WATER QUALITY EVALUATION NEAR UTTARA EPZ AREA, NILPHAMARI

Md. Asif All Azad*[1], Md. Hafijur Rahman Sabbir[2]

[1] *Undergraduate student, Khulna University of Engineering & Technology, Bangladesh, e-mail:* asif.che.kuet@gmail.com
[2] *Undergraduate student, Khulna University of Engineering & Technology, Bangladesh, e-mail:* sabbir.hafijur.rahman@gmail.com

***Corresponding Author**

ABSTRACT

Managing industrial wastewater is a significant environmental concern in the Uttara Economic Processing Zone (UEPZ), located in the Nilphamari district of Bangladesh. The UEPZ accommodates a wide range of industrial activity, including but not limited to textiles, tanneries, and food processing. These industries are responsible, for producing an amount of wastewater, which is often released into the environment without treatment. This wastewater may contain pollutants, such as metals, harmful chemicals and organic waste. It's worth noting that the Uttara Export Processing Zone, a known area directly releases its industrial waste into a nearby pond. This practice carries the risk of contaminating groundwater, which is vital for the community. The main objective of this study is to evaluate whether regulatory guidelines for disposing of waste in this area are being followed and to determine if there are any negative effects, on the water quality of nearby drinking water reservoirs. During this inquiry, six samples were obtained from six separate locations. These locations included three samples each of industrial effluents and drinking water. The laboratory analysis of the industrial wastewater samples 1, 2, and 3 yielded the following range of parameters: pH=(6.60–7.20), Color=(860–1280) Pt-Co, Turbidity=(38–53) NTU, Hardness=(98–155) mg/l, TS=(530–850) mg/l, TDS=(390–670) mg/l, TSS=(140–310) mg/l, DO=(0.8–1.3) mg/l, BOD_5=(48–60) mg/l, COD=(161–268) mg/l, Cl=(83–115) mg/l, Fe=(0.75–1.82) mg/l, Mn=(1.98–4.10) mg/l. Nevertheless, the presence of arsenic was not detected in the wastewater samples. The pH value of the industrial wastewater sample was within the allowed limit. The observed turbidity, hardness, TSS, BOD_5, and COD values exceeded the acceptable thresholds. Dissolved oxygen (DO) was also below the required limit. The other parameters associated with wastewater were determined to be within acceptable limits. Upon analyzing the water quality index (WQI) of the drinking water samples, it was observed that sample 4 exhibits a WQI reading of 206.77, indicating its unsuitability for drinking purposes; sample 5 demonstrated a WQI reading of 89.29, signifying inferior water quality. Lastly, sample 6 displayed a WQI reading of 110.23, confirming its unsuitability for drinking. In general, the source of drinking water was deemed unsuitable for use as a potable water source.

Keywords: *Uttara EPZ, industrial wastewater, drinking water quality, effluent disposal*

1. INTRODUCTION

The Export Processing Zones (EPZs) in Bangladesh have significantly contributed to the nation's economy by fostering investment, exports, and employment opportunities. The Uttara Export Processing Zone (UEPZ), situated in the northern region, plays a pivotal role in this regard. The UEPZ, which was established in September 2001, has an area of roughly 213.66 acres in the Sangalshi region of Nilphamari town. It is situated at a latitude of 25˚51'29" North and a longitude of 88˚51'50" East (Uttara Export Processing Zone, 2023). Water is an indispensable constituent of our life support system, playing a crucial role in maintaining human health, supporting marine and terrestrial ecosystems, and facilitating a multitude of life-sustaining endeavors. When comparing surface water to groundwater, it is widely acknowledged that groundwater is cleaner and less contaminated. In Bangladesh, 97% of the population relies on tubewell water as their main source for drinking and cooking (Shaibur et al., 2023). The United Nations estimates that about one third of the world's population is exposed to water sources contaminated by pollutants. Moreover, the World Health Organization (WHO) emphasizes the role of drinking water in contributing to around 80% of diseases found in developing countries (Abbasnia et al., 2019). The deterioration of groundwater quality is a concerning issue posing challenges in terms of regulation, prediction, mitigation and setting pollution standards. The urgency of this matter grows as people come closer to contaminated groundwater sources, thereby increasing the harm to health.

