ASSESSMENT OF WATER QUALITY IN TURAG RIVER & ITS IMPACTS ON ENVIRONMENT

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This Report Presented in Partial Fulfillment of The Requirements for The Degree of Bachelor of Science (B.Sc.) in Environmental Science and Disaster Management (ESDM)

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APPROVAL

This thesis report titled **"ASSESSMENT OF WATER QUALITY IN TURAG RIVER & ITS IMPACTS ON ENVIRONMENT"**, submitted by Faisal Kabir (ID: 181-30-003) to the Department of Environmental Science and Disaster Management (ESDM), Daffodil International University (DIU) has been accepted as satisfactory for the partial completion of the requirements for the degree of Bachelor of Science (B.Sc.) in Environmental Science and Disaster Management (ESDM) and approved as to its style and contents. The presentation has been held on 4rth January of 2022.

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DECLARATION

I hereby declare that; this thesis, titled as **"ASSESSMENT OF WATER QUALITY IN TURAG RIVER & ITS IMPACTS ON ENVIRONMENT"** has been conducted and executed by myself and myself only, under the superintendence of **Dr. A.B.M. Kamal Pasha, Associate Professor and Head, Department of Environmental Science and Disaster Management (ESDM), Daffodil International University (DIU).** This thesis is a representation of my own exertion and any portion of this thesis paper has not been previously submitted elsewhere in any kind of format for any award of qualification or degree.

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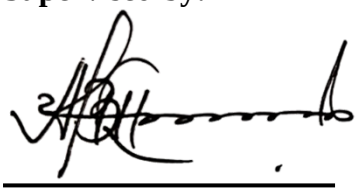

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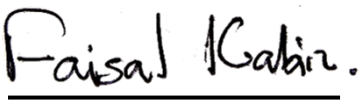

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ABSTRACT

Bangladesh is a country with hundreds of rivers. Which has a great significance in the development and economic value of our country. However, the mass industrial development creates a pressure in the nearby rivers and its environment. The Turag River in Bangladesh, which is situated in the northern part of capital city Dhaka, is facing rapid heavy industrialization and urbanization. Mostly due to the unplanned development works. These anthropogenic activities are causing environmental degradation in The Turag River in many ways. The following study was conducted to measure and evaluate the present water quality in the downstream zone of The Turag River and its impact on life & environment. The pollution sources were also identified. A comparison was made between upstream and downstream water quality of the river in the same season with the help of previous studies. The water quality was measured based on the physicochemical parameters which includes Salinity, pH, EC, TDS, Temperature, Total Hardness, Ca Hardness, Mg hardness, Free CO_2, Alkalinity, Acidity and TSS. The samples were collected on 19th September 2021 from eight (8) different points of The Turag River with exact coordinates from Aminbazar Bridge to Birulia Bridge. To find out the impact of The Turag River water, physical questionnaire surveys were made in the same locations in December 2021. From the survey, many important data regarding the condition of the river, pollution source identification, daily uses & agricultural uses, health diseases, fish resources and key reasons behind poor river management were determined. From the laboratory experiment, it can be said that the physicochemical parameters of The Turag River water showed moderately good quality in contrast to the standard permissible values except for Free CO_2 & Acidity. The monsoon water is a factor here, as the samples were collected in the wet season, which has diluted the water. When compared with three (3) other previous studies on upstream water quality of The Turag River, the result seemed better or similar. Yet from physical surveys and direct observations, it was noted that the water quality degrades as soon as the monsoon passes away. Which suggests the necessity of testing the river water from each season for seasonal variations. Though, The Turag River water is not usable for domestic purposes in any of the season, agriculture is practiced only once during dry season with contaminated water due to no other options, fish resources have decreased significantly as well, based on the opinion of the local community.

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LIST OF SYMBOLS AND ABBREVIATIONS

Symbol or Unit	Name of the Symbol or Unit
‰	Per Mille
ºC	Degree Celsius
µS/cm	Micro Siemens Centimeter
mg/L	Milligrams Per Liter
mS/cm	Milli Siemens Centimeter
ppt	Parts Per Thousand
ppm	Parts Per Million
m	Meter
ml	Milliliter
km	Kilometer

Abbreviation	Full Form of the Abbreviation
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DIU	Daffodil International University
DO	Dissolved Oxygen
DoE	Department of Environment
EBT	Eriochrome Black T
EC	Electrical Conductivity
EDTA	Ethylenediamine tetra Acetic Acid
EIA	Environmental Impact Assessment
ESDM	Environmental Science and Disaster Management
ETP	Effluent Treatment Plant
FAO	Food and Agriculture Organization
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
WASA	Water Supply and Sewerage Authority
WHO	World Health Organization

Keywords: Turag river, water quality, pollution, physicochemical parameters, effluent, life & environment

Author: Faisal Kabir, 2022

CHAPTER 1: INTRODUCTION

This is the introductory chapter of the following study. Where it describes the preliminary matters and information about the research study. Which includes a brief discussion about the background of the study, problem statement, research questions and the objectives of the study. The chapter is divided into 4 compartments.

1.1 Background of The Study

The Turag River is one of the most significant rivers of Bangladesh. Located almost in the center of the country, flows by the densely industrial area of the Mega City Dhaka and its neighborhood cities. The river has great economic values as it is located in a very strategic position as well as historical importance. As development is taking place in this era, unplanned urbanization is happening and the environment is taking the toll of it. Due to commercial development, excessive anthropogenic activities, industrial activities and rapid population growth, pollution is taking place into the city rivers. The Turag River is facing a similar fate as well and is deteriorating day by day. In the dry season, some specific areas and points of the river are so smelly and dirty that they cannot be used at all. **(A. K. M. L. Rahman et al. 2012)** The Turag River flows marking the margin of the Dhaka city in its northern side with a population of nearly 15 million and increasing. Like every other river near the cities, it is receiving most of the municipal, urban, agricultural and industrial wastes of the city as a permanent disposal site of waste effluents. **(Zaman and Noman 2015)** Moreover, new industries and factories are continuously increasing every year without planning. It is creating an adverse effect on the river, and people living near the river. These kinds of water situations can have a high impact on the environment and economic growth. The river water is no longer suitable for drinking or for any other day to day life works without proper treatment. **(Aktar and Moonajilin 2017)** It is even impacting the river bank soils, plants and irrigation. Increasing heavy metal concentration is another critical concern which causes fatality for aquatic habitats. **(Banu et al. 2013)**

The Department of Environment (DoE) declared The Turag River to be an ecologically critical zone in September 2009. Because of the serious pollution discharges that are taking place due to the industries and factories near the river. The uncontrolled pollution

has increased to a level that it has affected the fish resources of the Turag River. Most of the factories has paid less attention to the environmental laws regarding sustainable use of resources and made the river visibly discolor. **(Aktar and Moonajilin 2017)**

The significance of The Turag River to Dhaka City and to the country is highly important. As it plays a role in the economy, its navigational route support as a communication & transport channel, helps in agriculture & in cultivation. The river also helps to maintain the balance in the ecology and in the environment. There is no doubt that rivers play a vital role in our country. And the Turag River should be taken care of properly. Since fresh water is an essential requirement of all life supporting activities including domestic purposes, public uses, agriculture purposes, aquaculture purposes, agricultural purposes, navigable route etc. **(Aktar and Moonajilin 2017)**

The quality of a river's water is based on a number of properties and factors. They can be classified into 3 groups. **(Aktar and Moonajilin 2017)**

They are:

- Physical factors (Such as color, odor, temperature etc.)
- Chemical properties (Such as organic substances, inorganic substances – pH, turbidity, alkalinity, acidity, TDS, EC etc.)
- Heavy metal properties (Such as arsenic, lead, zinc, copper etc.)

In this study, only the physical and chemical properties will be discussed and explained.

1.2 Problem Statement

In the last couple of decades, The Tuag River water quality has decreased at an alarming rate. Due to massive industrialization, urbanization, uncontrolled and untreated effluent dumping and lack of proper management is degrading the water quality of the river day by day. It is impacting on the local community in a negative way as people living near or on the bank side are dependent on the river in many ways. The lifestyle of people is changing as well. The physicochemical parameters are staying above the permissible limit most of the year. Higher concentrations of heavy metals can also be found. Which has a negative impact on human and aquatic lives in many ways. People who ever use the river water, get affected by many water-borne diseases as well as skin disease and irritation. Traditional occupations like fishing are at the edge of extinction. As the source of fish stock is almost to its minimal level. Individual families are struggling

with income sources and reforming their social structure. Overall, the condition of the river water quality and its impacts are very much visual. **(Sikder et al. 2016)** A flow chart is added (Figure 1.1) for better understanding the stated problem.

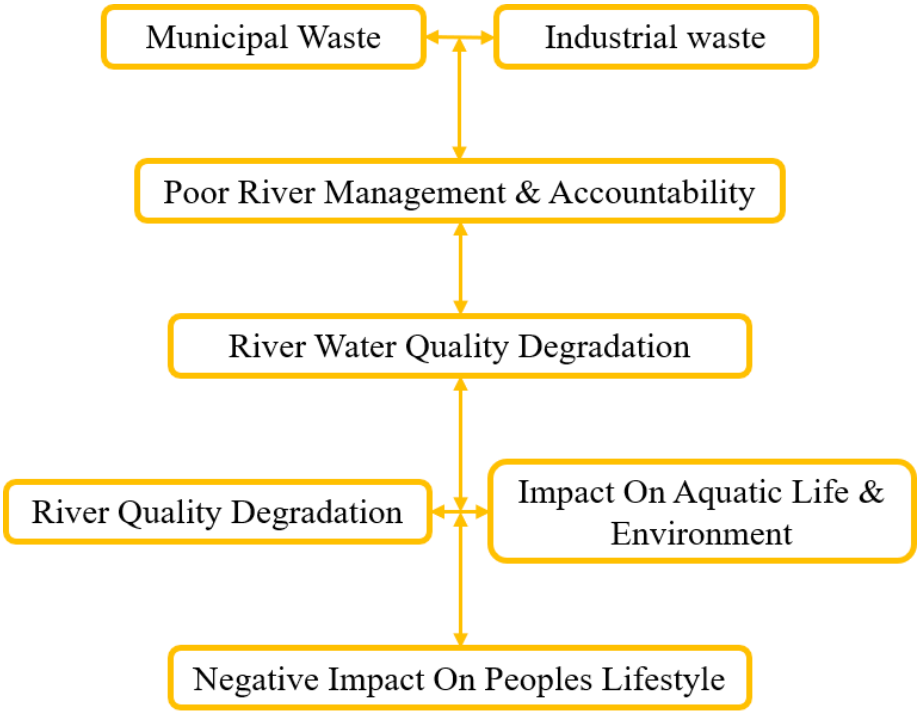


Figure 1.1: Flow chart of Turag River water degradation and its impact on life.

Source: Own Illustration.

1.3 Research Question

The following study was conducted to address these research questions.

- What is the current water quality status of The Turag River?
- What is the impact of The Turag River on life and environment?
- What are the changes in quality of The Turag River water compared to various scientific studies?

1.4 Objectives of The Study

The overall objectives of the study are to make a comparison of the water quality of The Turag River and find the sources of pollution as well. In view of the research questions above, the following objectives were addressed to give direction to the present study:

- To examine the present physicochemical parameters for water quality status of The Turag River.
- To identify the waste and pollution sources of The Turag River.
- To assess the Impacts and problems on human life & environment due to the water pollution of the Turag River.
- To Assess a comparison analysis of The Turag River water quality parameters and river quality status with standard values and its previous stats from other existing research studies of The Turag River.

CHAPTER 2: LITERATURE REVIEW

This chapter reviews the detailed description about the study based on previous research papers and literature. A brief detail about river quality standard, river water uses, causes of pollution with reasons and sources, its condition and its impact on life and environment are reviewed here. and many more important topics are added here. The chapter is split into 7 sections.

2.1 River Water Quality Standard

The standard of river water quality can be measured based on various parameters and symptoms. The most common parameters are pH, DO, EC, TDS, TSS, BOD, COD. These parameters must be in permissible limits for daily uses, irrigation, aquatic ecosystem, preservation and growth. An increase of heavy metals can also lower the quality of a river's water if there's any industrial area near or bank of the river. Some other common symptoms of quality degradation are cloudy or turbid water which can be seen in visual eyes and smelly water which can be felt by breathing. **(Enderlein, Enderlein, and Williams 1996)**

2.1.1 Acceptable Water Quality for Aquatic Life

A certain quality is required for fish culture and aquatic life in the river. Such as the suitable pH level of the water should be around 6.5~9, which is more comfortable for aquatic life. Any presence of chemicals into the water can cause fatal damage to aquatic species including flora and fauna. As they have their own unique biotic and abiotic conditions in an ecosystem. To protect and safeguard aquatic animals and fish life, the physicochemical parameters are taken on account as the water quality criteria. The concentration of dissolved oxygen and temperature are another two important factors. As the lack of proper dissolved oxygen can kill fish and aquatic species. In warm waters, the temperature range should be from 20~30 ºC. As excessive heat can kill or damage aquatic life under water. The average dissolved oxygen range of specific aquatic species at different stages is 5~9.5 mg/l. The minimum dissolved oxygen level for warm-water biota is 5-6 mg/l and the minimum dissolved oxygen level for cold water biota is 6.5-9.5 mg/l. If the concentration of dissolved oxygen is low and comes in touch with the existence of toxic materials then it may cause stress to aquatic

ecosystems with certain elements like zinc and copper. The introduction of synthetic chemicals and heavy metals in river water can be fatal for aquatic animals to grow, reproduce and develop effectively. **(Enderlein, Enderlein, and Williams 1996)**

2.1.2 Water Quality for Irrigation

River water are densely used for irrigation purposes. If the quality of the water is not up to the mark, then it may affect the irrigated crops. Both treated and untreated river water is being used for irrigation purposes. But in our country, mostly untreated water is used. The salinity level should be checked properly. Usually in river water, there is no sign of salinity. Unless any industrial activity is dumping any chemical salts. Sodium elements and concentrations in water can create phytotoxic trace elements which may cause crop tolerance issues in soil. Sodium can adversely affect the structure of soil which in turn can reduce the water moving rate into and through soil particles. Salinity can cause damage to the root area of crops by blocking permeability of the soil. It may even cause permanent damage to the soil after a period of time and make the land unfit for any agricultural activities. The use of pesticides can lead to toxicity of the soil or water with the presence of pathogenic organisms. The standard range of some of the elements in water quality criteria for irrigation water is shown below. **(Enderlein, Enderlein, and Williams 1996)**

Table 01. Standard water quality criteria for irrigation waters.

