows the total amount of dissolved oxygen in the waters for breathing and metabolic processes, while BOD5 shows the amount of dissolved oxygen needed by microorganisms to decompose or decompose organic matter under aerobic conditions (Pawari and Gavande, 2015).

TURBIDITY

The most common method of turbidity assessment is nephelometry, defined as measuring the amount of light scattered data 90° angle from a fixed light beam by particles in the water column (Sadar, 1998). It is thought this angle can be used to estimate all light scattering, assuming an empirical relationship between turbidity and particle concentration. The exact specifications can be found in EPA method 180.1, which is the recommended method by the EPA for drinking water assessment (O'Dell, 1993). Many sensors, particularly if following EPA method 180.1, measure water turbidity in Nephelometric Turbidity Units (NTUs), however, turbidity can be measured in Formazin Nephelometric Units (FNUs) (O'Dell, 1993; Ankcorn 2003). Formazin refers to a white polymer substance that is commonly used as a standard for turbidity (Ankcorn, 2003). Formazin is used for turbidity measurement in both NTUs and FNUs, though the calculation is slightly different and generally the two units are not considered equivalent (Ankcorn, 2003).

CHAPTER 4

RESULT AND DISCUSSION

In the experimental samples, the major physio-chemical constituents such as Color, Odor, pH, Total Dissolved Solids (TDS), EC, Turbidity, DO, BOD5 were observed. The obtained analytical results have been represented in Tables (5, 6, 7, 8). The salient features of the experimental findings presented in this chapter and discussed under appropriate headings and supported with 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 was 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. 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. The water samples color was black, ash and also light grey in Chunkuri, Dhaki and Vodra river.

Flura *et al.* (2016) found that continuous sewage disposal, fertilizer from the crop field, industrial waste were the reasons for the change of water color. In future it is harmful for aquatic life & surrounding environment of the aquatic bodies.

4.1.2 Odor

Severe pollution has reduced the Chunkuri, Dhaki and Vodra 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. During the investigation, the collected freshwater samples were found with bad smells and also in some case severe foul odor.

Adarsh *et al.* (2019) said that industrial effluents, sewage, wash out of fertilizer from the crop field, household water etc mixed with the water bodies which increases the population of phytoplankton, macro algae which forms the eutrophication in water bodiesand causes odor.

Table 5: Parameter & concentration of fresh water in Chunkuri river

Sample	pH	EC (μscm^{-1})	TDS ($mg\ l^{-1}$)	Turbidity (NUT unit)	Cl^{-1} ($mg\ l^{-1}$)	DO ($mg\ l^{-1}$)	BOD5 ($mg\ l^{-1}$)
CF 1	8.01	546.00	247.00	11.33	158.62	6.04	4.45
CF 2	7.98	544.00	246.00	11.29	158.06	6.03	5.01
CF 3	7.89	538.00	244.00	11.16	156.24	6.06	4.98
CE 1	8.06	612.00	307.00	10.10	141.40	9.23	3.46
CE 2	7.99	597.00	275.00	23.10	323.40	7.11	3.79
CE 3	8.02	604.00	302.00	32.50	455.00	7.97	1.11
Mean	7.99	573.50	270.17	16.58	232.12	7.07	3.80
Maximum	8.06	612.00	307.00	32.50	455.00	9.23	5.01
Minimum	7.89	538.00	244.00	10.10	141.40	6.03	1.11
SD	0.06	34.21	28.98	9.20	128.75	1.31	1.46
CV (%)	0.71	5.97	10.73	55.47	55.47	18.58	38.37

CF1 = Sample collected form1 km distance from Chunkuri river in tide time
CF1 = Sample collected form2 km distance from Chunkuri river in tide time
CF1 = Sample collected form3 km distance from Chunkuri river in tide time
CE1 = Sample collected form1kmdistance from Chunkuri river inEbb time
CE1 = Sample collected form2 km distance from Chunkuri river in Ebb time
CE1 = Sample collected form3 km distance from Chunkuri river in Ebb time

Table 6: Parameter & concentration of fresh water in Dhaki river

Sample	pH	EC (μscm^{-1})	TDS ($mg\ l^{-1}$)	Turbidity (NUT unit)	Cl^{-1} ($mg\ l^{-1}$)	DO ($mg\ l^{-1}$)	BOD5 ($mg\ l^{-1}$)
DF 1	8.02	597.00	297.00	33.76	472.64	3.09	1.16
DF 2	8.03	597.00	275.00	57.20	800.80	5.23	1.96
DF 3	8.00	601.00	273.00	56.87	796.18	5.20	1.95
DE 1	8.06	569.00	260.00	28.30	396.20	7.59	4.97
DE 2	8.02	671.00	245.00	27.89	390.46	7.55	4.96
DE 3	8.03	578.00	240.00	26.52	371.28	7.42	4.91
Mean	8.03	602.17	265.00	38.42	537.93	6.01	3.32
Maximum	8.06	671.00	297.00	57.20	800.80	7.59	4.97
Minimum	8.00	569.00	240.00	26.52	371.28	3.09	1.16
SD	0.02	35.99	21.16	14.63	204.77	1.82	1.81
CV (%)	0.24	5.98	7.98	38.07	38.07	30.34	54.47

DF1 = Sample collected form1 km distance from Dhaki river in tide time
DF1 = Sample collected form2 km distance from Dhaki river in tide time
DF1 = Sample collected form3 km distance from Dhaki river in tide time
DE1 = Sample collected form1 km distance from Dhaki river in Ebb time
DE1 = Sample collected form2 km distance from Dhaki river in Ebbtime
DE1 = Sample collected form3 km distance from Dhaki river in Ebb time

Table 7: Parameter & concentration of fresh water in Vodra river

Sample	pH	EC (μscm^{-1})	TDS (mg l^{-1})	Turbidity (NUT unit)	Cl^{-1} (mg l^{-1})	DO (mg l^{-1})	BOD5 (mg l^{-1})
VF 1	8.10	671.00	335.00	110.00	1540.00	10.06	3.77
VF 2	7.99	794.00	395.00	115.00	1610.00	10.51	3.94
VF 3	7.97	889.00	401.00	107.00	1498.00	9.78	3.67
VE 1	8.00	559.00	279.00	18.60	260.40	6.70	4.64
VE 2	7.98	551.00	275.00	18.32	256.48	6.67	4.63
VE 3	7.90	545.00	272.00	18.14	253.96	6.66	6.62
Mean	7.99	668.17	326.17	64.51	903.14	8.40	4.55
Maximum	8.10	889.00	401.00	115.00	1610.00	10.51	6.62
Minimum	7.90	545.00	272.00	18.14	253.96	6.66	3.67
SD	0.06	145.21	60.32	50.63	708.78	1.90	1.10
CV (%)	0.81	21.73	18.49	78.48	78.48	22.61	24.21