A group of researchers recently conducted a study to assess the health risks associated with the discharge of metals into the wastewater from factories located in Tongi, Shitalakkhya and Dhaleshwari regions of Bangladesh (Uddin & Alam, 2023). Metal levels in the water exceeded the limits set by the Department of Environment. Based on their findings, it was evident that there are health concerns related to exposure to these metals through ingestion and skin contact as indicated by hazard quotient values consistently exceeding 1. Researchers recommend improving wastewater treatment infrastructure to protect health and address this issue. Additionally, the environmental impact of activities carried out within Dhaka Export Processing Zone (DEPZ) was investigated (Khan et al., 2011). Since its establishment, DEPZ has had an effect on the environment particularly contributing to contamination of surface and groundwater in its vicinity. Industrial effluents from DEPZ have been identified as a source of contamination that adversely affects groundwater quality. As a result of these industrial activities, water resources integrity is at risk. The studies conducted on textile and dyeing industries in EPZs such as Dhaka and Chittagong have revealed that wastewater contains levels of pollutants, heavy metals and dyes exceeding both Bangladesh and international standards (Khan et al., 2011). The discharge of partially treated wastewater from EPZs into rivers and canals leads to eutrophication levels of dissolved oxygen and loss of biodiversity in water bodies (Rahman et al., 2012). The contamination of water sources with metals and other pollutants originating from EPZs poses health risks to neighboring communities either through consumption or through bioaccumulation in the food chain (Islam et al., 2017). Irrigation with wastewater from EPZs can result in soil contamination and decreased agricultural productivity (Rahman et al., 2012). The use and release of water, from these activities have the potential to change the patterns and characteristics of water flow leading to environmental complexities. The discharge of pollutants carries levels of pollution loads. However, it is important to note that these discharges can also serve as a water source for meeting needs, such as irrigation and domestic use. Research has demonstrated chromium, sulphide, and ammonia concentrations in Savar Tannery EPZ (Chamon et al., 2023). An analysis in Chittagong EPZ have revealed that the wastewater from chemical industries exhibits acidity, salinity, and the presence of organic compounds (Islam et al., 2017). A thorough examination of existing literature suggests that Export Processing Zones (EPZs) can have environmental impacts, which may be either positive or negative. despite their main purpose being the promotion of economic growth. Many research studies have investigated the consequences of export processing zones (EPZs) in Bangladesh. However, it is necessary to investigate the environmental impact of Uttara EPZ (UEPZ). Considering the consequences associated with export processing zones (EPZs), it is crucial to comprehensively analyze their adverse effects. Therefore, this current study aims to assess the quality of water near areas where industrial effluents are discharged in order to identify hazards.

2. METHODOLOGY

The methodology section outlines the procedural aspects of this investigation, encompassing the formulation of a sample area identification strategy, the systematic collection of samples, and the subsequent determination of water parameters through rigorous laboratory testing. In Figure 1, a depiction of the flow can be seen.