Element	Unit	FAO
Aluminium	mg/L^{-1}	5.0
Arsenic	mg/L^{-1}	0.1
Cadmium	mg/L^{-1}	0.01
Chromium	mg/L^{-1}	0.1
Copper	mg/L^{-1}	0.2
Manganese	mg/L^{-1}	0.2
Nickel	mg/L^{-1}	0.2
Zinc	mg/L^{-1}	2.0

Sources: FAO, 1985.

2.2 Uses of The Turag River Water

The Turag River water is used for various activities including day to day life chores. The local people depend on the river for many purposes including irrigation, fishing, drinking, livestock cleaning, household activities, boating and even as a waterway for movement and recreation. **(Tahmina et al. 2018), (Hafizur, Nuralam, and Rumainul 2017)**

2.3 Geographic Location of The Turag River

The Turag River is in the north-western part of Dhaka city, the capital city of Bangladesh. Which is located in the upper tributary of The Buriganga River. **(A. K. M. L. Rahman et al. 2012)** The river originates from the Bangshi River and connects to the Buringanga River towards the south of Dhaka in Mirpur. It is one of the major rivers in the country and serves as the primary waterway in its area. **(KHAN et al. n.d. 2020)**

2.4 Causes of Turag River Water Pollution

Dhaka city is surrounded by four major rivers. The Buriganga, The Turag, The Shitalakshya River and The Balu River. These rivers are interconnected with each other. All these rivers share a similar trait, and that is river water pollution. Rapid industrialization & urbanization in Bangladesh are the main causes of this pollution. The Turag River has various sources of pollution including many consumer goods industries such as detergents and soaps, garments and textile industries, dyeing industries, match industries, pharmaceuticals industries, aluminum industries, lots of tanneries, chemical factories, used oils or lubricants from many types of boats and launches, pulp and paper factories, paint industries, frozen food factories, hospitals garbage, shopping waste, iron industries, ink manufacturing industries and steel workshop etc. **(A. K. M. L. Rahman et al. 2012)**, **(Shawon, Ahmed, and Karim 2021)** The number of the industries is continually increasing every year. Among these industries and factories most of them discharge their untreated or partially treated effluent materials directly or indirectly into the Turag River. Including organic & inorganic waste effluents. Which degrades the water body and soil to a level which is not suitable for life and environment. **(Afrad et al. 2020)** The municipal sewage draining system of Dhaka North has made the river a dumping ground for every kind of liquid, solid and chemical waste materials that in return polluting the river bank and the surface water. An unbalanced presence of heavy metals like As, Zn, Cd, Pb and Hg

can be found in different locations of The Turag River. So, it can be said that all these land use patterns are causing the Turag River water pollution in general. **(A. K. M. L. Rahman et al. 2012)**

Table 02. DoE standard value for the physicochemical parameters.

Parameters	Inland Surface Water	Irrigable Land
pH	6-9	6-9
Temperature °C	40	40
Salinity	-	-
TDS (mg/L)	2100	2100
TSS	-	-
EC (µS)	1200	1200
DO (mg/L)	4.5-8	4.5-8
COD (mg/L)	200	400
BOD_5 (mg/L) at 20 °C	50	100
E. coli	-	-
Cr (mg/L)	0.5	0.1
Cu (mg/L)	0.5	3.0
Zn (mg/L)	5.0	10.0
Pb (mg/L)	0.1	0.1
Ni (mg/L)	1.0	1.0
Cd (mg/L)	0.05	0.5
Hg (mg/L)	0.01	0.01
Fe (mg/L)	2.0	2.0
As (mg/L)	0.2	0.2
Mn (mg/L)	5.0	5.0

Source: (Sarkar, Islam, and Akter 2016).

2.5 Sources of Water Pollution in The Turag River

Various sources of water pollution can be noticeable in The Turag River. The major ways of river water pollution are noted down below.

- Chemical pollution is one of the major contributors in the list, which is introduced by the bankside industries and factories. The chemical materials disrupt the natural balance of the water parameters and increase the concentration of heavy metals. **(Banu et al. 2013)**
- Effluent & wastewater release from industrial activities during manufacturing their product. A large number of by-products are produced in the course of the

product processing. And these are released into the river without proper treatment from the nearby industries & municipalities. **(Afrad et al. 2020)**

- Use of harmful pesticides for cultivation in the crop fields near the river is another major source. Which includes potential toxic heavy metal substances and agricultural runoff. **(Banu et al. 2013)**
- Increasing urbanization & population pressure are creating tons of municipal solid and liquid waste. These are being dumped from nearby cities and connection with sewerage drains is polluting The Turag River water. **(A. K. M. L. Rahman et al. 2012)**

Figure 2.1: Untreated municipal waste from sluice gate 3 in Turag River.

Source: Own photograph.

2.6 Reason Behind the Water Pollution in Turag River

Bangladesh is a developing country and it has many shortcomings. Yet the ignorance of policy planners, absence of accountability, proper strategies, effective law enforcement, irregular poor monitoring and insufficient role of the authorities are main reasons behind the pollution cycle of river water. There are approximately 6000 large and medium industries and 24000 small industries that are producing harmful effluents in the country. The Department of Environment (DoE) has marked 900 large pollutant

factories with no water treatment facilities. There are many illegal and unplanned establishments varying from commercial buildings to industries of different sizes and scales. According to the policy of the country, industries cannot operate without effluent treatment plants (ETP). But the ETP system is a bit costly, and to save money they are releasing pollutants almost directly to the environment. **(Afrad et al. 2020)**

2.7 Impacts of Turag River Pollution on Life & Environment

The regular and indiscriminately dumping of toxic industrial discharge has a serious impact on life and environment near and in the water body. Industrial discharge is the wastewater produced by the industrial activity which carries substances that are no longer necessary and is dumped away during the manufacturing process. **(Afrad et al. 2020)** Regular and consistent deposition of domestic wastewater, industrial hazardous chemicals and mixture of complex substances with both organic and inorganic compounds are making the river water unsuitable day by day for aquaculture, irrigation and daily uses. Untreated industrial effluent has a fatal impact on the crops, animals, birds and on human lives. **(A. K. M. L. Rahman et al. 2012)** In the winter season, The Turag River water along with its effluent materials are pumped into the nearby and bankside crop fields for irrigation purposes. As they have no other alternate source for irrigation water. In this way, toxic elements and contaminated water enter the food chain. As a result, it affects and creates an impact on human health, ecosystems, agriculture, and food security in a whole. **(Afrad et al. 2020)** Different biochemical and chemical interactions have deteriorated the quality of the river water causing an adverse effect in the river bank and its surrounding area. The standard water quality parameter degradation is a proof of the polluted water. Ecosystem service failure is another issue to be noted. **(A. K. M. L. Rahman et al. 2012)**

2.7.1 Impacts on Life

River water pollution has a negative impact on the livelihood of the nearby local community with various health hazards and water transmitted diseases. The river is widely used for transporting people, commodities and agricultural products in its area. Pollution has a negative impact on every aspect of this wide criteria. **(Shawon, Ahmed, and Karim 2021)** Contaminated river water is used for irrigation in the river banks sides for rice and other crop production. **(Afrad et al. 2020)** Which in return causes many health diseases. The regular water borne health diseases are diarrhea, cholera,

dysentery, jaundice, hepatitis A, skin diseases etc. **(Hafizur, Nuralam, and Rumainul 2017)** As we all know that the wastewater from industries and similar sources contains a huge amount of harmful heavy metals, it eventually pollutes the river water. And if this water is used for agricultural purposes, then it can cause a major threat to human health. **(Shawon, Ahmed, and Karim 2021)** Heavy metal concentration is the reason for many severe human diseases such as kidney damage, cancer, development of malformation, adverse effect on mental health and behavior and even death in some circumstances. Harmful & toxic metals can cause many other symptoms like high blood pressure, short time memory loss, depression, poor concentration, fatigue, irritability, sleep problems etc. A few heavy metals like zinc, copper, chromium, iron, manganese is necessary for the human body in small amounts. But in excessive amounts they can be very harmful for human health. Toxic heavy metals can cause both mental and physical health problems. **(Banu et al. 2013)** It can even change the chemical properties of the soil like pH, EC or soil organic matter. **(Afrad et al. 2020)**

2.7.2 Impacts on Environment

Fresh & clean water with unpolluted soil is most favorable for plant growth and for aquatic animals' habitat. In the same manner, if the water body is contaminated and the soil is polluted, it is most likely to cause harm for plant growth and aquatic animals to survive. **(Afrad et al. 2020)** River ecosystem plays a crucial role when it comes to economy and ecology. Harmful effluent discharge is creating a serious impact into the environment near and in the Turag River. If the ecosystem is disturbed then the economy and ecology will feel the adverse effect. **(Sikder et al. 2016)** The toxic discharges interact adversely with the river ecosystem and decline the quality of the river water. The contaminated water can destroy aquatic life and substantially decrease the reproductive ability. Which can drastically lessen fish resources of a river. It also has an adverse effect in the surrounding land area and contaminates the soil. **(Mobin et al. 2014)**

2.8 Impact of Turag River Water from Related Study

Some of the major impacts of The Turag River water to its nearby community is shown below from related scientific study.

2.8.1 Study 01

Water Pollution and its Impact on Human Health. **(Halder and Islam 2015)**

i) Health Profile by Community Perception: In this study, it was found that the most common health diseases mentioned by the local community are diarrhea, respiratory illness (asthma, common cold), skin diseases and gastric ulcers. Some of them also added hypertension, indigestion, pneumonia, gout, conjunctivitis, tuberculosis and cancer. 70% of the participants reported suffering from skin diseases, diarrhea and other intestine problems. On the paper they noted that they found a linkage between water pollution and health problems. **(Halder and Islam 2015)**

2.8.2 Study 02

Impact of industrial effluent on water, soil and Rice production in Bangladesh: a case of Turag River Bank. **(Afrad et al. 2020)**

i) Impact of Industrial Effluents on Soil Quality: In the study, it was found that the soil quality has degraded after the establishment of industries and factories. As soil and water are very closely related to each other. In a survey, 91.2% of the respondents have reported that the soil quality has degraded. These changes have adversely affected rice cultivation as well. **(Afrad et al. 2020)**

ii) Impacts on Surface & Ground Water Quality: In the study it was stated that the surface water quality and ground water quality of The Turag River has deteriorated from earlier conditions. Where the survey report showed 96.2% local participants said that the surface water is polluted, 92.5% said that the groundwater level is polluted. And 100% of them responded that the water quality was far better before the industrialization phase. **(Afrad et al. 2020)**

CHAPTER 3: METHODOLOGY

In this chapter, the materials and methods used in this research study are explained widely. It also discusses the study period, study location, systematic approach, instrumental techniques and data analysis procedure that were used to conduct the research. The chapter is divided into 6 parts.

3.1 General

For comparative analysis of water pollution, the river water samples were collected by grab sampling method. The physicochemical parameters were tested in laboratory experiments using different experimental techniques. The parameters are Salinity, pH, EC, TDS, Temperature, Total Hardness, Ca (Calcium) Hardness, Mg (Magnesium) hardness, Free CO_2, Alkalinity, Acidity and TSS. Physical surveys were conducted in the field for primary data collection. A direct observation method was used by observing the conditions of selected areas and its surroundings.

3.2 Study Time

The entire study was evaluated in a timely manner. Initially the preparations began on 1st September 2021 and ended on 20th December 2021. The water samples were collected on 19th September 2021 and the lab experiments were conducted from 21st September 2021 to 10th October 2021. On field questionnaire survey was made from 11th December 2021 to 15th December 2021. A detail of the study time is shown in the following table.

Table 03. The timeline of the study period.

Study Time				
Date	**September 2021**	**October 2021**	**November 2021**	**December 2021**
1-10	Preliminary study			
11-18	Site area selection			
19-20	Sample collection			
21-30	Laboratory test			
1-10		Laboratory test		
11-21		Paper writing		

22-31		Break		
1-15			Literature review	
16-20			Break	
21-30			Paper writing	
1-10				Paper writing
11-15				Physical survey
16-18				Paper writing
19-20				Result & discussion

Source: Own preparation.

3.2.1 Work Flow Diagram

The total work has been done by the following ways which is shown below in the figure.

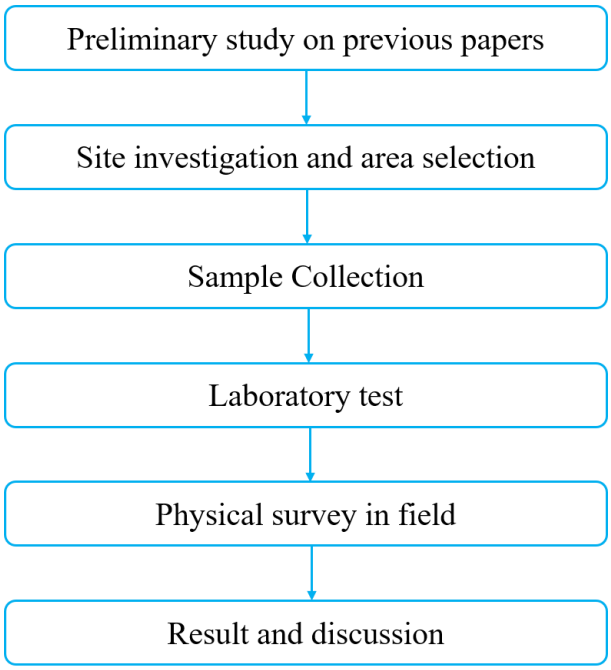


Figure 3.1: Work flow diagram of the following study.

Source: Own illustration.

3.3 Selection of the Study Area

The Turag River is one of the most prominent rivers of Bangladesh. The complete length of the river is 62 km. The average depth and width of the Turag river are about 13.5 m and 82 m. **(M. A. T. M. T. Rahman, Moly, and Saadat 2013)** In the following work, the study area was pre-selected by the honorable supervisor. And that is from Gabtoli Amin Bazar Bridge to Birulia Bridge, which is in the downstream zone. As

there are very few studies conducted in this zone. It is approximately 10 km according to the Google Map. A total of 8 areas were selected for better and more accurate results.

Figure 3.2: The water sampling location of the study are shown in this map.

Source: Google Map.

3.3.1 Water Sample Collection Locations

The water samples were collected on 19th September 2021. From the 10 km study area, 8 locations were selected and 3 samples were collected from each location. A total of 24 samples were collected. The sample collection area, the coordinates and collection time is noted below.