VF1 = Sample collected form1 km distance from Vodra river in tide time
VF1 = Sample collected form2 km distance from Vodra river in tide time
VF1 = Sample collected form3 km distance from Vodra river in tide time
VE1 = Sample collected form1 km distance from Vodra river in Ebb time
VE1 = Sample collected form2 km distance from Vodra river in Ebb time
VE1 = Sample collected form3 km distance from Vodra river in Ebb time

Table 8: Parameter & concentration of fresh water among different location

Source	pH	EC (μscm^{-1})	TDS (mg l^{-1})	Turbidity (NUT unit)	Cl^{-1} (mg l^{-1})	DO (mg l^{-1})	BOD5 (mg l^{-1})
Chun kuri	7.99 ± 0.06	573.50 ± 34.21	270.17 ± 28.98	16.58 ± 9.20	232.12 ± 128.75	7.07 ± 1.31	3.80 ± 1.46
Dhaki	8.03 ± 0.02	602.17±35.99	265.00 ± 21.16	38.42 ± 14.63	537.93 ± 204.77	6.01 ± 1.82	3.32 ± 1.81
Vodra	7.99 ± 0.06	668.17±145.21	326.17 ±60.32	64.51 ± 50.63	903.14 ± 70.78	8.40 ± 1.90	4.55 ± 1.10
DL	8.10 ± 0.13	1047.03 ± 18.17	520.35 ± 5.73	19.32 ± 0.40	268.39 ± 3.11	4.79 ± 0.08	7.71 ± 0.06
VL	8.07 ± 0.07	1051.19 ± 11.85	521.60± 9.26	19.45 ± 0.25	272.81 ± 3.04	4.78 ± 0.10	6.74 ± 0.10
RJ	8.14 ± 0.07	557.89 ± 9.75	253.92± 4.79	11.34 ± 0.21	163.49 ± 5.18	5.09 ± 0.09	4.42 ± 0.08

DL1 = Sample collected form locality of Dhaki river
VL3 = Sample collected form locality of Vodra river
RJ = River junction

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 Chunkuri was recorded as 7.89 and 8.06. The average values of pH of Chunkuri 7.99. Minimum and maximum pH value of Dhaki river were recorded 8.00 and 8.06 respectively and average 8.03. On the other hand, minimum and maximum pH value of Vodra river were recorded 7.90 and 8.10 respectively and average 7.99. In comparison among 6 (six) location viz. Chunkuri, Dhaki, Vodra, DL, VL and RJ location the highest pH found from RJ sample (8.14 ± 0.07) and the lowest was found from Chunkuri (7.99 ± 0.06) and Vodra river water (7.99 ± 0.06).

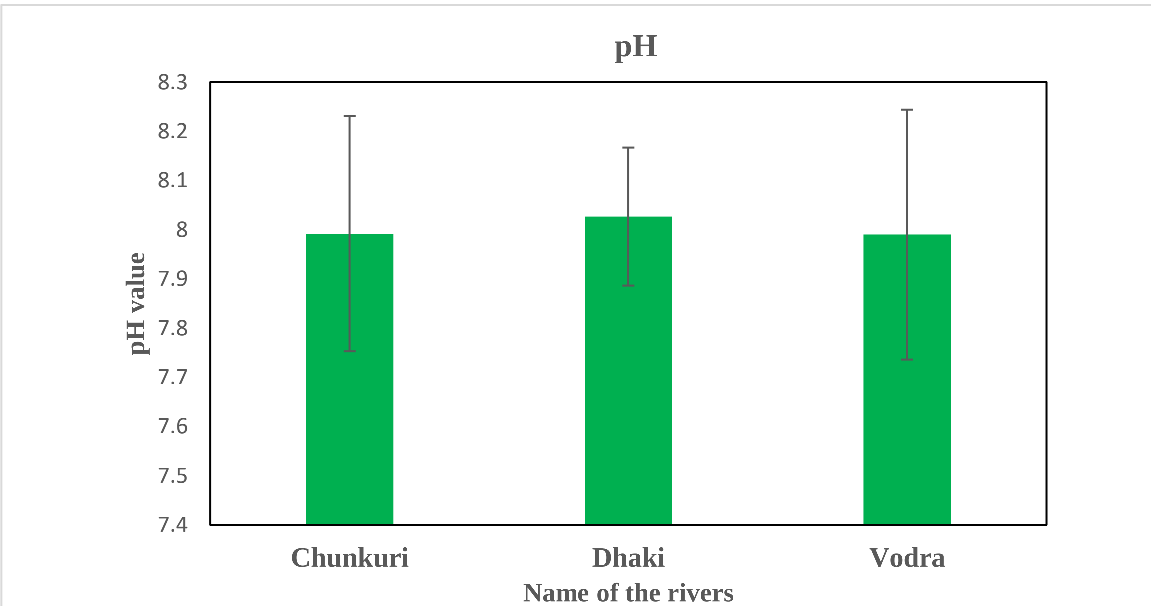

Figure 4: Mean PH value of chunkuri, dhaki and vodra river water

The acceptable range of pH for irrigation water quality is from 6.0 to 9 (Ayers and Westcot, 1985). The pH of the Chunkuri river water is not so problematic for aquatic growth, the optimum range so pH for aquatic life is 6.8 to 9.0 (Trivedi, 2010). According to the water quality standard for aquaculture, the recommended pH value ranges from 6.5 to 8.0. On the basis of their comments, it can be concluded that the water samples for three 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 36 locations under the three rivers were within the ranges of 244.00 to 307.00 mg/L in Chunkuri; 240.00 to 297.00 mg/L for Dhaki river and 272.00 to 401.00 mg/L for Vodra river. The average TDS values of Chunkuri, Dhaki and Vodra river were 270.17, 265.00 and 326.17mg/L, respectively. From the result, it was found that TDS values were higher in Vodra river of water. In comparison among 6 (six) location viz. Chunkuri, Dhaki, Vodra, DL, VL and RJ location the highest TDS content of water found from VL water sample (521.60 ± 9.26) and the lowest was found from RJ water sample (253.92 ± 4.79).