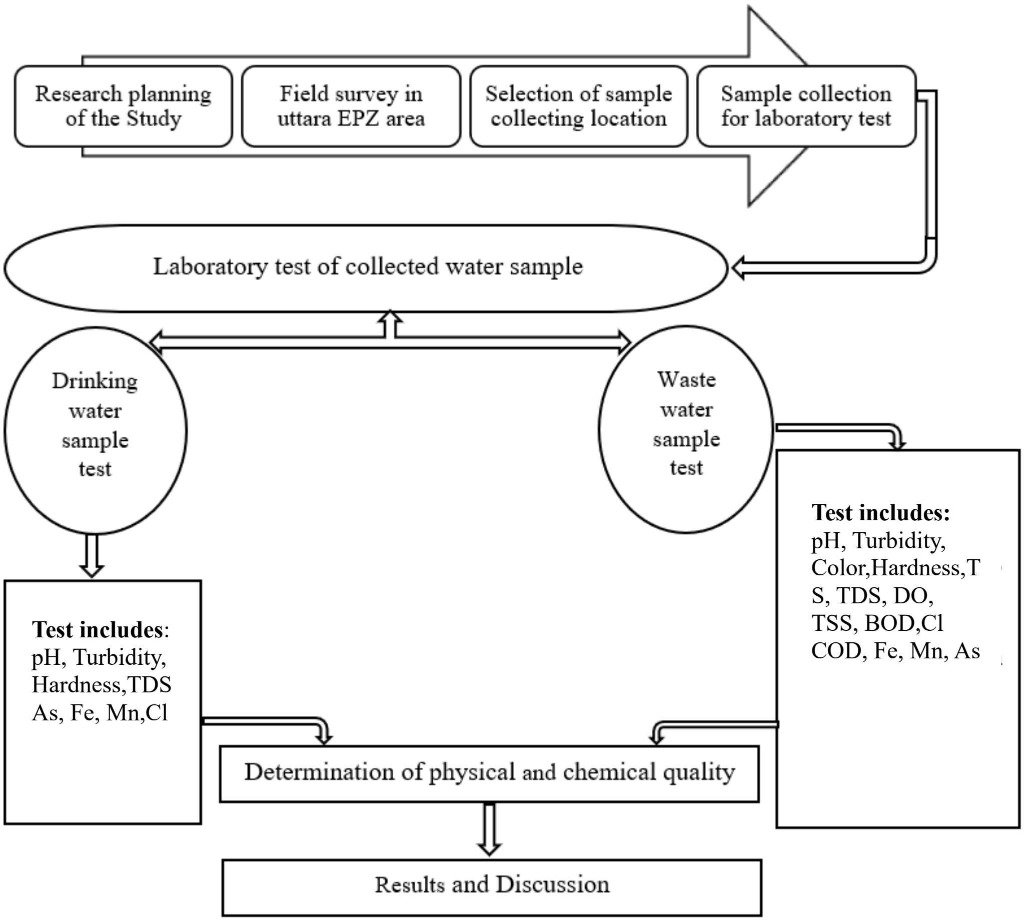

Figure 1: Flow chart of the experimental procedure

3. Study Area

The Uttara Export Processing Zone (UEPZ), alternatively referred to as the Uttara EPZ or the Nilphamari EPZ, is the seventh out of eight designated zones in Bangladesh. It is strategically situated within the Nilphamari district. The export processing zone located inside the Rangpur division in the northern region of Bengal holds the distinction of being the sole zone of its kind in the area. The UEPZ was established in September 2001, encompassing a land area of roughly 213.66 acres located in the Sangloshi sector of Nilphamari town. The industrial zone consists of 180 plots, of which 138 have been allocated, 12 are already in operation, 33 are yet to be developed, and nine remain vacant (Haque et al., 2019). The UEPZ site offers significant logistical benefits, as it is conveniently positioned 10 kilometres from the Nilphamari district centre by road. Additionally, it is situated 18 kilometres from the Saidpur airport and at distances of 360 kilometres and 640 kilometres from Dhaka and the Chittagong Sea Port, respectively (Islam & Sarkar, 2023). The region exhibits efficient connectivity to Dhaka and the Chittagong seaport via a comprehensive road, rail, and air transportation infrastructure network.