Table 04. Sample collection area coordinates.

Location Name	Sample No.	Latitude	Longitude	Time
Amin Bazar Bridge	Sample 1	23.785895	90.337260	9.42 am
Amin Bazar Bridge	Sample 2	23.786323	90.336696	9.44 am
Amin Bazar Bridge	Sample 3	23.787331	90.337461	9.45 am
Mirpur Diabari	Sample 4	23.799222	90.342866	9.59 am
Mirpur Diabari	Sample 5	23.799499	90.342554	10.04 am
Mirpur Diabari	Sample 6	23.800569	90.342407	10.05 am
Nobaberbag	Sample 7	23.808132	90.339916	10.12 am
Nobaberbag	Sample 8	23.809926	90.339226	10.14 am
Nobaberbag	Sample 9	23.813067	90.339443	10.17 am
Tamanna Park	Sample 10	23.818446	90.338400	10.22 am
Tamanna Park	Sample 11	23.819269	90.336631	10.24 am
Tamanna Park	Sample 12	23.821895	90.337376	10.26 am

S4 Sluice gate	Sample 13	23.826928	90.341558	10.30 am
S4 Sluice gate	Sample 14	23.828264	90.339809	10.32 am
S4 Sluice gate	Sample 15	23.829365	90.338958	10.33 am
Govt. Water Pump	Sample 16	23.837347	90.337887	10.41 am
Govt. Water Pump	Sample 17	23.837910	90.338085	10.42 am
Govt. Water Pump	Sample 18	23.839970	90.340097	10.44 am
Birulia Launch Terminal	Sample 19	23.844930	90.338341	10.49 am
Birulia Launch Terminal	Sample 20	23.846980	90.337075	10.51 am
Birulia Launch Terminal	Sample 21	23.847225	90.337010	10.52 am
Birulia Bridge	Sample 22	23.850202	90.338531	10.55 am
Birulia Bridge	Sample 23	23.851231	90.338892	10.57 am
Birulia Bridge	Sample 24	23.851156	90.339098	10.58 am

Source: Own preparation.

3.4 Data Collection Techniques

In the following study, various data collection methods were used for physicochemical analysis and water quality status. Among them, the primary data collection technique was broadly focused. The data collected from the field for lab testing, survey data regarding the study and photographs taken from the field are all primary data. For comparison study and analysis, secondary data were used from various scientific research papers and related journals. The data collection technique is shown below in a framework.

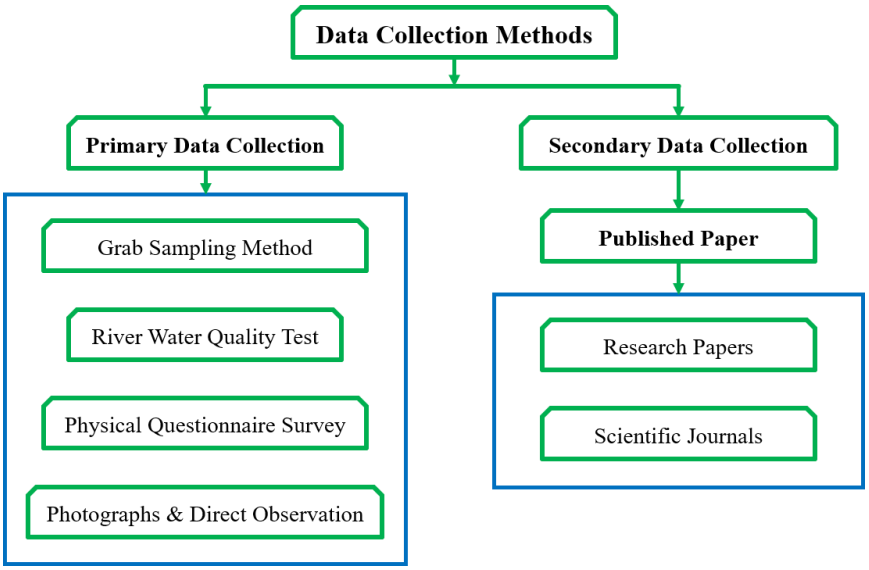


Figure 3.3: Data collection techniques of the study.

Source: Own illustration.

Figure 3.4: Collecting sample water by grab sampling method.

3.4.1 Water Sample Collection Techniques

To evaluate the effluent materials in the river water, samples were collected accordingly. All the necessary precautions were taken respectively to collect the water samples accurately. The river water was collected in sample bottles of 500 ml. 24 sample bottles were used. The sample bottles were new and intake. So, it can be said that they were free of contamination. A motor boat was used to move in the 8 pre-selected location area. The sample bottles were labelled with location name and number before collection. In every sampling location, water was collected in a sample bottle very carefully. The bottles were air tight. All the samples were collected with grab sampling. **(A. K. M. L. Rahman et al. 2012)** The process was repeated 24 times. The coordinates of each location were noted instantly with the help of google map from android. Adequate precautions were maintained during water collection and handling, including protective gloves (where necessary) and safety masks. The samples were preserved in the laboratory in cold and dry places attentively.

3.4.2 Water Sample Quality Test

To measure the water quality and for comparative study, the physicochemical parameters were tested in the Department of Environmental Science & Disaster Management (ESDM) Research Laboratory of Daffodil International University (DIU), Savar, Dhaka. The tested physicochemical parameters are Salinity, pH, EC, TDS, Temperature, Total Hardness, Ca Hardness, Mg hardness, Free CO_2, Alkalinity, Acidity

and TSS. Here the physical parameters were measured directly with digital meters and equipment's. And the chemical parameters were tested through titration process. A total of 12 parameters were tested for 24 samples individually. All the parameter testing and laboratory experiments were supervised by the lab instructor.

3.4.3 In Field Physical Survey

Questionnaires surveys were made from 11th December 2021 – 15th December 2021, physically to identify the impact of the river in local communities' lifestyle. The locations were near or same to the water sample collection spots. The local communities living near the bank or working there were selected for the surveys. A total of 50 people was interviewed in 2 days regarding The Turag River and its impact on their daily life. The survey was conducted individually and sometimes in groups. The survey was helpful for hand to hand data regarding the study. Questions regarding the subject were asked from a premade form, and their opinions were noted instantly in the paper. Only the local people living on the bank of the river were selected for the following survey.

The questions of the physical survey are given below:

- What's the present condition of The Turag River?
- Is the Turag River Polluted?
- Is the river water smelly?
- If the Turag River is polluted, should we be concerned?
- How the Turag River is getting Polluted?
- How do you use the river water for your purpose or daily life?
- How & when is Turag River Water used for Irrigation?
- Are there enough fish resources in the river?
- Are the fishermen of the Turag river switching their occupation?
- What kind of health diseases do you get from using the river water?
- Are you satisfied with current water pollution control by the authority?
- What are the key reasons behind poor river water management?
- Do you think individual initiative can reduce river water pollution?
- What do you think could be the solution to prevent The Turag River Water Pollution?

Figure 3.5: Floating white foam, a kind of pollutant material near Govt. water pump.

Source: Own Photograph.

3.4.4 Direct Observation of The Study Area

During every visit in the study area, field inspections were made. Throughout the visits, the environmental condition of The Turag River and its nearby surrounding areas were observed to identify any consequences or issues regarding the study. In the beginning of the filed visits (September 2021), the river water color was clearer and normal. But in the later visits (December 2021), the color at some point of the river looked a bit turbid and blackish. Disturbing odor at some point was noticeable from the start of the visits. Which gradually got worse from monsoon to winter season. Especially in the S4 sluice gate area and in govt. water pump house station. The river water was not drinkable in any of the seasons and the local people living there suggest that too. The land use pattern looked irregular throughout the study area. Especially from Aminbazar Bridge to Mirpur Diabari area. Mostly due to the lack of proper monitoring from the authority. Direct waste dumping and sewerage lines were detected in Mirpur Diabari area and in sluice gate 3 & 4. The local community living on the bank of the river sounded a bit disappointed about the river and its condition. Some photographs were captured during the visits and local peoples were interviewed.

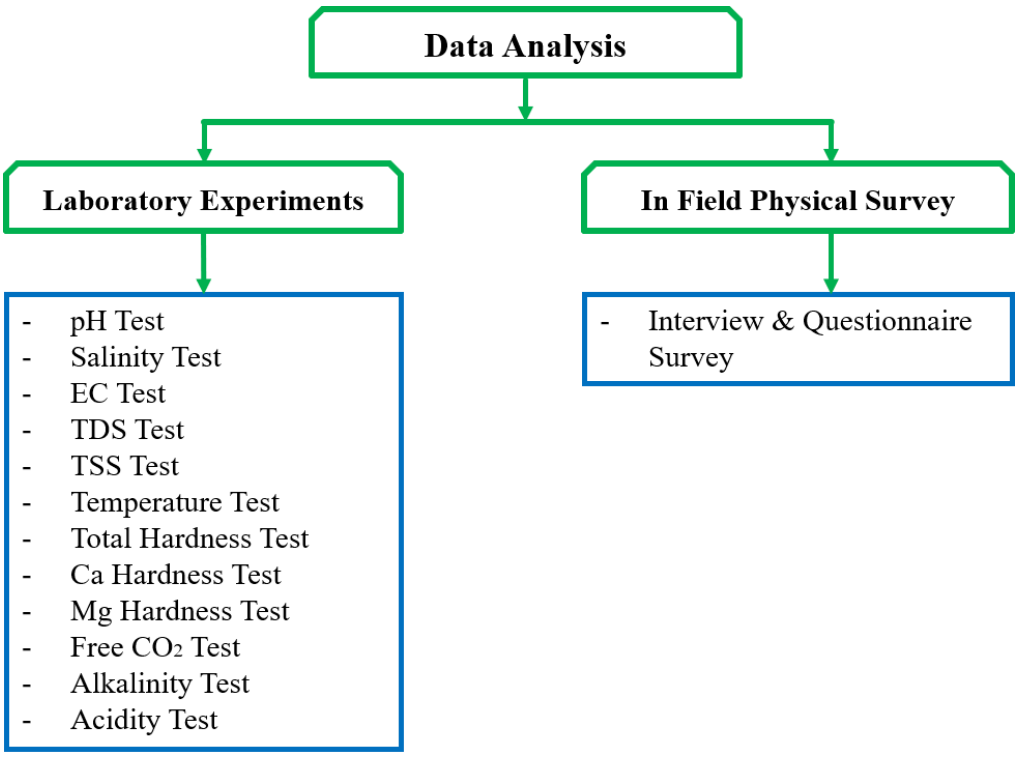


Figure 3.6: Structured framework for data analysis.

Source: Own illustration.

3.5 Data Analysis and Laboratory Experiments

The study is to verify the latest condition of The Turag River water and its quality. The collected 24 samples were all tested for 12 experiments individually to measure the total quality of the Turag River water. The collected data have been analyzed according to the following framework.

3.5.1 Physicochemical Parameter Determination

An explanation of each and every laboratory experiment is described here in an orderly manner.

i) Determination of Salinity: In fresh water, the salinity concentration is usually none or very low, as less than 0.5 ppt. Here the salinity was measured from every sample separately with a portable refractometer. The model number is REF211. The process was evaluated with delicate touch as the probe is very sensitive. Only a drop of sample water was used with a dropper from each sample during individual sample reading. Distilled water was used before and after taking the reading. A piece of clean cloth was used to dry the probe in between. The unit of the parameters were taken in ppt.

Figure 3.7: During the lab experiment of the physical parameters.

ii) Determination of pH: The pH level of water indicates the acidic and alkaline condition in a nutshell. The range is from 0 to 14, where 7 is neutral. If the reading is less than 7 then the water is acidic and if the reading is higher than 7, the water is alkaline. **(Aktar and Moonajilin 2017)** The pH level of the water was determined using a digital pocket pH tester of Hanna. The model number is pHep HI98107. The electrode of the tester was rinsed thoroughly by using distilled water and wiped by using a clean white handkerchief. Then the electrode was immersed into 50 ml sample water and was kept until the stable reading was observed. The final reading was recorded instantly.

iii) Determination of Electrical Conductivity (EC): Water has the capacity of conducting electricity due to the dissolved ions it contains. Which is measured as electrical conductivity (EC). The expressed unit is micro-siemens (µS/cm). The EC of the water was determined by using a Hanna EC tester. The model number was HI98304 DiST®4. The meter initially gave the reading in milli-siemens (mS/cm) after dipping into 50 ml sample water. Then it was converted to micro-siemens (µS/cm) multiplied by 1000, as per the instruction of the lab instructor. Here also the same precautions were taken like the pH measurement.

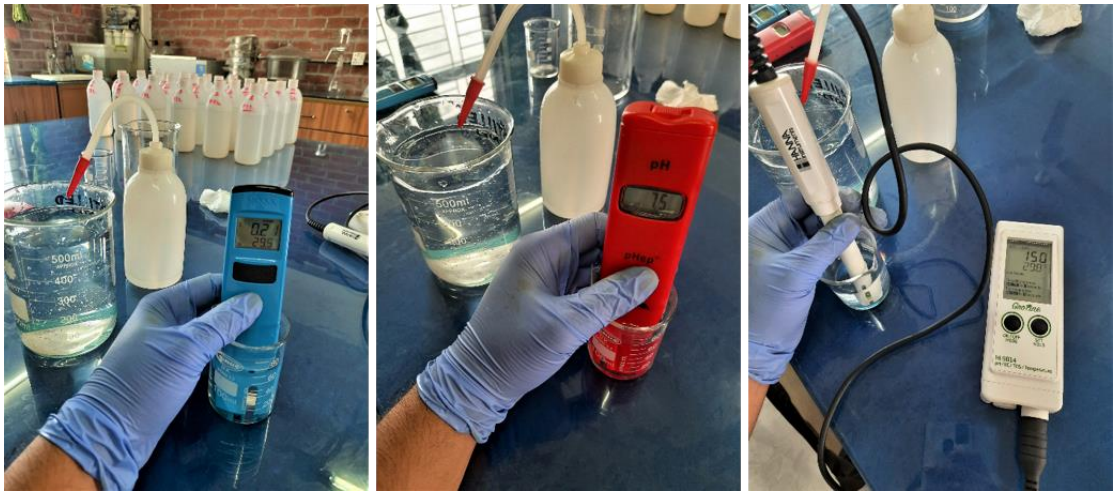


Figure 3.8: During the pH, EC, TDS & Temperature test in ESDM Lab.

iv) Determination of Total Dissolved Solid (TDS): TDS means the total dissolved solid or particles in water. **(Aktar and Moonajilin 2017)** Here the TDS was measured by using a digital TDS meter of Hanna which is a multiparameter probe. The model number is HI9814. The unit of all these parameters are in ppm. Meter handling and testing was done in the same process of pH and EC measurements. 50 ml sample water was used and the calibration medium was distilled water.

v) Determination of Temperature: Temperature in fresh water or river water play a vital part for aquatic life and plants. Here the temperature was measured twice for more accuracy with 2 separate devices during EC and TDS test. As both of the devices were capable of giving the temperature reading. The devices are Hanna EC tester with model number HI98304 DiST®4 and Hanna multiparameter probe with model number HI9814 accordingly. The unit of the parameters were taken in °C.

vi) Determination of Total Hardness: To determine the total hardness, titration method was used. Necessary equipment's were conical flask, burette, burette stand, dropper, funnel, pipette and distilled water. All the equipment's were cleaned with distilled water prior using. 25 ml sample water were taken in a conical flask with the help of a pipette. Then 2 drops of phenolphthalein indicator as reagent and 1 drop of Eriochrome Black T (EBT) as indicator was added with dropper along with 2 ml Na_2SO_4 (0.1N) solution with pipette into the conical flask. The known concentration which is EDTA (0.01 N) was then added into the solution drop by drop slowly from a burette with the help of a burette stand. When the solution color changed from purple

to blue, the reading was noted down immediately. The unit of the parameters are in mg/L.