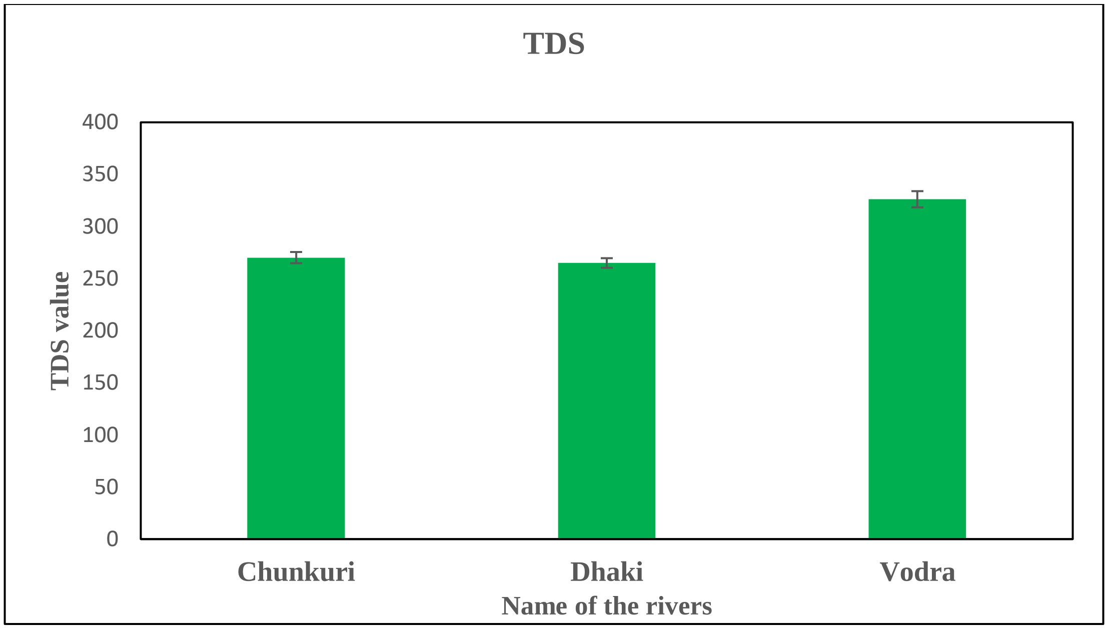

Figure 5: Mean TDS value (mg/l) of chunkuri, dhaki and vodra river water

Similar observation was reported by Meghla *et al.* (2013) for the assessment of physio-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 2010of 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 (Rafiqul *et. al.* 2016). The standard of TDS for domestic water supplies is 500 mg/L by USPH. 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 than 1000 mg/L were graded as fresh water in quality. Therefore, these waters might safely be used for irrigation and also were suitable for crop production in respect of TDS.

4.2.3 Electrical Conductivity (EC)

The EC of all collected water samples from 36 locations under the three rivers were within the ranges of 538.00 to 612.00 µscm^{-1} in Chunkuri, 569.00 to 671.00 µs cm^{-1} for Dhaki river and 545.00 to 889.00 µs cm^{-1} for Vodra river. The average EC value of Chunkuri, Dhaki and Vodra river were 573.50, 602.17 and 668.17µscm^{-1}, respectively.In comparison among 6 (six) location viz. Chunkuri, Dhaki, Vodra, DL, VL and RJ location the highest EC content of water found from VL water sample (1051.19 ± 11.85) and the lowest was found from RJ water sample (557.89 ± 9.75).

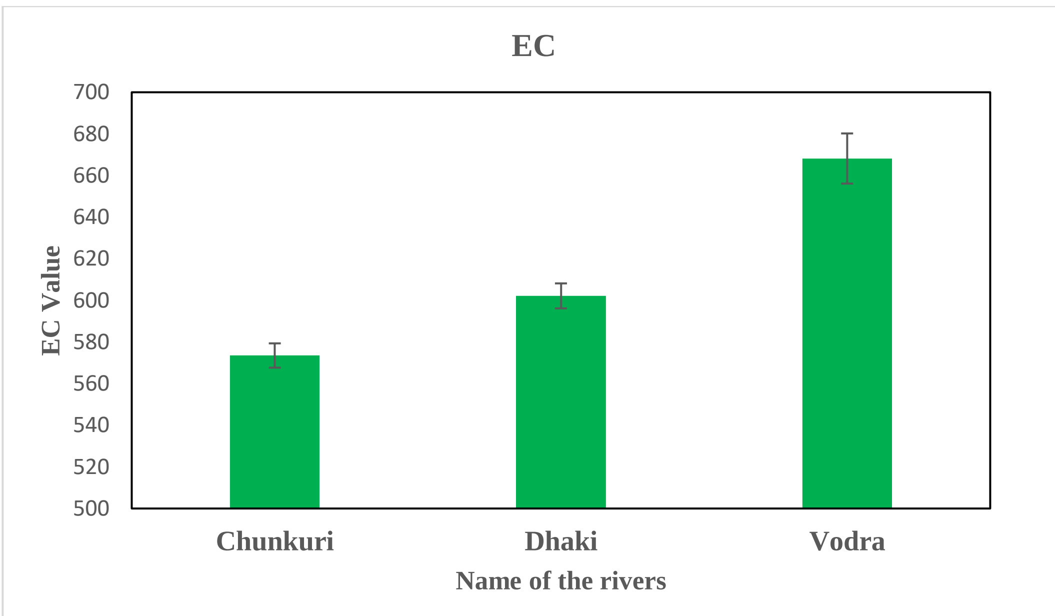

Figure 6: Mean EC value (µscm^{-1}) of chunkuri, dhaki and vodra river water

Flura *et al.* (2016) said that EC increases the phytoplankton & zooplankton community which indicate the water quality safe for agricultural uses but not safe for drinking purpose.

4.2.4 Turbidity

The turbidity of all collected water samples from 36 locations under the three rivers were within the ranges of 10.10 to 32.50 NTU in Chunkuri, 26.52 to 27.20 NTU for Dhaki river and 18.14 to 115 for Vodra river. The average turbidity of Chunkuri, Dhaki and Vodra river were 16.58, 38.42 and 64.51NTU, respectively. In comparison among 6 (six) location viz. Chunkuri, Dhaki, Vodra, DL, VL and RJ location the highest turbidity content of water found from Vodra river water sample (64.51 ± 50.63) and the lowest was found from RJ water sample (11.34 ± 0.21).