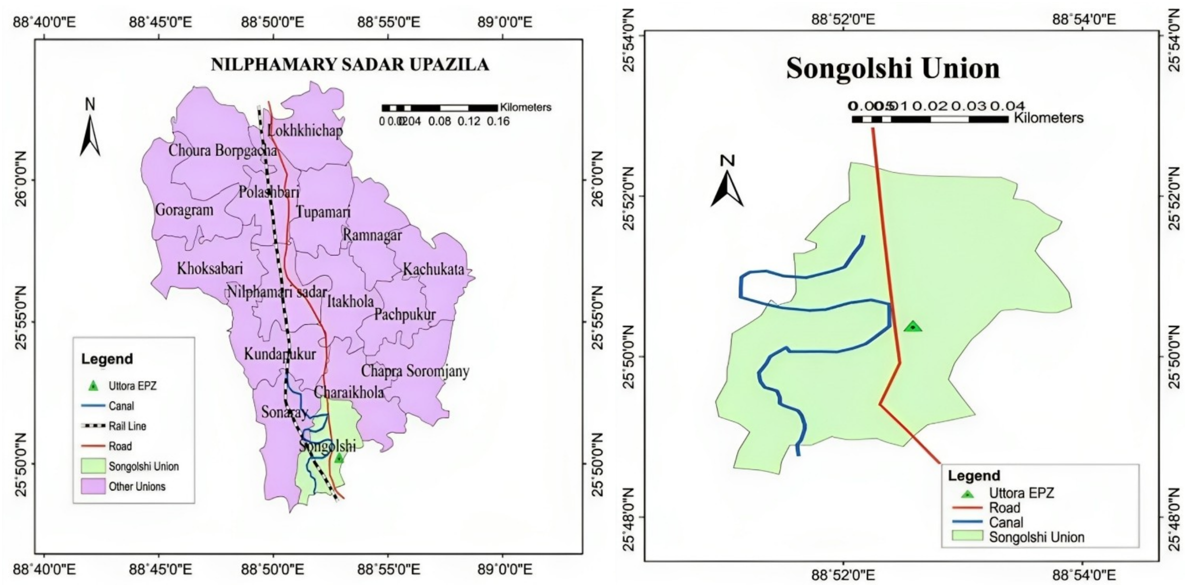

Figure 2: Location of the study area (Haque et al., 2019)

4. Site Selection and Sampling

After a thorough reconnaissance assessment, six sampling locations were selected, and six samples were collected: three industrial effluent samples and three drinking water samples. The sampling locations were strategically chosen to be as close as possible to the discharge points to ensure that the samples accurately represent the effluents from UEPZ. The time for collecting samples was determined carefully considering the environmental conditions. The samples were collected in the afternoon during the dry season in May 2023. Six bottles were used, each of holding 1.5 liters to gather the water samples. Before collecting the samples, the bottles were rinsed three times with the distilled water. The bottles were dried properly before collecting the samples. To maintain the integrity of the samples during transportation from Nilphamari to Khulna University of Engineering & Technology (KUET), sealed container was utilized and the samples were preserved in a chilled state with the aid of ice packs. The collected samples were stored at KUET under appropriate conditions.

Table 1: Location of sampling

Location	Location 1	Location 2	Location 3	Location 4	Location 5	Location 6
Latitude	25°51’30”	25°51’27”	25°51’26”	25°51’32”	25°51’34”	25°51’31”
Longitude	88°51’31”	88°51’29”	88°51’27”	88°51’33”	88°51’24”	88°51’20”