This equation was used for Total Hardness. Which was provided by the lab assistant.

$$\text{Total Hardness} = \frac{\text{EDTA} \times \text{N} \times 100 \times 1000}{\text{Volume of sample}}$$

Here,

EDTA = used volume of EDTA and N = Normality of EDTA = 0.01

vii) Determination of Ca Hardness: To determine the Ca hardness, titration method was used. Necessary equipment's were conical flask, burette, burette stand, dropper, funnel, pipette and distilled water. All the equipment's were cleaned with distilled water prior using. 25 ml sample water were taken in a conical flask with the help of a pipette. Then 1 drop of murexide indicator was added with dropper along with 2 ml NaOh (1N) solution with pipette into the conical flask. The known concentration which is EDTA (0.01 N) was then added into the solution drop by drop slowly from a burette with the help of a burette stand. When the solution color changed to light pink from pink, the reading was noted down immediately. The unit of the parameters are in mg/L.

This equation was used for Ca Hardness. Which was provided by the lab assistant.

$$\text{Ca Hardness} = \frac{\text{EDTA} \times \text{N} \times 50 \times 1000}{\text{Volume of sample}}$$

Here,

EDTA = used volume of EDTA and N = Normality of EDTA = 0.01 N

viii) Determination of Mg Hardness: To determine Mg hardness, the reading of Ca hardness was subtracted from the reading of total hardness value. The unit of the parameters are in mg/L.

This equation was used for Mg Hardness. Which was provided by the lab assistant.

$$\text{Mg Hardness} = \text{Total Hardness} - \text{Ca Hardness}$$

ix) Determination of Free CO_2: To determine the Free CO_2, titration method was used. Necessary equipment's were conical flask, burette, burette stand, dropper, funnel and distilled water. All the equipment's were cleaned with distilled water prior using. 25 ml sample water were taken in a conical flask with the help of a pipette. Then 2 drop of phenolphthalein indicator was added as reagent with a dropper into the conical flask. The known concentration which is NaOH (0.05 N) was then added into the solution drop by drop slowly from a burette with the help of a burette stand. When the solution color changed to pink, the reading was noted down immediately. The unit of the parameters are in mg/L.

$$\text{Free } CO_2 = \frac{V \times N \times 44{,}000}{\text{Volume of sample}}$$

Here,

V = Volume of used NaOH and N = Normality of NaOH = 0.05

Figure 3.9: During the titration experiment for some of the chemical test.

x) Determination of Alkalinity: To determine the alkalinity of the river water, titration method was used. Necessary equipment's were conical flask, burette, burette stand, dropper, funnel and distilled water. All the equipment's were cleaned with distilled water prior using. 25 ml sample water were taken in a conical flask with the help of a pipette. Then 2 drops of phenolphthalein were added as reagent with 2 drops of methyl red as indicator with dropper accordingly into the solution. The known concentration

which is HCL (0.02 N) was then added into the solution drop by drop slowly from a burette with the help of a burette stand. When the solution color changed to pink from red, the reading was noted down immediately. The unit of the parameters are in mg/L.

This equation was used for Alkalinity. Which was provided by the lab assistant.

$$\text{Alkalinity} = \frac{V \times 1000}{\text{Volume of sample}}$$

Here,

V = Volume of used HCL = 0.02 N

xi) Determination of Acidity: To determine the acidity, titration method was used. Necessary equipment's were conical flask, burette, burette stand, dropper, funnel, pipette and distilled water. All the equipment's were cleaned with distilled water prior using. 25 ml sample water were taken in a conical flask with the help of a pipette. Then 2 drops of phenolphthalein indicator as reagent and 2 drops of methyl orange as indicator was added with dropper accordingly into the conical flask. The known concentration which is NaOH (0.02 N) was then added into the solution drop by drop slowly from a burette with the help of a burette stand. When the solution color changed from orange to red, the reading was noted down immediately. The unit of the parameters are in mg/L.

This equation was used for Acidity. Which was provided by the lab assistant.

$$\text{Acidity} = \frac{A \times N \times 50{,}000}{\text{Volume of sample}}$$

Here,

A = Volume of the used NaOH and N = Normality of NaOH = 0.02 N

xii) Determination of Total Suspended Solid (TSS): The TSS is the total suspended solid particle of water that remains in suspension in water. It is actually the measurement of actual weight of particulate matter of a given volume of sample. The unit is mg/L. The necessary instruments were glass microfiber filter, tweezer, burette, distilled water, analytical weight balance, Schlage nitrate filter, cylinder, Buchner funnel and flask, vacuum pump and petri dish. For each experiment, a glass microfiber

filter paper was taken from its box with a tweezer and then put into the analytical weight balance for the pre weight of the filter paper. After a few minutes later the reading was noted down. 50 ml sample water is taken from the sample bottle with a burette. The filter paper was set in the vacuum pump instrument and the 50 ml water is poured into it accordingly. The sample bottle was shaken well before taking the water for proper mixing. After a few seconds later, the filter paper was removed and a changed color was noticeable in the filter paper. Then the filter paper was put into a petri dish. The petri dish was then dried up in the sunlight for about half an hour. Finally, the dried filter paper was again put into the analytical weight balance with the help of the tweezer. After a few minutes later, the final reading was noted again. Then the previous reading was subtracted from the final reading for the exact value of the TSS. Then burette was washed before and after use with clean water & distilled water. The process was repeated for every sample bottle, a total of 24 times.

3.6 Instrumental Techniques

To evaluate the study properly, various instruments and tools were used. The name of those instruments is noted below accordingly.

Table 05. Used instruments, tools and software's to evaluate the study.

Category	Parameters	Name/Model
Instruments	Water Salinity	Portable Salinity Refractometer REF211
	TDS & Temperature	*HANNA* Ph/EC/TDS/Temperature Meter (HI9814)
	EC & Temperature	*HANNA* EC Tester (HI98304) DiST®4
	pH	*HANNA* pH Tester pHep (HI98107)
Lab Instruments	Total hardness, Ca hardness, Mg hardness, Free CO_2, Alkalinity, Acidity, TSS	conical flask, burette, burette stand, dropper, funnel, pipette, distilled water, glass micro fiber filter, tweezer, burette, analytical weight balance, Schlage nitrate filter, cylinder, Buchner funnel and flask, vacuum pump and petri dish
GPS Tool	Co-ordinates & Data	Google Map on Android 11, Samsung M21
Software's	Figures & diagrams	Microsoft PowerPoint 2019
	Tables & Figures	Microsoft Excel 2019

Source: Own preparation.

CHAPTER 4: RESULT & DISCUSSION

The final outcome and result of the research study is discussed in this chapter. The research objectives and its findings are analyzed here in an orderly manner. For better understanding, a discussion section is also added here. A total of 5 sections can be found in this chapter.

4.1 Study Findings/Results

In this section, all the findings and results of the study are disclosed accordingly. The Turag River water quality status was broadly tested with lab experiments of 12 physicochemical parameters. Which is compared with the existing previous studies of scientific research papers on the discussion section. The impact on environment and human life was also taken into consideration and was physically surveyed on near the bank of the river. The findings are significant as it reveals the day to day life impact and necessity of the Turag River. Sequentially the experimental assessments and the results are discussed in this section.

4.1.1 Lab Assessment Report

The detailed assessment report of all the evaluated lab experiments is analyzed here in a well-organized way. (Collection date: 19th September 2021, Monsoon season)

Table 06: Physicochemical Parameters of The Turag River. (Location 1-3)

Parameters	Unit	LOCATION								
		Amin Bazar Bridge			Mirpur Diabari			Nobaberbag		
		Sampling Point								
		S1	S2	S3	S4	S5	S6	S7	S8	S9
Salinity	Ppt/ ‰	0	0	0	0	0	0	0	0	0
pH	--	7.8	7.7	7.7	7.6	7.5	7.7	7.7	7.6	7.5
EC	µS/cm	200	210	190	270	240	240	200	190	190
TDS	ppm	170	170	160	220	210	210	160	150	150
Temperature	°C	30.1	29.8	29.7	29.9	29.7	29.9	29.9	30.1	29.9
Total Hardness	mg/L	96	72	96	72	84	80	84	92	76
Ca2++ Hardness	mg/L	70	50	70	54	66	56	60	68	56
Mg hardness	mg/L	26	22	26	18	18	24	24	24	20
Free CO2	mg/L	61.6	52.8	44	70.4	70.4	44	44	52.8	52.8
Alkalinity	mg/L	180	184	184	168	152	168	180	176	168
Acidity	mg/L	100	112	112	108	100	100	112	116	116
TSS	mg/L	0.0058	0.0045	0.0033	0.0068	0.0077	0.0011	0.0033	0.0144	0.0047

Table 07: Physicochemical Parameters of The Turag River. (Location 4-6)

Parameters	Unit	LOCATION								
		Tamanna Park			S4 Sluice gate			Govt. Water Pump		
		Sampling Point								
		S10	S11	S12	S13	S14	S15	S16	S17	S18
Salinity	Ppt/ ‰	0	0	0	0	0	0	0	0	0
pH	--	7.5	7.4	7.5	7.3	7.2	7.2	7.2	7.2	7.5
EC	µS/cm	200	200	200	210	200	210	300	270	220
TDS	ppm	150	150	160	160	170	160	230	210	160
Temperature	°C	30	29.9	30.1	30.1	30	30	30	30	29.9
Total Hardness	mg/L	84	84	92	80	84	84	100	100	80
Ca2++ Hardness	mg/L	62	64	70	60	58	64	68	70	56
Mg hardness	mg/L	22	20	22	20	26	20	32	30	24
Free CO2	mg/L	70.4	44	70.4	70.4	52.8	44	52.8	44	61.6
Alkalinity	mg/L	156	168	156	172	172	180	192	188	196
Acidity	mg/L	104	108	100	140	148	160	172	172	144
TSS	mg/L	0.0030	0.0021	0.0082	0.0088	0.0045	0.0020	0.0028	0.0066	0.0044

Table 08: Physicochemical Parameters of The Turag River. (Location 7-8)

Parameters	Unit	LOCATION					
		Birulia Launch Terminal			Birulia Bridge		
		Sampling Point					
		S19	S20	S21	S22	S23	S24
Salinity	Ppt/ ‰	0	0	0	0	0	0
pH	--	7.4	7.5	7.4	7.5	7.4	7.5
EC	µS/cm	190	190	190	190	180	190
TDS	ppm	160	150	150	150	140	150
Temperature	°C	29.9	30	29.8	29.9	30.1	30
Total Hardness	mg/L	88	84	80	84	88	84
Ca2++ Hardness	mg/L	66	62	58	66	64	62
Mg hardness	mg/L	22	22	22	18	24	22
Free CO2	mg/L	52.8	61.6	70.4	70.4	61.6	70.4
Alkalinity	mg/L	168	164	184	172	192	208
Acidity	mg/L	120	108	136	124	144	160
TSS	mg/L	0.0034	0.0039	0.0026	0.0023	0.0040	0.0038

Source of table 6,7 & 8: Lab experiments. (Primary data)

i) Salinity: The permissible limit of salinity in Bangladesh is ≤5 ‰. **(Afrad et al. 2020)** After a number of laboratory experiments, no salinity was detected in the sample water. So, In the evaluated study area, the Turag River Water was completely salinity free at the time of collection.

Table 09: Total mean/average value of each of the locations.

Parameters	Unit	All Location Average Value								Total Average
		L-1	L-2	L-3	L-4	L-5	L-6	L-7	L-8	
Salinity	Ppt/ ‰	0	0	0	0	0	0	0	0	0
pH	--	7.7	7.6	7.6	7.5	7.2	7.3	7.4	7.5	7.5
EC	µS/cm	200	250	193	200	207	263	190	187	211
TDS	ppm	167	213	153	153	163	200	153	147	169
Temperature	°C	29.9	29.9	30	30	30	30	29.9	30	30
Total Hardness	mg/L	88	79	84	87	83	94	84	84	85
Ca2++ Hardness	mg/L	63	59	61	65	61	67	62	64	63
Mg hardness	mg/L	25	20	23	21	22	29	22	21	23
Free CO2	mg/L	52.8	61.6	50	61.6	55.7	52.8	61.6	67.4	57.9
Alkalinity	mg/L	183	163	175	160	175	192	172	191	176
Acidity	mg/L	108	103	115	104	149	163	121	143	126
TSS	mg/L	0.0045	0.0052	0.0075	0.0044	0.0051	0.0046	0.0033	0.0034	0.0047

Source: Lab experiments. (Primary data)

ii) pH: The average pH of all the collected sample waters from 8 locations was 7.5, with the lowest and highest value of 7.2 and 7.8 respectively. The standard pH for river water and aquatic life is 6.5-8.5. If explained further, then for irrigation water the range is 6.5-8.5 according to Bangladesh standards, FAO standards and Bangladesh Environment Conservation Rule. The suitable range for fish culture is 6.5-8.0, for drinking water it is 6.5-8.5, for recreational uses it is 6.0-9.5, for industrial water it is 6.0-9.5 and for livestock water it is 5.5-9.0. more or less the acceptable range is 6.5-8.5 in general. **(Mobin et al. 2014)** So, it can be said that the pH of The Turag River water was within permissible range at the time of collection date (19th September 2021). Which was in the wet season.

iii) Electrical Conductivity (EC): The average EC of all the collected sample waters from 8 locations was 211 µS/cm, with the lowest and highest value of 180 µS/cm and 300 µS/cm respectively. The highest concentration of EC was found near the govt. water pump house station. The standard of EC in general is 1200 µS/cm for inland surface water or freshwater. But it can differ in some cases. For recreational purposes, the acceptable EC of water is 500 µS/cm, for irrigation it is 750 µS/cm and for aquaculture it is 800-1000 µS/cm. **(Mobin et al. 2014)** In the dry season, the river water flow is weak. Which increases EC. In a previous scientific study, The EC values of The Turag River water ranged from 691 to 822, 618 to 1334 and 155 to 276 µS/cm in post-monsoon, pre-monsoon and monsoon season respectively. **(Mobin et al. 2014)** So, as per the standard level, it can be said that the EC of the Turag River was within

permissible range in the time of collection date (19th September 2021). Which was in the wet season.