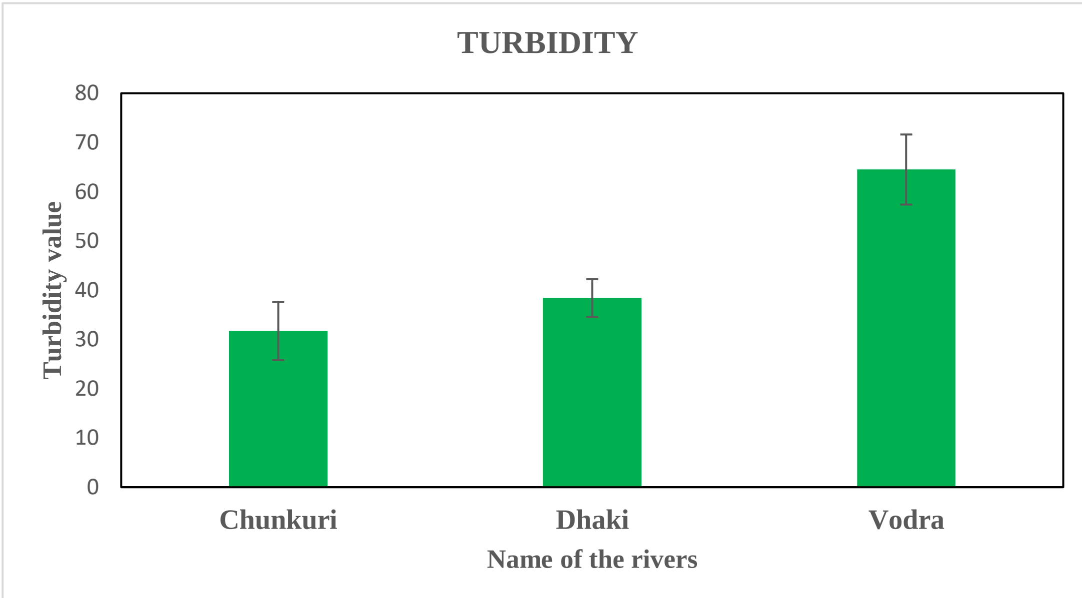

Figure 7: Mean turbidity value (NTU) of chunkuri, dhaki and vodra river water

Agbaire *et al*. (2015) found that the turbidity (9.23+1.63 NTU). These result were within the WHO limits for drinking water. Our results showed that turbidity suitable for water is 5NTU but ideal 1NTU. The turbidity is not suitable for agricultural crop.

4.2.5 Chlorine (cl^{-1})

The chlorine of all collected water samples from 36 locations under the three rivers were within the ranges of 144.40 to 455 mg/L in Chunkuri; 371.28 to 800.80 mg/L for Dhaki river and 253.96 to 1610 mg/L for Vodra river. The average chlorine value of Chunkuri, Dhaki and Vodra river were 232.12, 537.93 and 903.14 mg/L respectively. Higher chlorine is not good for aquatic life. In comparison among 6 (six) location viz. Chunkuri, Dhaki, Vodra, DL, VL and RJ location the highest Cl^{-1}content of water found from Vodra river water sample (903.14 ± 70.78) and the lowest was found from RJ water sample (163.49 ± 5.18).

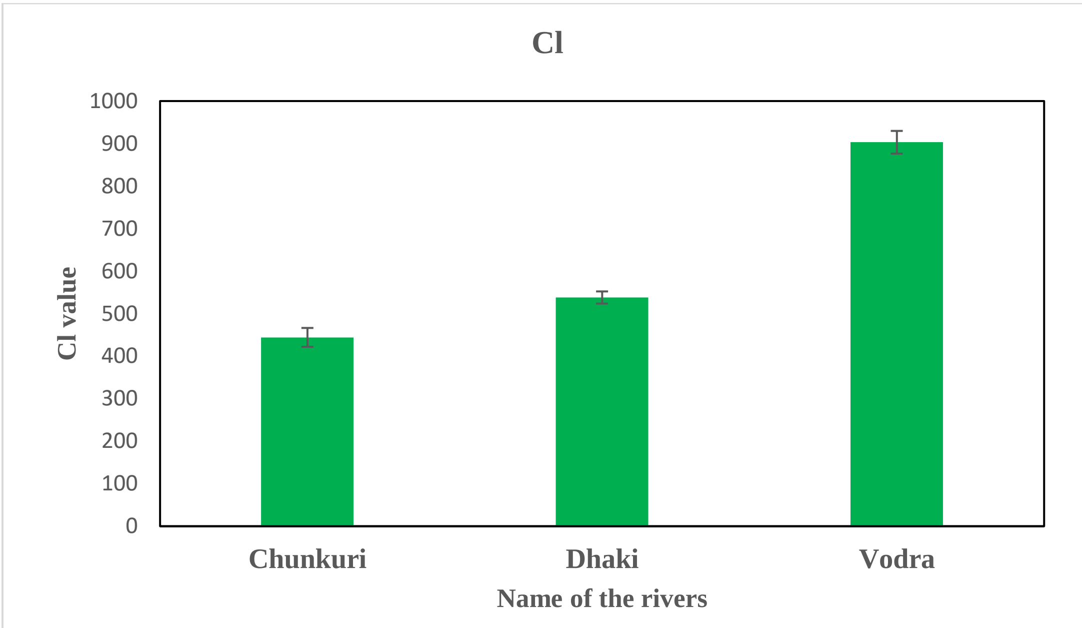

Figure 8: Mean Cl^{-1} value (mg/l) of chunkuri, dhaki and vodra river water

Another investigation was done by Behera *et al.* (2014) to investigate the physio-chemical properties of water sample which were compared with the water qualities standard of Bureau of Indian Standard (BIS). They found the chlorine content (4389-12575 mg/l).

4.2.6 Dissolve Oxygen (DO)

The DO of all collected water samples from 36 locations under the three rivers were within the ranges of 6.03 to 9.23 mg/L in Chunkuri; 6.03 to 9.23 for Dhaki river and 6.66 to 10.51 mg/L for Vodra river. The average DO value of Chunkuri, Dhaki and Vodra river were 7.07, 7.07 and 8.40 mg/L. 5mg/L or more dissolve oxygen is suitable for agriculture and aquatic life. So, the water is suitable for agriculture. In comparison among 6 (six) location viz. Chunkuri, Dhaki, Vodra, DL, VL and RJ.

the highest TDS content of water found from Vodra river water sample (8.40 ± 1.90) and the lowest was found from VL water sample (4.78 ± 0.10).