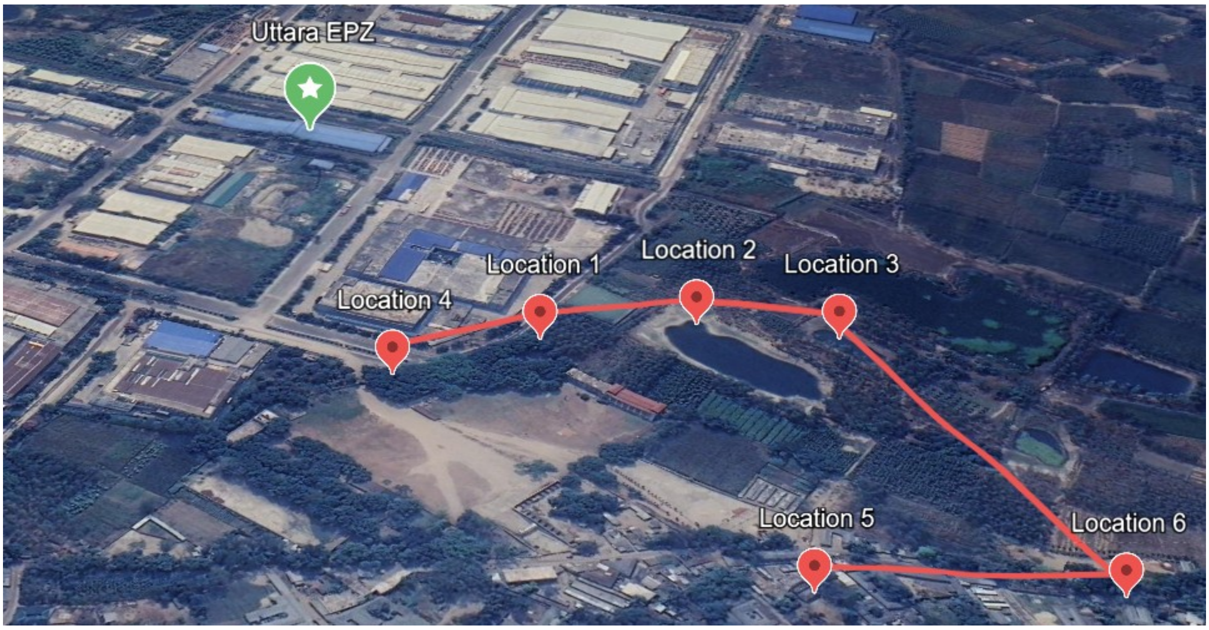

Figure 3: Location of sampling of water of the study area

5. Analytical Methods

Several characteristics of wastewater were evaluated in this study, including pH, color, turbidity, hardness, total solids, total dissolved solids, total suspended solids, electrical conductivity, chlorine ions, and dissolved oxygen. The quality of drinking water was also assessed using indicators like pH, color, turbidity, hardness, dissolved solids content, chlorides levels as well as the presence of total coliforms and fecal coliforms. To analyze the properties of these samples accurately, established protocols were followed and appropriate analytical tools were used. For measuring parameters like dissolved oxygen levels, pH values and electrical conductivity, readings were taken using meters designed specifically for each parameter. Hardness and chloride concentrations were determined by titration. Arsenic, iron, manganese, nitrates, sulfates, and phosphates were determined using spectrophotometry. The gravimetric technique was used to measure solids content while determining the dissolved solids involved implementing a drying method which required evaporating a water sample at 105°C for 24 hours. Microsoft Office Excel 2016 was used to collect and analyze the data.

6. Water Quality Index (WQI) Analysis

The Water Quality Index (WQI) measures the quality of water numerically. For specific purposes such as drinking, irrigation, and recreational activities, these indices combine parameters related to water quality into a value allowing comparison with established standards. The concept of WQIs was initially introduced by Horton in 1965 when he proposed an eight-parameter index to assess the quality of a water system (Silva et al., 2023). Later on, Brown et al. (1972) collaborated with the National Sanitation Foundation (NSF) of the United States and modified this index. The revised version is known as the National Sanitation Foundation Water Quality Index (NSFWQI) which is considered responsive to changes, in water quality compared to indices. For doing the calculation of WQI requires four steps:

- Selection of parameter
- Determination of weightage
- Determination of sub-indices
- Integration of sub-indices in mathematical expression

7. Selection of Parameter

The initial stage involves selecting the parameters. Seven parameters have been chosen to calculate the WQI based on the drinking water quality standards suggested by the World Health Organization (WHO).

8. Determination of Weightage

The weightage, W_i:

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i}$$

Where:

- w_i represents the unit weightage.
- w_i is proportional to the inverse of the recommended standard (S_i) for the i-th parameter.

$$w_i = \frac{k}{S_i}$$

$$k = \frac{1}{\sum \frac{1}{S_i}}$$

9. Determination of Sub-indices

The sub-index (Q_i) for each parameter is calculated as follows:

$$Q_i = 100 \times \frac{V_i}{S_i}$$

Where:

- Q_i is the sub-index for the i-th parameter.
- V_i is the monitored value of the i-th parameter.
- S_i is the recommended standard for the i-th parameter.