Table 10. Comparison of lowest and highest value of the parameters with standard.

Parameters	Unit	Lowest Value	Highest Value	Average	Standard Value
Salinity	Ppt/ ‰	0	0	0	≤5 *(Afrad et al. 2020)*
pH	--	7.2	7.8	7.5 ±0.17	6.5-8.5 *(Mobin et al. 2014)*
EC	µS/cm	180	300	211 ±30.83	<750-1200 *(Mobin et al. 2014)*
TDS	ppm	140	230	169 ±26.09	<1000 *(Afrad et al. 2020)*
Temperature	°C	29.7	30.1	30 ±0.11	20-30 *(Mobin et al. 2014)*
Total Hardness	mg/L	72	100	85 ±7.61	<200-500 *(Mobin et al. 2014), (Si Luo et al. 2016)*
Ca2++ Hardness	mg/L	50	70	63 ±5.66	< 150 *(Si Luo et al. 2016)*
Mg hardness	mg/L	18	32	23 ±3.48	< 150 *(Si Luo et al. 2016)*
Free CO2	mg/L	44	70.4	57.9 ±10.67	8-12 (*A. K. M. L. Rahman et al. 2012)*
Alkalinity	mg/L	152	208	176 ±13.52	100-500 *(Mobin et al. 2014), (Afrin et al. 2015), (Tahmina et al. 2018)*
Acidity	mg/L	100	172	126 ±23.73	-- (52.5-122.5) *(Afrin et al. 2015)*
TSS	mg/L	0.0011	0.0144	0.0047 ±0.0029	<150 *(Aktar and Moonajilin 2017)*

Source: Lab experiments. (Primary data)

iv) Total Dissolved Solids (TDS): The average TDS of all the collected sample waters from 8 locations was 169 ppm, with the lowest and highest value of 140 ppm and 230 ppm respectively. The highest concentration of TDS was found near the govt. water pump house station. The standard of TDS can be different based on various aspects. For domestic uses it is 500 ppm, for drinking water the acceptable range is 1000 ppm, for industrial purposes it is 1500 ppm and for livestock washing it is 5000 ppm. **(Mobin et al. 2014)** According to the Department of Public Health Engineering, the permissible limit of TDS for Bangladesh is 1000 ppm. **(Afrad et al. 2020)** In the dry season the TDS level of Turag River rises due to the presence of bicarbonates, sulphates and chlorides of Ca, Mg and Na. **(Mobin et al. 2014)** So, as per the standard level, it can be said that the TDS of the Turag River was within permissible range in the time of collection date (19th September 2021). Which was in wet season.

v) Temperature: The average temperature of all the collected sample waters from 8 locations was 30°C, with the lowest and highest value of 29.7°C and 30.1°C respectively. The standard temperature for river water and aquatic life is 20 to 30°C both in dry and wet season as per DoE standard. **(Mobin et al. 2014)** So, it can be said

that the temperature of The Turag River water was marginally within permissible range at the time of collection date (19th September 2021). Which was in the wet season.

vi) Total Hardness: The average total hardness of all the collected sample waters from 8 locations was 85 ppm, with the lowest and highest value of 72 ppm and 100 ppm respectively. The standard total hardness for drinking water, river water and aquatic life is 200 to 500 ppm as per DoE standard. **(Mobin et al. 2014)** It is 500 ppm as per WHO standard. **(Tahmina et al. 2018)** According to another research, the concentration of total hardness higher than 480 ppm has a clear negative impact on fish culture. **(Si Luo et al. 2016)** The hardness of water can be classified into various categories. Such as, soft water (<75 ppm), moderately hard water (75-150 ppm), hard water (150-300 ppm) and very hard water (>300 ppm). **(Mobin et al. 2014)** So, it can be said that the total hardness of The Turag River water was moderately hard which is within permissible range in the time of collection date (19th September 2021). Which was in the wet season.

vii) Ca Hardness: The average Ca hardness of all the collected sample waters from 8 locations was 63 ppm, with the lowest and highest value of 50 ppm and 70 ppm respectively. The standard Ca hardness for river water and aquatic life is <150 ppm. **(Si Luo et al. 2016)** So, it can be said that the Ca hardness of The Turag River water was within permissible range in the time of collection date (19th September 2021). Which was in the wet season.

viii) Mg Hardness: The average Ca hardness of all the collected sample waters from 8 locations was 23 ppm, with the lowest and highest value of 18 ppm and 32 ppm respectively. The standard Mg hardness for river water and aquatic life is <150 ppm. **(Si Luo et al. 2016)** So, it can be said that the Mg hardness of The Turag River water was within permissible range at the time of collection date (19th September 2021). Which was in the wet season.

ix) Free CO_2: The existence of free carbon dioxide (CO_2) may be good or bad depending on the pH and alkalinity level of the water. By "free" it means that it is not combined with anything. Free CO_2 will act as a neutralizer if the alkalinity is high. But if the water is acidic or the pH level is low, then the free CO_2 will increase the acidity even further/ making the water unsuitable for aquatic life. Most fish can tolerate up to 20 mg/L of free CO_2. **(A. K. M. L. Rahman et al. 2012)** The average free CO_2 of all

the collected sample waters from 8 locations was 57.9 ppm, with the lowest and highest value of 44 ppm and 70.4 ppm respectively. The standard free CO_2 for river water and aquatic life is 8-12 ppm. **(A. K. M. L. Rahman et al. 2012)** So, it can be said that the free CO_2 of The Turag River water was not within permissible range at the time of collection date (19th September 2021). Which was in the wet season.

x) Alkalinity: The average alkalinity of all the collected sample waters from 8 locations was 176 ppm, with the lowest and highest value of 152 ppm and 208 ppm respectively. The standard alkalinity for river water and aquatic life is >100 ppm. **(Mobin et al. 2014)** In another research it is said up to 200 ppm alkalinity is permissible for surface water. **(Afrin et al. 2015)** The DoE standard for alkalinity is 200-500 ppm. (**Tahmina et al. 2018)** According to WHO standard it is 200 ppm. **(Tahmina et al. 2018)** So, it can be said that the alkalinity of The Turag River water was within permissible range at the time of collection date (19th September 2021). Which was in the wet season.

xi) Acidity: The average acidity of all the collected sample waters from 8 locations was 126 ppm, with the lowest and highest value of 100 ppm and 172 ppm respectively. The exact standard of acidity for fresh water was not found. As there are very few studies that were conducted before. But an acidity test was conducted at the similar location (Amin bazar bridge) in 2013-2014. When the acidity level was maximum 87.5 ppm and minimum 52.5 ppm. **(Afrin et al. 2015)** From which the current study indicates higher levels of acidity. So, it can be said that the acidity of The Turag River water was not within permissible range at the time of collection date (19th September 2021). Which was in the wet season.

xii) TSS: The average total suspended solid (TSS) of all the collected sample waters from 8 locations was 0.0047 ppm, with the lowest and highest value of 0.0011 ppm and 0.0144 ppm respectively. The standard TSS for river water and aquatic life <150 ppm. **(Aktar and Moonajilin 2017)** As there are no significant/major industries right on the bank of the river in the study area, the TSS value here was so limited. So, it can be said that the TSS of The Turag River water was within permissible range at the time of collection date (19th September 2021). Which was in the wet season.

4.1.2 In Field Physical Survey Analysis

A questionnaire survey was evaluated in field, as a primary data collection method regarding the pollution impact on local communities and their lifestyle. The survey was

made in mid-December 2021. It was quite a tough task to make the participants understand the questionnaire. As the effective people for the survey have literacy issues. A total of 50 people participated in the survey voluntarily. The result of the survey is shown below.

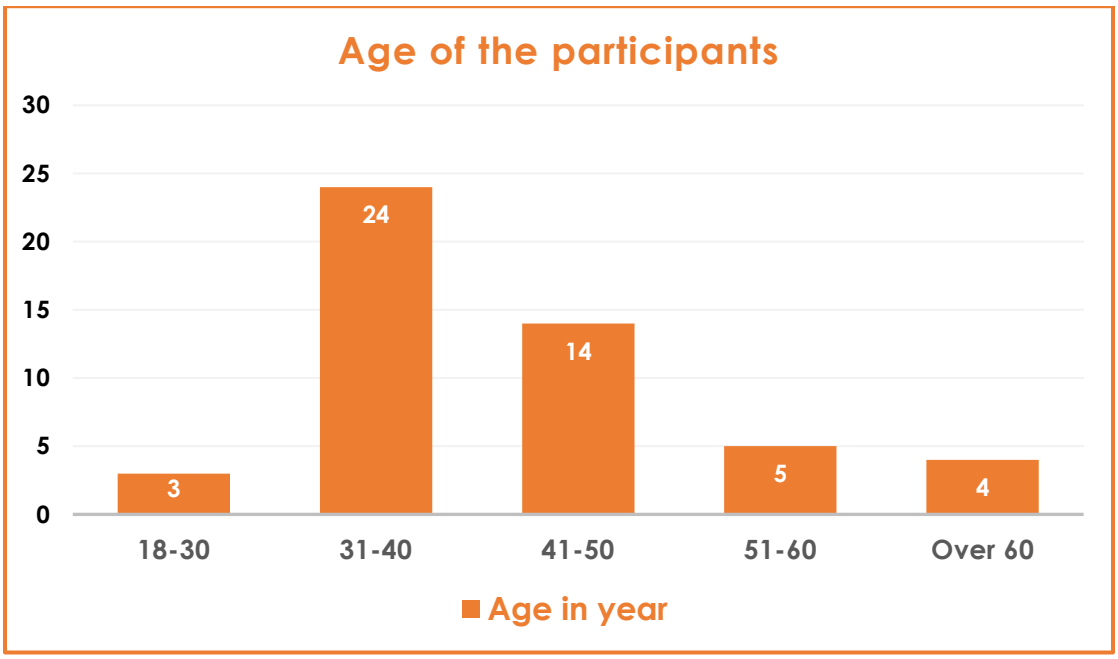


Figure 4.1: Age variation of the responded participants.

Source: Social survey. (Primary data)

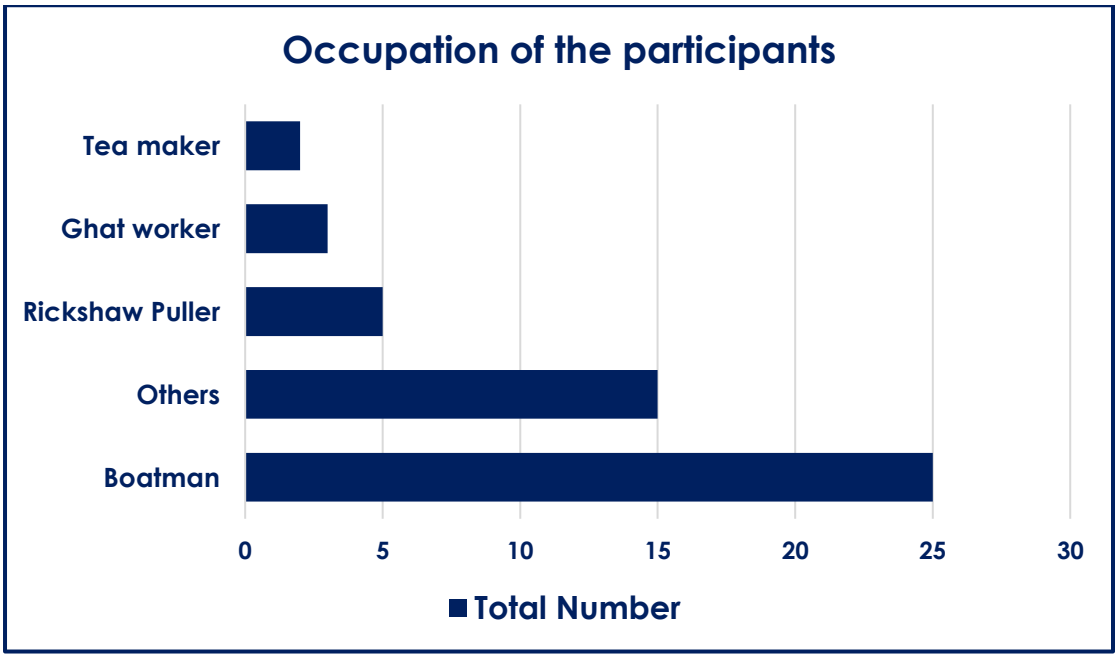


Figure 4.2: Occupation of the responded participants.

Source: Social survey. (Primary data)

The personal information of the participants is shown in figure 4.1 and in figure 4.2. All of them are native people on the bank of The Turag River. Most of them were aged from 31-40 years. And the largest of the participants were boatmen. As they were the most interested individuals to talk about the river and its pollution. Other participants were chosen from the nearby tea stalls and passersby.

4.1.2.1 Survey Information

A detail of the conducted social survey is given here with all the information that was collected. The on field physical survey was made in mid-December, which is 3 months after the sample water was collected. That is why the survey showed a different outcome as the river water condition deteriorated very much during the survey period. The results are shown with bar-diagrams and pie-charts with brief explanations.