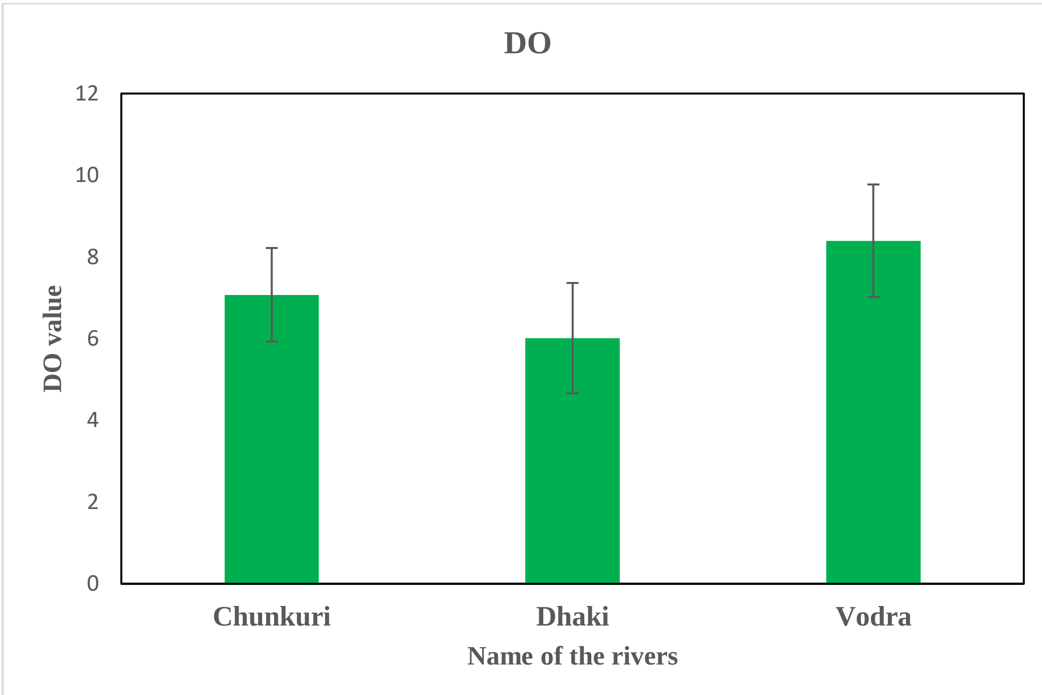

Figure 9: Mean DO value (mg/l) of chunkuri, dhaki and vodra river water

Adarsh *et al.* (2019) said that due to eutrophication the DO always decreases which gives the change in color of water bodies & the quality of water goes under the quality level of WHO. The water is suitable for Agricultural purposes.

4.2.7 Biological Oxygen Demand (BOD5)

The BOD5 of all collected water samples from 36 locations under the three rivers were within the ranges of 1.11 to 5.01mg/L in Chunkuri; 1.16 to 4.97 mg/L for Dhaki river and 3.67 to 6.62 mg/L for Vodra river. The average BOD5 value of Chunkuri, Dhaki and Vodra river were 3.80, 3.32 and 4.55 mg/L respectively. The water with high BOD5 value can pollute the water by reducing dissolve oxygen which is the prime necessity for the survival of living organism. In comparison among 6 (six) location viz. Chunkuri, Dhaki, Vodra, DL, VL and RJ location the highest BOD5 content of water found from DL sample (7.71 ± 0.06) and the lowest was found from Dhaki water sample (3.32 ± 1.81).

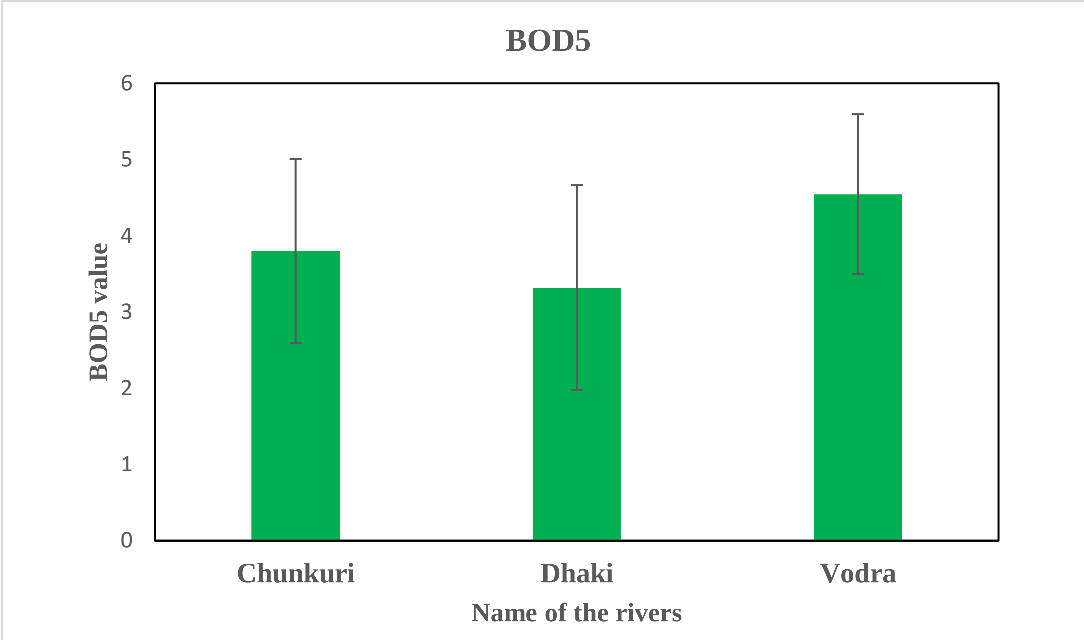

Figure 10: Mean BOD5 value (mg/l) of chunkuri, dhaki and vodra river water

Another investigation was done by kesalkear *et al.* (2012) and said that BOD5 varies from 268-387 mg/l. The result showes that BOD5 values does not meet the permissible standards.

4.3 Correlation matrix of Chunkuri, Dhaki and Vodra River

The correlation matrix presented in Tables 9, 10, 11 & 12 showed both positive and negative significant correlations among the different physio-chemical parameters. In tannery effluents and adjacent river among the parameters. In case of Chunkuri river, the pH has positive correlation with EC, TDS, Turbidity, Cl^{-1}, DO and negative correlation with BOD5 but both the relation was not significant. EC has significant positive correlation with DO ($r=0.965^{**}$) and TDS ($r=0.965^{**}$) and insignificant positive correlation with Turbidity and Cl^{-1} but insignificant negative correlation with BOD5. TDS has significant positive correlation with DO ($r=0.918^{**}$) and insignificant positive correlation with Turbidity and Cl^{-1} but significant negative correlation with BOD5 ($r=-0.821^{*}$). Turbidity has significant positive correlation with Cl^{-1}($r=0.90^{**}$) and insignificant positive correlation with DO but significant negative correlation with BOD5 ($r=-0.849^{*}$). Cl^{-1} insignificant positive correlation with DO but significant negative correlation with BOD5 ($r= -0.849^{*}$). DO has insignificant negative correlation with BOD5.