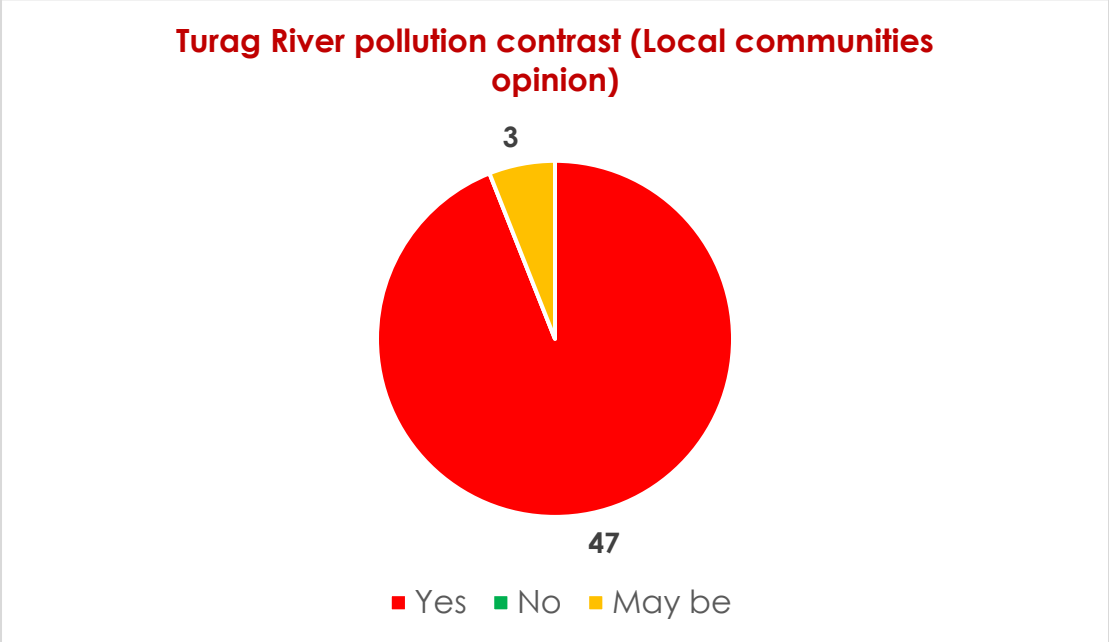


Figure 4.3: Turag river pollution contrast based on the opinion of local community.

Source: Social survey. (Primary data)

When people were asked whether The Turag River was polluted or not, 47 of them answer 'Yes' without any hesitation or any second thought. Only 3 of them were a bit confused and said that maybe it is polluted. Interestingly, no one answered 'No'. the local people living there are quite unhappy with the river and its condition. As the water pollution is pretty much visible in thin eyes.

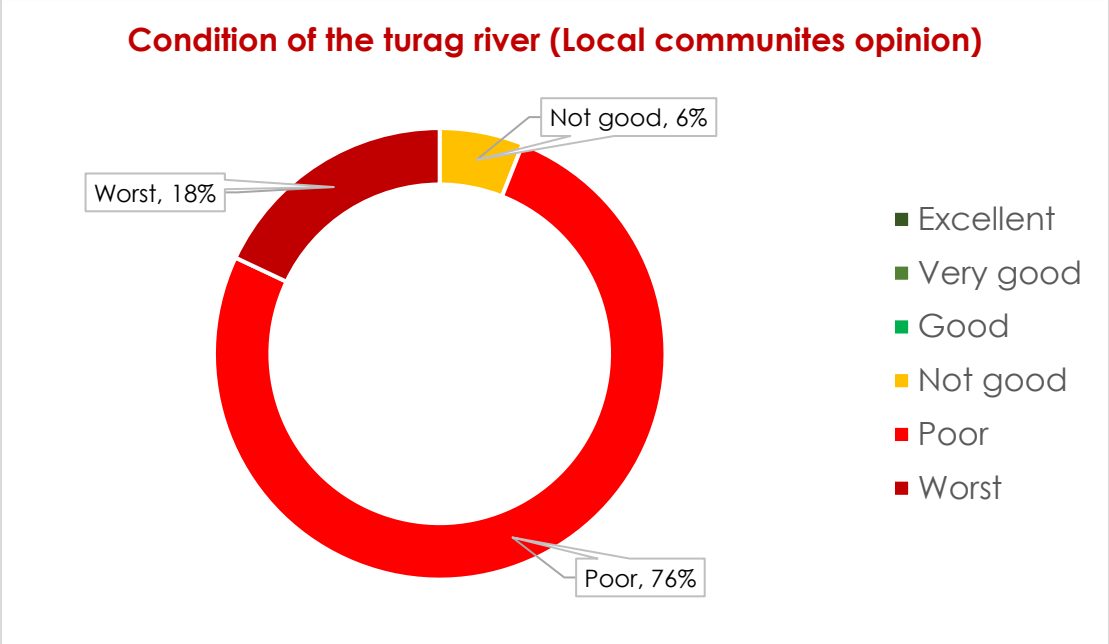


Figure 4.4: Turag rivers condition based on the opinion of the local community.

Source: Social survey. (Primary data)

The participants were asked about The Turag River Condition. And a scale was set from excellent to worst in six different phases. No one picked the answer excellent, very good or good. 76% of them agreed on the condition 'poor'. And 18% of them gave their opinion as 'worst. Rest of the 6% noted as 'not good'. They were also asked if we should be concerned about the river pollution or not. Every individual agreed on that, it is a matter of concern.

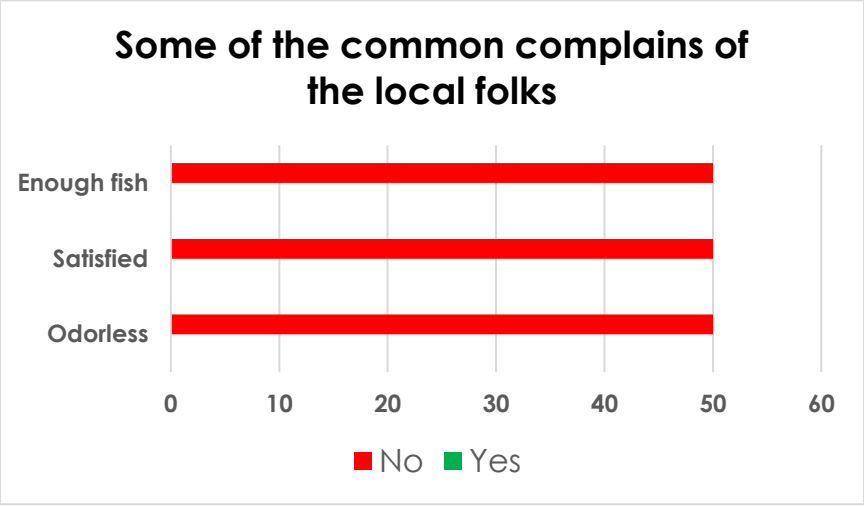


Figure 4.5: Some of the common complains of all the participants about The Turag River Water.

Source: Social survey. (Primary data)

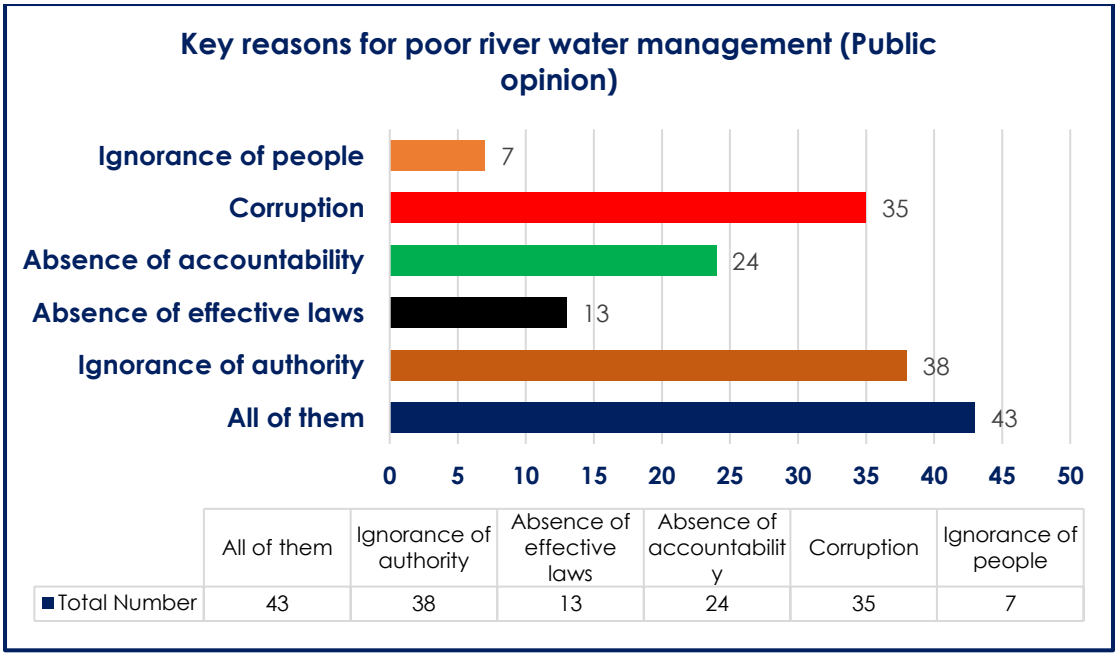


Figure 4.6: Key reasons behind poor river water management. (Public opinion)

Source: Social survey. (Primary data)

The local participants were asked if they were satisfied by the current pollution control system of The Turag River. 100% of them said that they were not satisfied at all. And they all looked very disappointed. The key reasons they pointed out for poor river management are shown in figure 4.6. Where they answered multiple options such as corruption, ignorance of authority, absence of effective laws and regulations, absence of accountability and ignorance of people. Some even marked all the above reasons for poor river management and condition. They were also asked if individual initiatives can reduce river pollution. They reported negatively and said that authority support is a must and necessary for reducing water pollution in The Turag River.

Participants were asked if there are enough fish resources available in the river. They reported negatively. Only during the rainy season, a few numbers of fish species can be seen in the river which is an exceptional case. And there was no active fisherman found in the study area. The fishermen are switching their job mostly to a boatman. Although a new type of foreign fish has been seen in the river recently, their description matches with the “Suckermouth catfish”. Which was recently found in The Buriganga River. This fish is not native here. And will create problems in the near future in the ecosystem.

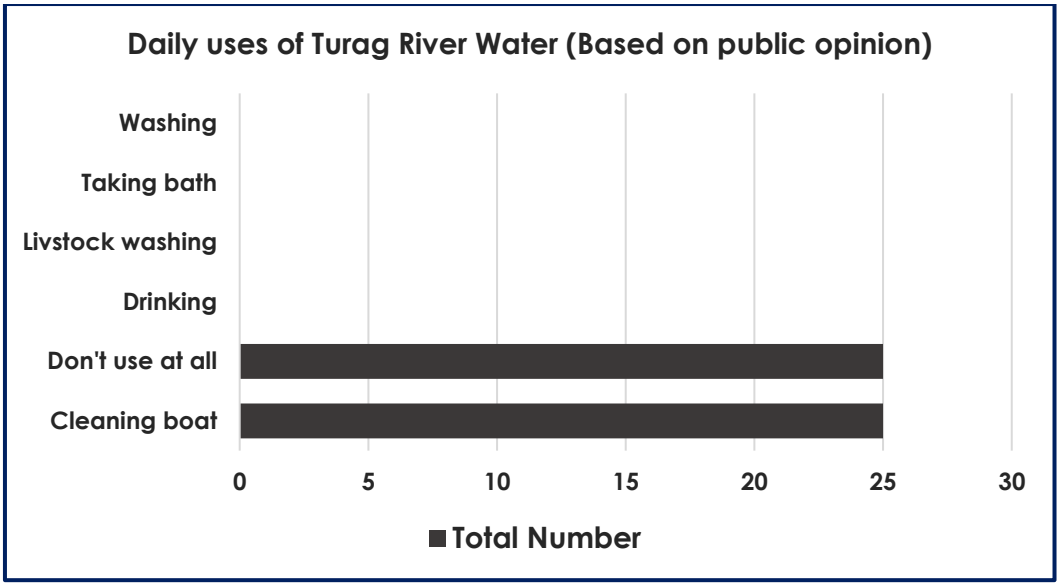


Figure 4.7: Uses of Turag River water for daily purposes based on public opinion.

Source: Social survey. (Primary data)

Currently, The Turag River water is not usable at all according to the local community who participated in the survey. They said that the water remains smelly for almost 8-9 months in a year. Only a few months in the monsoon period, the water looks somewhat good. But not drinkable or potable at all. They reported that in the monsoon season, a few children can be seen taking baths as entertainment. Which they don't support at all. Normally the local people don't use The Turag River water. Little they do is to wash their boats. Currently those who have irrigable land, they use the polluted river water in the dry season as they have no other options. Most of the agricultural land is irrigable for only 1 season. And that is in the dry season, when the water is polluted to its maximum level. As the land remains submerged during the other seasons.

The elder participants said that the river condition was not like this always. 20-30 years ago, the water quality was very good. And they used the water for various purposes like for cleaning dishes, livestock washing, bathing and for many other daily purposes. Fishermen were seen every here and there with fishing nets. Some fishes were larger than a man and it could be dangerous to catch one of them. Species like Wallago Attu (Native name bowal) & Channa Marulius (Native name Gojar) were reported as man eaters by Mr. Abbas Ali, a local living in the bank side of The Turag River.

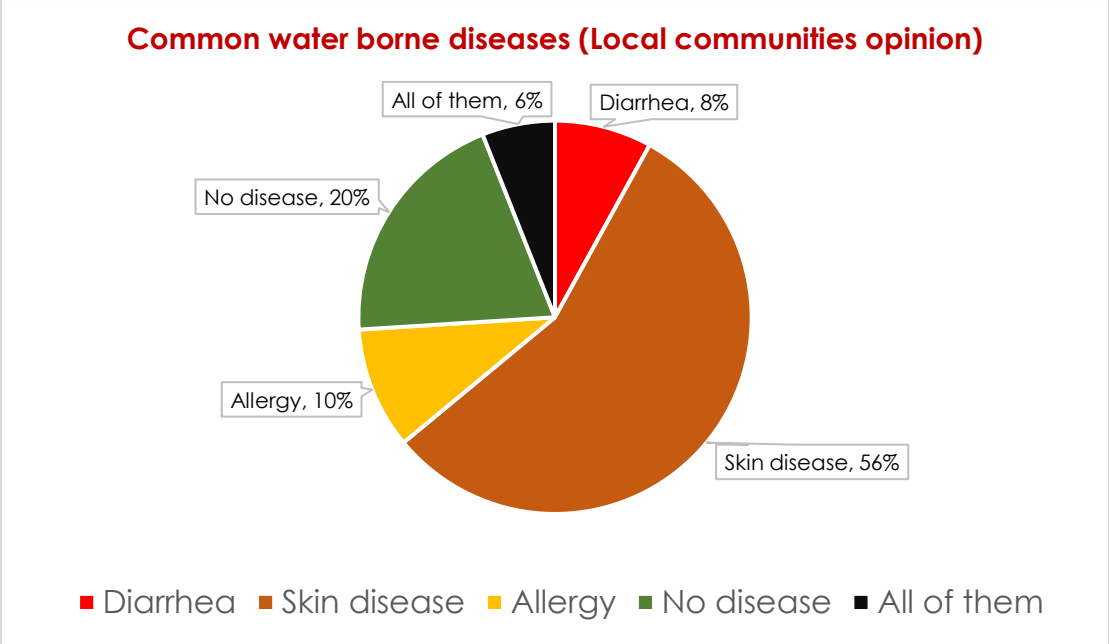


Figure 4.8: Common health diseases of Turag River based on public opinion.