Table 9: Correlation matrix among the parameters in Chunkuri river

	pH	EC	TDS	Turbidity	Cl^{-1}	DO	BOD5
pH	1						
EC	0.707	1					
TDS	0.717	0.965^{**}	1				
Turbidity	0.196	0.561	0.519	1			
Cl^{-1}	0.196	0.561	0.519	0.90^{**}	1		
DO	0.717	0.918^{**}	0.965^{**}	0.281	0.281	1	
BOD5	-0.533	-0.765	-0.821^{*}	-0.849^{*}	-0.849^{*}	-0.655	1

In case of Dhaki river, the pH has insignificant positive correlation with DO and BOD5 but insignificant negative correlation with EC, TDS, Turbidity and Cl^{-1}. EC has insignificant positive correlation with DO and BOD5 but insignificant negative correlation with TDS, Turbidity and Cl^{-1}. TDS has insignificant positive correlation with Turbidity and Cl^{-1} but significant negative correlation with DO ($r = -0.941^{**}$) and BOD5 ($r = -0.913^{*}$). Turbidity has significant positive correlation with Cl^{-1} ($r= 0.88^{**}$) and insignificant negative correlation with DO and BOD5. Cl^{-1} insignificant negative correlation with BOD5. DO has significant negative correlation with BOD5 ($r= 0.961^{**}$).

Table 10: Correlation matrix among the parameters in Dhaki river

	pH	EC	TDS	Turbidity	Cl^{-1}	DO	BOD5
pH	1						
EC	-0.451	1					
TDS	-0.245	-0.219	1				
Turbidity	-0.490	-0.074	0.481	1			
Cl^{-1}	-0.490	-0.074	0.481	0.88^{**}	1		
DO	0.477	0.121	-0.941^{**}	-0.487	-0.487	1	
BOD5	0.539	0.122	-0.913^{*}	-0.708	-0.708	0.961^{**}	1

In case of Vodra river, the pH has insignificant positive correlation with EC, TDS, Turbidity, Cl^{-1} and DO but insignificant negative correlation with BOD5. EC has significant positive correlation with TDS (r= 0.982^{**}), Turbidity(r= 0.871^{*}), Cl^{-1}(r= 0.871^{*}) and DO (r= 0.854^{*}) but insignificant negative correlation with BOD5. TDS has significant positive correlation with Turbidity (r= 0.923^{**}), Cl^{-1} (r= 0.923^{**}) and DO (r= 0.961^{**}) but insignificant negative correlation with BOD5. Turbidity has significant positive correlation with Cl^{-1} (r= 0.92^{**}) and DO (r= 0.997^{**}) but insignificant negative correlation with BOD5. Cl^{-1}significant positive correlation with DO (r= 0.997^{**}) but insignificant negative correlation with BOD5. DO has insignificant negative correlation with BOD5.

Fatema *et al.* (2018) found that pearson correlation analysis showed that correlations exist among temperature and other parameters, such as DO, conductivity, pH, phosphate at significant level ($p<0.01$). Correlations also present among DO and other parameters, such as conductivity, pH, phosphate and Fe at significant level ($p<0.01$). Correlations exist among conductivity and other parameters, such as pH, phosphate at significant level ($p<0.01$).

Table 11: Correlation matrix among the parameters in Vodra river

	pH	EC	TDS	Turbidity	Cl^{-1}	DO	BOD5
pH	1						
EC	0.151	1					
TDS	0.226	0.982^{**}	1				
Turbidity	0.510	0.871^{*}	0.923^{**}	1			
Cl^{-1}	0.510	0.871^{*}	0.923^{**}	0.92^{**}	1		
DO	0.509	0.854^{*}	0.919^{**}	0.997^{**}	0.997^{**}	1	
BOD5	-0.717	-0.685	-0.709	-0.745	-0.745	-0.736	1

CHAPTER 5
SUMMARY AND CONCLUSION

The investigation was conducted at the Agricultural Chemistry laboratory at Khulna University to assess the physio-chemical parameters in Chunkuri, Dhaki and Vodra rivers of Bangladesh. For this purpose, 36 samples were collected from different locations in each river to analyze the physio-chemical parameters like pH, EC, TDS, Turbidity, Cl-1, DO, BOD5.

The water samples color was black, ash and also light grey in Chunkuri, Dhaki and Vodra river. The collected freshwater samples were found with bad smells and also in some case severe foul odor. The highest pH found from RJ sample (8.14 ± 0.07) and the lowest was found from Chunkuri (7.99 ± 0.06) and Vodra river water (7.99 ± 0.06). According to the water quality standard for aquaculture, the recommended pH value ranges from 6.5 to 8.0. On the basis of their comments, it can be concluded that the water samples for three rivers were not problematic for irrigating agricultural crops and any other activities rather than use of drinking water. In case of EC, the highest EC content ofwater found from VL water sample (1051.19 ± 11.85) and the lowest was found from RJ water sample (557.89 ± 9.75). The highest TDS content of water found from VL water sample (521.60± 9.26) and the lowest was found from RJ water sample (253.92± 4.79).

For Turbidity, the highest Turbidity of water found from Vodra river water sample (64.51 ± 50.63) and the lowest was found from RJ water sample (11.34 ± 0.21). The highest Cl^{-1} content of water found from Vodra river water sample (903.14 ± 70.78) and the lowest was found from RJ water sample (163.49 ± 5.18). The highest DO content of water found from Vodra river water sample (8.40 ± 1.90) and the lowest was found from VL water sample (4.78 ± 0.10). The highest BOD5 content of water found from DL sample (7.71 ± 0.06) and the lowest was found from Dhaki water sample (3.32 ± 1.81). Therefore, these waters might safely be used for irrigation and also were suitable for crop production in respect of TDS.

In case of Chunkuri river, EC has significant positive correlation with DO ($r = 0.965^{**}$) and TDS ($r = 0.965^{**}$). TDS has significant positive correlation with DO ($r = 0.918^{**}$) and significant negative correlation with BOD5 ($r = -0.821^{*}$). Turbidity has significant positive correlation with Cl^{-1} ($r= 0.90^{**}$) and significant negative correlation with BOD5($r = -0.849^{*}$). Cl^{-1} significant negative correlation with BOD5 ($r= -0.849^{*}$). EC increases the phytoplankton & zooplankton community which indicate the water quality safe for agricultural uses but not safe for drinking purpose.

In case of Dhaki river, the TDS has significant negative correlation with DO ($r = -0.941^{**}$) and BOD5 ($r = -0.913^{*}$). Turbidity has significant positive correlation with Cl^{-1} ($r= 0.88^{**}$) and DO has significant negative correlation with BOD5 ($r= 0.961^{**}$). From the result, it was found that TDS values were higher in Vodra river of water. Therefore, these waters might safely be used for irrigation and also were suitable for crop production in respect of TDS.

In case of Vodra river, the EC has significant positive correlation with TDS ($r= 0.982^{**}$), Turbidity ($r= 0.871^{*}$), Cl^{-1} ($r= 0.871^{*}$) and DO ($r= 0.854^{*}$). TDS has significant positive correlation with Turbidity ($r= 0.923^{**}$), Cl^{-1} ($r= 0.923^{**}$) and DO ($r= 0.961^{**}$). Turbidity has significant positive correlation with Cl^{-1} ($r= 0.92^{**}$) and DO ($r= 0.997^{**}$). Cl^{-1}significant positive correlation with DO ($r= 0.997^{**}$).

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 BOD5 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.

CONCLUSION:

This study was conducted to assess the water quality especially physio-chemical properties of river water collected from different point of Chunkuri, Dhaki and Vodra Rivers. Total 36 samples were collected from the three rivers to analyze the physio-chemical properties such as Color, Odor, pH: 7.99, 8.03 and 7.99; Total Dissolved Solids (TDS): 270.17, 265 and 326.17 mg/l; EC: 573.5, 602.17 and 668.17; Turbidity: 16.58, 38.42 and 64.51 mg/l; Chlorine: 232.12, 537.93 and 903.14 mg/l; DO: 7.07, 6.01 and 8.4 mg/l and BOD5: 3.8, 3.32 and 4.55 mg/l. The results of the present study shows that most of the parameters were not exceed the maximum permissible limit except Turbidity. The average turbidity of Chunkuri, Dhaki and Vodra rivers were 16.58, 38.42 and 64.51 NTU. Standard Turbidity 5 NTU but ideal 1 NTU. At present the water of Chunkuri, Dhaki and Vodra 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. Therefore, the results of this study indicated a bad quality of water in these three rivers. Thus it could be posed a health and environmental risk to the communities that rely on these rivers, in particular to the flora and fauna, and finally the human being. So, this study recommended the further development of the environmental pollution control and a routine monitoring of water quality of the Chunkuri, Dhaki and Vodra rivers by responsive authority.

RECOMMENDATIONS:

1. Organization of educational programs to provide information to people in the local area about the benefits of riparian management.

2. Monitoring program should be set up to track changes in water quality and to monitor the progress of remedial measures.

3. Local organizations and residents, and provincial and Government of the departments all need to become involved in the restoration of the Chunkuri, Dhaki and Vodra Rivers.

4. The Chunkuri, Dhaki and Vodra Rivers are vital natural water resource to many people. The health of these ecosystems is essential to the well being of the surrounding watershed. So this study recommended the further development of the environmental pollution control and a routine monitoring of water quality of the by responsive authority.

REFERENCES

Adarsh, S., Manasa, M. P. and Prakas, M. N. S. (2019). Water Quality Assessment of Lakes in Mysuru, India. *Int. J. Eng. Res. and Technol*. **8**(6):2278-2288.

Agbaire, P. O. and OBI, C.G. (2009). Seasonal Variation of some Physico-chemical properties of River Ethiope water in Abraka, Nigeria. *J. Appl. Sci. Environ. Manage*. **13**(1): 55-57.

Agbaire, P. O., Samuel, O. A. and Emoyan O.O. (2015). Determination of Some Physico-chemical parameters of water from artificial concrete fish ponds in abraka and its environs, Delta State, Nigeria. *Int. J. Plant. Anim. Environ. Sci***.** **5**(3):70-76.

Akter, M., Sikder, T. and Ullah, A. K. M. (2014). Water Quality Assessment of an Industrial Zone Polluted Aquatic BOD5y in Dhaka, Bangladesh. *Am. J. Environ. Protection*. **3**(5): 232-237.

Ankcorn, P.D. (2003). Clarifying turbidity-The potential and limitations of turbidity as a surrogate for water-quality monitoring.

Ayers, R.S. and Westcot, D.W. (1985). Water Quality for Agriculture. FAO Irrigation and Drainage Paper. FAO, Rome.

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. *Am. J. Marine. Sci*. **2**(1):19-24.

Bhasin, S., Arvind, N., 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.

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

Deepali, K.K. and Gangwar, K.K. (2010). Metals Concentration in Textile and Tannery Effluents, Associated Soils and Ground Water. *N. Y. Sci. J.* 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. *Eur. J. Sci. Res*. **41**(3):383-390.

Egun, N.K; Ogiesoba, C. U. (2018). Physico-chemical and Water Quality Index analysis of the Okhuaihe River, Edo State, Nigeria. *Afr. J. Aquat. Sci*. **43**(4):345-351.

Eze,V.C.and Ogbaran, I.O. (2010). Microbiological and Physico-chemical Characteristics of Fish Pond Water in Ughelli Delta State, Nigeria. *Int. J. Curr. Res.* ***3****:82-87.*

Fatema, K., Begum, M. Zahid, M. A. and Hossain, M. E. (2018). Water quality assessment of the river Buriganga, Bangladesh. *J. biodivers. conserv. bioresour. manag.* **4**(1): 47-54.

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. Fish. Aquat. Stud.* **4**(2): 161-165

Freeze, R. A and Cherry, J. A. (1979). A comprehensive presentation of groundwater hydrology.

Hema, P. and Pandey, S. (2008). Physico-chemical characterisation of textile chemical sludge generated from various cetpsinindia. *J. Environ. Res. Develop*. **2**(3):329- 339.

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

Jana, B.B. (1979). Temporal plankton succession and ecology of a tropical tank in West Bengal, India. *Intl. Rev. Hydrobiol*. **63**: 661-671.

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. *Pak. 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. Eng. Res.* **2**(4):137-143.

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 BOD5y in Ghuma village, District Ahmedabad, Gujarat. Life Sciences Leaflets. **2**:68-67.

Kumar, D; Verma, A; Dhusia, A. and Nandkishor. (2005). Water Quality Assessment of River Gomti in Lucknow. *Univers. j. environ. res. technol*. **3**(3): 337-344.

Kumar, M. and Kumar, M. (2013). Assessment of Physico-Chemical properties of Ground Water in granite mining area in Goramachia, Jhansi (India). **2**(1): 19-24.

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.

Majumder, S. I;Talukder, S; Hasan, I; Islam, M. S; Islam, M. K;Hawlader, N. H. (2018). Water Quality Assessment: A Case Study of the Jhenai River in Bangladesh. *J. Appl. Res.* **04** (7):1884-1888.