Source: Social survey. (Primary data)

As the river water is polluted, people living nearby do not use the water at all. Little they use, can get skin diseases, allergy or diarrhea as common water borne diseases. 56% of them told about skin disease, 10% of them reported allergy, 8% of them told about diarrhea. No significant diseases like typhoid, cholera, hepatitis-A were reported from them.

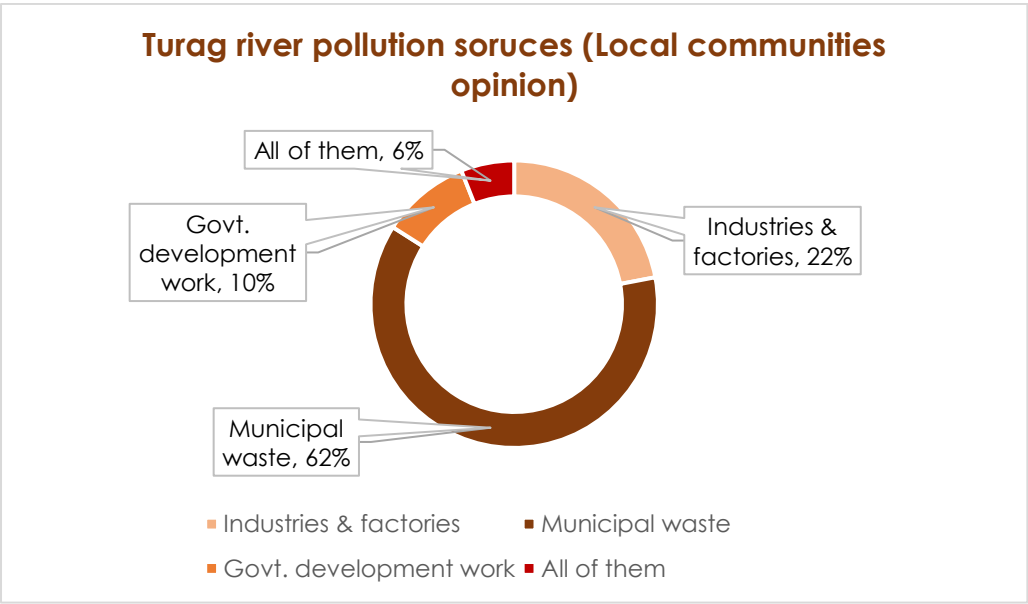


Figure 4.9: Sources of Turag River water pollution according to the local community.

Source: Social survey. (Primary data)

The participants were asked about the potential pollution sources of The Turag River. At this point they seemed very frustrated. They blamed the municipal waste (64%) and tannery industries (21%) as the common sources. Especially sluice gate no 3 and 4 in the study area. Where it was visually seen that untreated municipal waste was directly being dumped into the river water. Besides this, the ongoing govt. development work (9%) in the bankside were also blamed in a small percentage.

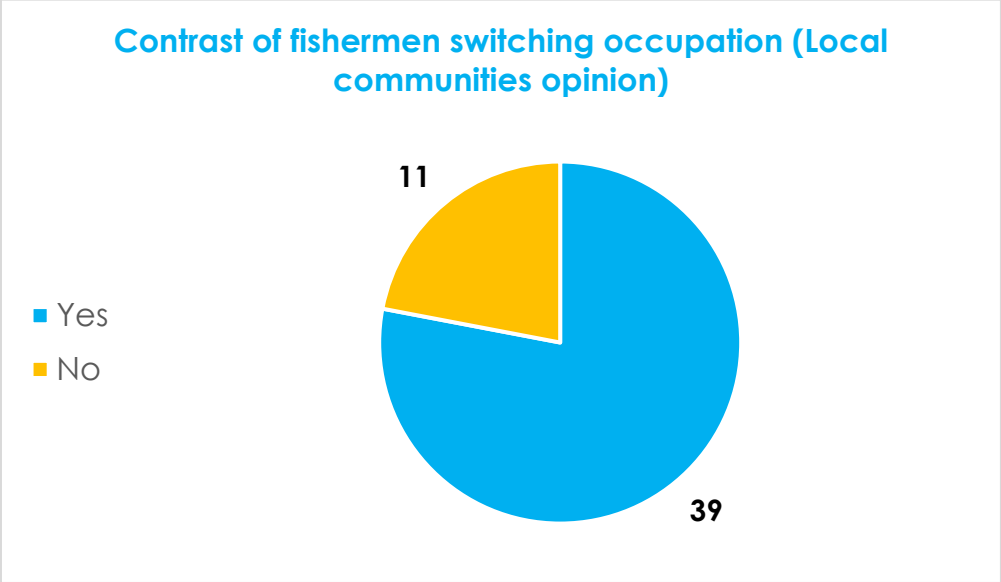


Figure 4.10: Percentage of switching occupation of fishermen according to local community.

Source: Social survey. (Primary data)

The fishermen of The Turag River are reported switching their job. Due to the lack of fish resources. Which is not enough for profit. They are mostly switching to boatman or other odd jobs as they have very few options in hand. It is creating a pressure on the veteran boatmen because the number of boats is increasing in this way. And due to the development of road transport and communication systems, the river route is not being used like before. So, the boatmen are also at stake with their occupation and living a very poor life.

When the people were asked about their opinion about The River, they said that the authority should do their job properly and corruption should be terminated completely. The pollution sources (which is already identified) should be taken care of immediately with green initiatives and proper treatment system should be applied for quality river water. They believe that authority has to play a major role here.

4.1.3 Transparency, Color and Odor

From direct observation, the river water looked turbid. Normally water is odorless and colorless. In the following study, the river water color was natural or can be said okay in the monsoon season (September 2021). But in December 2021, the water color completely changed to dark/black as the monsoon water left. And a disgusting odor can be felt easily in almost every location. In some points of water sample collection, the odor is irresistible. Specifically, in S4 sluice gate area and in govt. water pump house station. A kind of floating white foam can be seen spilled everywhere there. Which looked like a chemical pollutant material. (Figure 3.5) This observation was made from September 2021 – December 2021. Which covers the ending of the monsoon season and the starting of winter/dry season. The river water transparency, color and odor gradually became worse in the dry season.

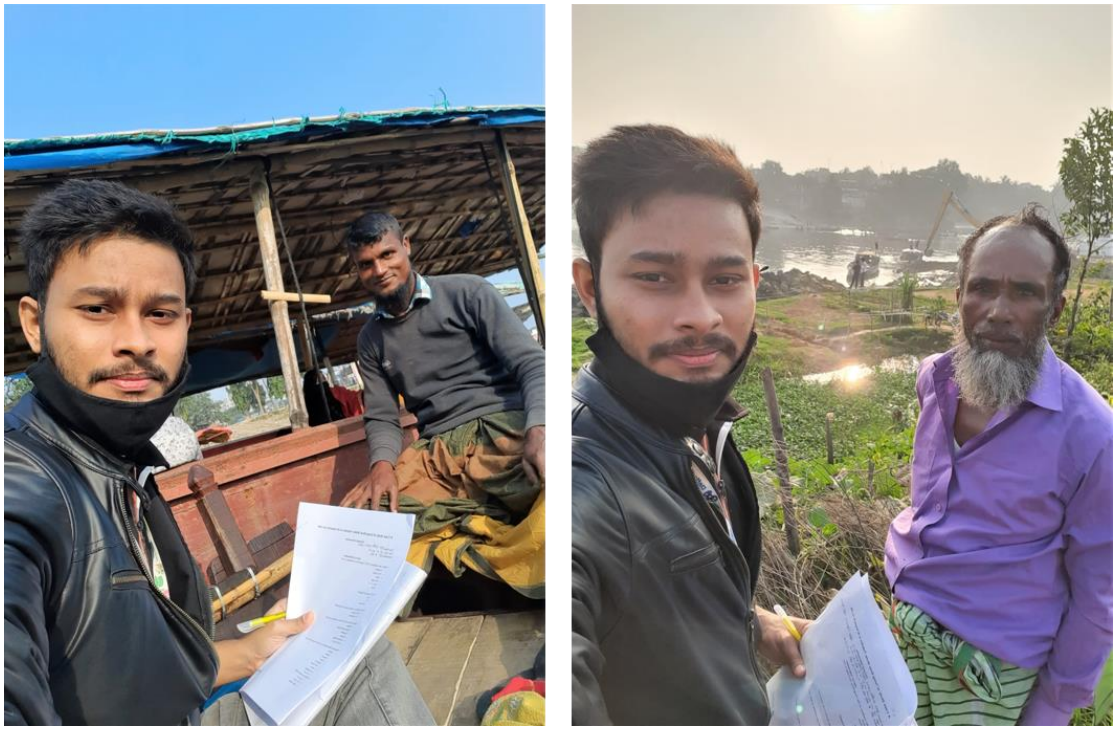


Figure 4.11: Mr. Sumon Mia & Mr. Abbas Ali during the survey interview.

4.2 Discussion

An overall discussion of the whole study is made in this section part by part.

4.2.1 Turag River Water Quality

After conducting lab experiments on various physicochemical parameters, the water quality of The Turag River in the sampling area was in moderately good condition during the sample collection period (19th September 2021). Which was mostly because of the monsoon weather.

Table 11. Quality of the Turag River Water in the study area. (19th September 2021)

Parameters	Unit	Average Value	Standard Value	Quality Remarks
Salinity	Ppt/ ‰	0	≤5 ***(Afrad et al. 2020)***	Excellent
pH	--	7.5	6.5-8.5 ***(Mobin et al. 2014)***	Very Good
EC	µS/cm	211	<750-1200 ***(Mobin et al. 2014)***	Excellent
TDS	ppm	169	<1000 ***(Afrad et al. 2020)***	Excellent
Temperature	°C	30	20-30 ***(Mobin et al. 2014)***	Good
Total Hardness	mg/L	85	<200-500 ***(Mobin et al. 2014), (Si Luo et al. 2016)***	Very Good
Ca2++ Hardness	mg/L	63	< 150 ***(Si Luo et al. 2016)***	Very Good
Mg hardness	mg/L	23	< 150 ***(Si Luo et al. 2016)***	Very Good
Free CO2	mg/L	57.9	8-12 (***A. K. M. L. Rahman et al. 2012)***	Poor
Alkalinity	mg/L	176	100-500 ***(Mobin et al. 2014), (Afrin et al. 2015), (Tahmina et al. 2018)***	Very Good
Acidity	mg/L	126	--	Poor
TSS	mg/L	0.0047	<150 ***(Aktar and Moonajilin 2017)***	Excellent

Source: Lab experiments. (Primary data)

A set of 12 physicochemical parameters were tested in the lab. Among them, 10 of them showed positive results. While 2 of them showed negative results. If table 11 is explained further, the average pH value was 7.5. Which was within the permissible limit. No salinity was detected which is a very good sign. The average of EC and TDS was 211 ppm and 169 ppm respectively. Which is a very lower value than usual. It's because of the monsoon season. The temperature was 30 °C on average. In some cases, it was a bit higher. According to the standard, it may look good. But average 30 °C is comparatively warm for aquatic life and habitats. The Total hardness, Mg hardness and Ca hardness was also within permissible range during sample collection. The alkalinity level was within the standard limit as well. The average TSS value was 0.0047 mg/L which seems very good. The free CO_2 was extremely higher than some of the previous studies. **(A. K. M. L. Rahman et al. 2012)** And finally, the average value of acidity was 126 mg/L or ppm. No standards were found for acidity. But compared with a previous study, it was very high. **(Afrin et al. 2015)** So, the quality of The Turag River

water from Aminbazar Bridge to Birulia Bridge during the monsoon period is moderately good.

4.2.2 Turag River Water Quality Based on Public Opinion

The public survey was made during the winter season, December 2021. When the quality of the river water significantly deteriorates. That is why the result of the public opinion survey resembles a different perspective from the water quality test of the physicochemical parameter that was taken in the monsoon period (19th September 2021).

Table 12. The public opinion comparison in a nutshell of the survey. (50 individuals)

Study Aspect of the on-Field Survey	Public Opinion
Turag River pollution	94% yes, 6% may be
Condition of Turag River	6% not good, 76% poor, 18% worst
Public concern about The Turag River Pollution	100% concerned
Smelly river water	100% smelly
Daily uses of river water	100% don't use at all (Boatmen uses for boat cleaning)
Turag River use for irrigation	Farmers use polluted water in dry season
Water borne health diseases if used	8% diarrhea, 56% skin disease, 10% allergy, 6% all of them, 20% no disease
Turag River pollution sources	22% industries, 62% municipal waste, 10% govt. development work, 6% all of them
Satisfaction of current pollution control	100% negative answers
Key reasons behind poor management (Multiple answers)	23.7% ignorance of authority, 4.4% ignorance of people, 8.1% absence of effective laws, 21.9% corruption, 15% No absence of accountability, 26.9% all of them
Individual initiative can reduce water pollution	100% negative, authority support required
Fish resource availability	Not enough for profit
Fishermen switching job	78% yes, 22% No
Disappointed about the river	100% disappointed

Source: Social survey. (Primary data)

From the survey information part of the result section, it is clearly seen that the local community living near the bank of the river are not happy at all about the rivers condition. And it has a significant negative impact on their lifestyle. As the fishermen no more can't depend on the fish resources for occupation, they have to change their jobs. Agriculture can be practiced only once in a year with contaminated river water. The river stays smelly for most of the year and is not drink worthy or usable at all. So,

the impact of The Turag River Water is negatively affecting the lifestyle of the local community.

4.2.3 Comparative Discussion with Previous Studies

There are a number of good research papers in the upstream zone of the Turag River. As the effluent concentration is higher there due to heavy industrial area. Compared to the upper zone, there has been less study in the lower zone. Where the following study is concentrated. A comparison of physicochemical properties with the upstream zone of a different timeline is shown in table 13 for better understanding.

Table 13: Comparison of physicochemical characteristics of Turag River water.

Location		Upstream	Upstream	Upstream	Downstream
Reference		*(A. K. M. L. Rahman et al. 2012)*	*(Mobin et al. 2014)*	*(Tahmina et al. 2018)*	This Study
Sample Collection Time (Wet Season)		August 2011	July 2013	September 2016	September 2021
Comparative Pollution		Low	Low	High	Low
Parameters	Unit	Average Value			
Salinity	Ppt/ ‰	0.15			0
pH	--	7.7	7.4	7.74	7.5
EC	µS/cm	232	43	1376	211
TDS	ppm	165	258	1233	169
Temperature	°C		30.4	25.7	30
Total Hardness	mg/L	54.65	50.02	692	85
Ca2++ Hardness	mg/L				63
Mg hardness	mg/L				23
Free CO2	mg/L	8.6		22.75	57.9
Alkalinity	mg/L		139	608	176
Acidity	mg/L				126
TSS	mg/L				0.0047

Source: Lab experiments & previous study. (Primary & secondary data)

In a comparative analysis in table 13, a lot of information can be understood at a glance. Such as, the pH value is becoming more acidic than 2011. Currently 7.5 in the downstream area which is kind of a safe zone. In hypothetical thought it can be said that it is even lower in the upper zone due to more concentrated heavy industries. The EC & TDS concentration looks moderate except for the 2016 study. Which shows a higher value of 1376 ppm and 1233 ppm respectively. The temperature value is in the permissible limit in every study. But a lower value near 20°C is better for aquatic life. As warmer conditions are not beneficial for them. The total hardness value seems moderate in every of the studies. Except for the 2016 study. Where it is as high as 692 ppm. In comparison, the free CO_2 value looks unusually higher in the current study. Which is 57.9 ppm. Where the other compared values are 8.6 ppm and 22.75 ppm. Then

again, the whole comparison was made only with wet season values. The dry season value of the physicochemical properties is different.

So, after critically reviewing the study, it can be said that,

- The Turag River water is moderately good in the wet season.
- The Free CO2 and acidity level were higher than the standard value.
- Downstream water quality is better than the upstream zone.
- The river water is not usable in any of the seasons according to the local community.

4.3 Limitations of The Study

The study has many limitations as it is an academic research work. When it comes to an extensive study on the quality of a river, its impact on life, time is necessary. A long study period is beneficial in this case. Which was an issue for the following study as it was as an undergrad academic research. This study covered only 10 km area of the river in the downstream zone. And it missed out some of the effective pollution zone of The Turag River in the upstream. Another major limitation was, the samples were collected only once due to time limitations and that is in the wet season (19th September 2021). Which may have diluted the samples due to regular rainfall at that time. Conducting the physical survey was much more difficult than expected. As the local community has literacy issue, and they were less interested for a conversation. Last but not least, some of the major chemical tests are not included in the work. Such as DO, BOD & COD. And no heavy metal test was conducted. They couldn't be tested due to some technical issues of the Lab equipment's. The resources and literature were also limited on The Turag River. In near future, there is a plan to extend the study further and overwhelm the present limitations. Another phase shall be added about the land use impact of the river.

CHAPTER 5: RECOMMENDATIONS & CONCLUSION

This is the final chapter of the study. A short detail of the full study is written here in a brief to conclude the paper. Including literature review, data collection, data analysis, results and discussions. Recommendations are given here based on the findings of the study and for future study & analysis in order to improve the present condition of The Turag River. The chapter is divided into 2 parts.

5.1 Recommendations

Based on the following study, some effective recommendations are suggested for the Turag River water management and maintenance.

- Unplanned, unnecessary development, residential areas, tourism spot and every other construction should be removed from the river bank side. For any kind of development, EIA (Environmental Impact Assessment) should be measured in the area, and only if it shows positive results, then the development should proceed. More specifically, the environment should be considered more, over economic benefits. As pollution has taken a toll in the river.
- Industries and factories shouldn't be established in a concentrated way near or on the bank of the river. Especially near the agricultural land. If established then tight protocols and effluent treatment methods and plants (ETP) should be applied to treat contaminated water. Low cost treatment process should be developed and implemented as soon as possible.
- Recycling projects can be applied for grey-water coming from the industries, factories and from municipalities.
- For irrigation and aquaculture, environmentally friendly zones should be made by creating hotspots. Where the water and soil quality should be in standard range. It is to support the local community and their living. If the authority fails to give them proper environment, then compensation should be given.
- Government institutions and responsible authorities like WASA, Water Development Board, City Corporation and other related parties should develop effective action plans and should work together in a coordinated manner for

preventing any more damage to The Turag River. And they all should take a sustainable approach for better river management.

- Conventional laws and regulations should be upgraded and should be applied for river water management and river bank-side pollution control with adequate enforcement. Corruption should be effectively handled.
- Pollution sources should be identified thoroughly and should be labelled as danger zones to make a concentrated treatment plan. Effluent should be passed through proper channels. The sluice gates and sewage channels which carry the municipal wastes and other effluents should be cleaned. And a treatment mechanism should be added.
- Regular monitoring should be evaluated from time to time by the government and authority for physicochemical parameters, heavy metal tests and other water quality tests. As well as public feedback and opinions should be taken on a regular basis to make the development up to date in the river and its bank to be more synchronized.
- Social awareness of people and authorities is a must for proper river water quality management. It could be through mass media such as TV, radio, newspaper and other media. Awareness campaign can be held on the bank side for native and local people. Collaboration between local community and authority is also necessary for river use and maintenance.

5.2 Conclusion

After critically reviewing the study, it can be said that The Turag River water is moderately good (in general). But even in this condition, the river water is not usable for any of the daily life or domestic purposes.

The study conducted a quantitative number of sample tests in lab-experiment which was only for the monsoon season. The evaluated physicochemical parameters are Salinity, pH, EC, TDS, Temperature, Total Hardness, Ca Hardness, Mg hardness, Free CO2, Alkalinity, Acidity and TSS. The result of the parameters was diluted because of the regular rainfall during the sample collection period. And it showed moderate to good quality of parameter almost in every location point. For a more accurate view, at least three (3) seasonal samples are required. Anyway, the in-field questionnaire survey, interview of local community and direct observation with photographs for four (4)

months, resembles a more critical scenario of The Turag River. The river water is not drinkable or usable in any of the seasons. Except for some thin purposes like washing boats. Irrigation is practiced only once in a year with contaminated water in the dry season. The color and odor of the river water is also disappointing. The water is unsuitable for aquatic habitats for most of the year.

In order to make positive changes and recoveries in The Turag River water, appropriate steps must be taken with a proper river management system immediately. Regular monitoring of the physicochemical parameter shall be made and uncontrolled, untreated dumping of municipal and chemical waste should come to end. A positive change in the river water quality will have a positive impact on the lifestyle and environment. Otherwise, we all know the future of the river. As we are already familiar with the condition of The Buriganga River. Which is connected with The Turag River in the downstream zone. The fate will be the same for The Turag River as well.

6. REFERENCES

The study required secondary data from various scientific papers, research journals and publications. The software **Mendeley** was used for accurate and effective referencing. The referencing method APA style was followed.

Afrad, Md Safiul Islam et al. 2020. "Impact of Industrial Effluent on Water, Soil and Rice Production in Bangladesh: A Case of Turag River Bank." *Journal of Environmental Health Science and Engineering* 18(2): 825–34.

Afrin, R et al. 2015. "Status of Water Pollution in Respect of Physicochemical Parameters and Anions in the Turag River of Bangladesh." *Bangladesh Journal of Environmental Science* 28: 113–18.

Aktar, Parvin, and Mst Sabrina Moonajilin. 2017. "Assessment of Water Quality Status of Turag River Due to Industrial Effluent." *International Journal of Engineering and Information Systems (IJEAIS)* 1(6): 105–18.

Banu, Zoynab, Md Shariful Alam Chowdhury, Md Delwar Hossain, and Ken'ichi Nakagami. 2013. "Contamination and Ecological Risk Assessment of Heavy Metal in the Sediment of Turag River, Bangladesh: An Index Analysis Approach."

Enderlein, R E, R E Enderlein, and W P Williams. 1996. "Chapter 2*—Water Quality Requirements." *Water Pollution Control—A Guide to the Use of Water, Quality Management Principles*.

Hafizur, R M, H M Nuralam, and I M Rumainul. 2017. "Investigation of Physicochemical Parameter, Heavy Metal in Turag River Water and Adjacent Industrial Effluent in Bangladesh." *Journal of Science, Technology and Environment Informatics* 5(1): 347–60.

Halder, Joshua Nizel, and M Nazrul Islam. 2015. "Water Pollution and Its Impact on the Human Health." *Journal of environment and human* 2(1): 36–46.

KHAN, SAQUIB AHMAD et al. 2020. "ASSESSMENT OF SELECTED WATER QUALITY PARAMETERS OF TURAG RIVER IN DHAKA, BANGLADESH."

Mobin, M N, M S Islam, M Y Mia, and B Bakali. 2014. "Analysis of Physicochemical Properties of the Turag River Water, Tongi, Gazipur in Bangladesh." *Journal of Environmental Science and Natural Resources* 7(1): 27–33.

Rahman, A K M Lutfor, M Islam, M Z Hossain, and M A Ahsan. 2012. “Study of the Seasonal Variations in Turag River Water Quality Parameters.” *African Journal of Pure and Applied Chemistry* 6(10): 144–48.

Rahman, Mirza A T M Tanvir, Sanjida Hoque Moly, and A H M Saadat. 2013. “Environmental Flow Requirement and Comparative Study of the Turag River, Bangladesh.” *International Journal of Scientific Research in Environmental Sciences* 1(10): 291.

Sarkar, M, J B Islam, and S Akter. 2016. “Pollution and Ecological Risk Assessment for the Environmentally Impacted Turag River, Bangladesh.” *Journal of Materials and Environmental Science* 7(7): 2295–2304.

Shawon, M Al-Amin, Sium Ahmed, and M Rezaul Karim. 2021. “Impact of Irrigation with Polluted River Water on the Accumulation of Toxic Metals in Soil and Crops in the Region of Dhaka, Bangladesh and Potential Effects on Health.” *Environmental Processes* 8(1): 219–37.

Sikder, Mohammad Nurul Azim et al. 2016. “Assessment of Physicochemical Parameters with Its Effects on Human and Aquatic Animals Giving Special Preference to Effective Management of Turag River.” *J of Environ. Sci. Toxico. Food Tech* 10: 41–51.

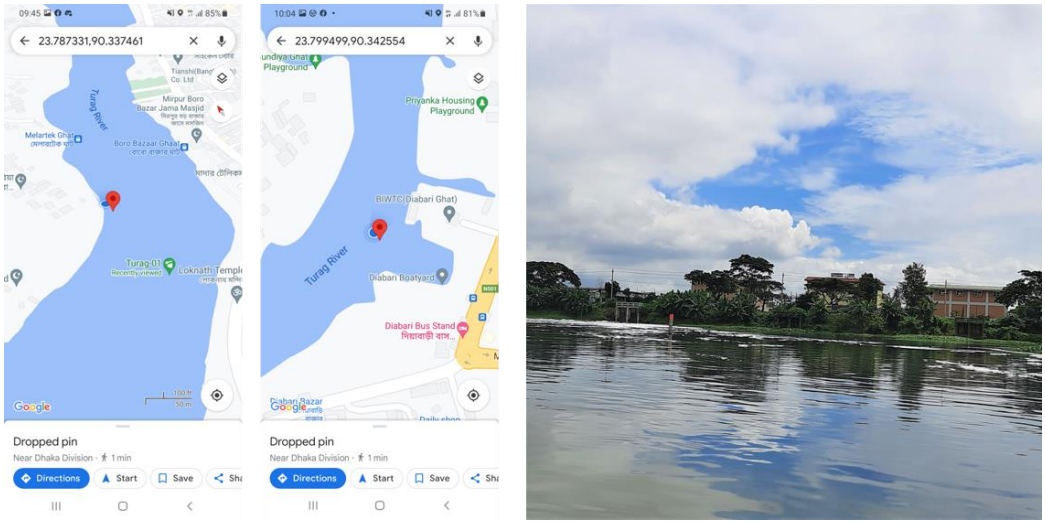
Si Luo, Benli Wu, Xiaogin Xiong and Jianwei Wang. 2016. " Effects of Total Hardness and Calcium:Magnesium Ratio of Water during Early Stages of Rare Minnows (Gobiocypris rarus)." 66(3): 181–187.

Tahmina, Begum et al. 2018. “Assessment of Surface Water Quality of the Turag River in Bangladesh.” *Res J Chem Environ* 22(2): 49–56.

Zaman, Md, and Abu Saeed Md Noman. 2015. “Effect of Land Use on the Water Quality of the Turag River.”

Appendix – I

Photographs



Photograph: Sample 3 & 5 collection co-ordinates in the left picture. Visible white foam pollutants Infront of govt. water pump house in the right picture.

Photograph: On field water sample collection from Turag River using a motor boat.

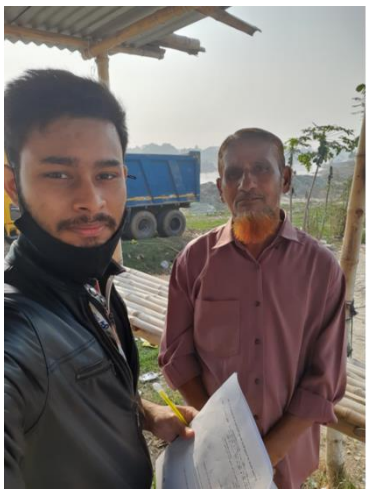
Photograph: TDS meter, pH meter and EC meter.

Photograph: During lab experiments at ESDM Lab.

Photograph: During lab experiments at ESDM Lab.

Photograph: Salinity meter & analytical weight balance at ESDM Lab.


Photograph: All the sample bottles & lab work photographs.



Photograph: On field questionnaire survey images of the volunteer participants.