Meghla, N. T., Islam, M.S., Ali, M.A. and Sultana N.(2013). Assessment of physic- chemical properties of water from the Turag River in Dhaka City, Bangladesh. *Int. J. Curr. Microbiol. App. Sci.* **2**(5), 110-122.

Mehedi, M. Y., Kamal, K., Azam and Khan, Y. S. A. (1999). Trace metals in coastal water along the ship breaking area, Chittagong, Bangladesh. Khulna Uni. Studies. **1**: 289-293.

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. Sci. & Eng. Res.* **6**(2): 1116-1123.

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

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. Sci. Technol. Environ. Inform.* **2**(2):51–60.

Nair, G. A; Bohjuari, J. A;Muftah, A; Mariami, A; Atia, F. A. and Fatma F. (2006). Carried out groundwater quality status by water quality index at North –East Libya,oct. **27**(4): 695-700.

Oboh, I. P; Agbala, C. S. (2017). Water quality assessment of the Siluko River, southern Nigeria. *Afr. J. Aquat. Sci*. **42**(3):279-286.

O'Dell, J. W. (1993). Determination of Turbidity by Nephelometry. Environmental Monitoring Systems Laboratory, Office of Research and Development, U.S. Environmental Protection Agency.

Ouyang, Y., Nkedi-Kizza, P., WuQ, T., Shinde, D. and Huang C.H. (2006). Assessment of seasonal variations in surface water quality. Water Research. **40**(20):3800- 3810.

Pawari, M. J. and Gavande, S. M. (2015). Assessment of water quality parameters. *Int. J. Sci. Res*. **4**(7): 1427-1431.

Ramakrishna, C; Rao, D. M; Rao, K. S; Srinivas, N. (2009). Studies on Ground Water Quality in slums of Visakhapatnam. *Chem. Asian. J*. **21**(6): 4246-4250.

Rafiqul, M. (2016). A Study on Total Dissolved Solids and Hardness Level of Drinking of the water quality. **4**(5): 164-169.

Riaz, O; Abbas, T; Rehman, S; Ullah, M. F; Khalid, M. (2017). Physico-chemical analysis of ground water and its impact on public health in Sargodha City, Pakistan. *J. Bio. Env. Sci.* **11**(5):376-384.

Sadar, M. J. (1998). Turbidity science. Technical Information Series. 11, Hach.

Sadashivaia, C; Ramakrishnaiah, C. R. and Ranganna, G. (2008). "Hydrochemical Analysis and Evaluation of Groundwater Quality in Tumkur Taluk, Karnataka State, India. *Int. J. Environ. Res.and Public Health.* **5**(3): 158-164.

Semwal, N. and Akolkar, P. (2006). Water quality assessment of sacred Himalayan rivers of Uttaranchal. *Curr. sci*. **91**(4):486-496.

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 physic-chemical parameters and correlation coefficient of Harsool-savangi Dam, District Aurangabad, India. Middle-East. *J. 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. 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. Environ. Protection*. **2**

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 physico-chemical parameters with its effects on human and aquatic animals giving special preference to effective management of Turag River. *J. Environ. Sci. Toxicol and Food Technol.* **10**(3):41-51.

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.

Tyagi, S; Sharma, B; Singh, P; Dobhal, R. (2013). Water Quality Assessment in terms of Water Quality Index. *Am. J. Water. Res*. **1**(3), 34-38.

Tanjung, R.H. (2019). Assessment of Water Quality and Pollution Index in Coastal Waters of Mimika, Indonesia. *J. Ecol. Eng*. **20**(2):87-94.

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

Trivedi, R. C. (2010). Water quality of the Ganga river- an overview. Aquatic Ecosystem Health and Management. **13**(4): 347-51.

Ugwu, A.I. and Wakawa, R.J. (2012). A study of seasonal physico-chemical parameters in river USMA. *Am. J. Environ. Sci.* **8**(5):569-576.

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

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-J. Chem*. **7**(1): 428-432.

APPENDICES

Appendix- 1. Data for water qualities

Sample ID	pH	EC	TDS	Turbidity	Cl^{-1}	DO	BOD5
	-	μs/cm	mg/L	NTU unit	mg/L	mg/L	mg/L
RJ	8.13	554	251	11.50	161.00	5.05	4.39
CF 1	8.01	546	247	11.33	158.62	6.04	4.45
CF 2	7.98	544	246	11.29	158.06	6.03	5.01
CF 3	7.89	538	244	11.16	156.24	6.06	4.98
CE 1	8.06	612	307	101	1414.00	9.23	3.46
CE 2	7.99	5.97	275	23.10	323.40	7.11	3.79
CE 3	8.02	604	302	32.50	455.00	7.97	1.11
DF 1	8.02	597	297	33.76	472.64	3.09	1.16
DF 2	8.03	597	275	57.20	800.80	5.23	1.96
DF 3	8.00	601	273	56.87	796.18	5.20	1.95
DE 1	8.06	569	260	28.30	396.20	7.59	4.97
DE 2	8.02	671	245	27.89	390.46	7.55	4.96
DE 3	8.03	578	240	26.52	371.28	7.42	4.91
VF 1	8.10	671	335	110	1540.00	10.06	3.77
VF 2	7.99	794	395	115	1610.00	10.51	3.94
VF 3	7.97	889	401	107	1498.00	9.78	3.67
VE 1	8.00	559	279	18.60	260.40	6.70	4.64
VE 2	7.98	551	275	18.32	256.48	6.67	4.63
VE 3	7.90	545	272	18.14	253.96	6.66	6.62
K 1	8.05	1044	520	19.11	267.54	4.75	7.64
K 2	8.11	1054	525	19.30	270.20	4.76	6.66

Appendix-2. Water salinity classes on the basis of Electrical conductivity

Soil salinity class	EC (µS/cm)	Effects on crop plants
Non-saline	0 – 250	Salinity effects negligible
Slightly saline	250 – 750	Yields of sensitive crops may be restricted
Moderately saline	750 – 2250	Yields of many crops are restricted
Strongly saline	2250-4000	Only tolerant crops yield satisfactorily
Very strongly saline	> 4000	Only very tolerant crops yield satisfactorily

Source: Bookess Tropical Soil Mannal, 1991

Appendix 3. Classification of water on the basis of P^H

Denomination	**pH range**
Ultra acidic	< 3.5
Extremely acidic	3.5–4.4
Very strongly acidic	4.5–5.0
Strongly acidic	5.1–5.5
Moderately acidic	5.6–6.0
Slightly acidic	6.1–6.5
Neutral	6.6–7.3
Slightly alkaline	7.4–7.8
Moderately alkaline	7.9–8.4
Strongly alkaline	8.5–9.0
Very strongly alkaline	> 9.0

Source: BARC, 2012