10. Integration of Sub-indices in Mathematical Expression

The Water Quality Index (WQI) is then determined by combining the sub-indices using the following formula:

$$WQI = \sum (W_i \times Q_i)$$

The WQI ranges from 0 to 100, with lower values indicating better water quality. The WQI can be classified into different categories according to the following Table 2.

Table 2: Classification of WQI (Shahriar & Moniruzzaman, 2022)

WQI Value	Rating of water quality	Grading
0-25	Excellent water quality	A
26-50	Good water quality	B
51-75	Poor water quality	C
76-100	Very poor water quality	D
Above 100	Unsuitable for drinking purpose	E

11. RESULTS AND DISCUSSION

12. Wastewater Quality Evaluation

Table 3: Tested results of water quality parameters in wastewater

Parameters	Unit	Location 1	Location 2	Location 3	Standard value (ECR,1997)
pH	-	6.60	6.90	7.20	6 – 9
Turbidity	NTU	38	45	53	10
Color	Pt-Co	860	1058	1280	-
Hardness	mg/l	98	140	155	500
TS	mg/l	530	850	810	2100
TDS	mg/l	390	670	540	2100
TSS	mg/l	140	180	270	150
DO	mg/l	0.8	0.9	1.30	4.5 - 8
BOD_5	mg/l	54	48	60	50
COD	mg/l	185	161	268	200
Fe	mg/l	0.75	1.45	1.82	2
Mn	mg/l	2.20	1.98	4.10	5
As	mg/l	0.00	0.00	0.00	0.2
Cl^-	mg/l	81	83	115	600

The wastewater quality parameters tested from the Uttara Export Processing Zone (EPZ) reveal certain deviations from the Environmental Conservation Rules (ECR) guidelines of Bangladesh. The pH values of the wastewater range from 6.6 to 7.2, which are within the ECR's acceptable range of 6.5 to 8.5. Turbidity levels, with values between 38 and 53 NTU, exceed the ECR guideline of 10 NTU. Elevated turbidity is often due to suspended solids in the water, which can originate from untreated or partially treated industrial effluents. The hardness levels in the wastewater, ranging from 98 to 155 mg/l, are well below the ECR threshold of 500 mg/l.

Dissolved oxygen (DO) levels are significantly lower than the ECR guidelines, which are set at 4.5 to 8 mg/l. The observed range of 0.8 to 1.3 mg/l indicates poor water quality and can lead to anoxic conditions that are harmful to aquatic life. Biochemical Oxygen Demand (BOD) values of 48 to 60 mg/l are close to the upper limit of the ECR guideline of 50 mg/l. A high BOD indicates the presence of a substantial amount of biodegradable organic matter, depleting oxygen levels and potentially affecting aquatic life. Chemical Oxygen Demand (COD) values between 161 to 268 mg/l are above the ECR guideline of 200 mg/l. Clearly, the water is oxidizable, meaning that there are organic and inorganic pollutants present, which can pose a challenge to treat and harm the environment. Iron (Fe) concentrations range from 0.75 to 1.82 mg/l, which are below the ECR guideline of 2 mg/l. Manganese (Mn) levels, observed at 1.98 to 4.10 mg/l, are also below the ECR guideline of 5 mg/l. Arsenic (As) was not detected, aligning with the ECR guideline of 0.2 mg/l. Chloride (Cl-) levels, which are recorded at 81 to 115 mg/l, are well below the ECR guideline of 600 mg/l. Turbidity, BOD, and COD values often increase due to the release of organic matter, chemicals, and suspended solids from industrial processes. The sub-optimal DO levels point towards an elevated oxygen demand in the water body, likely due to organic and chemical pollutants that require oxygen for their degradation.

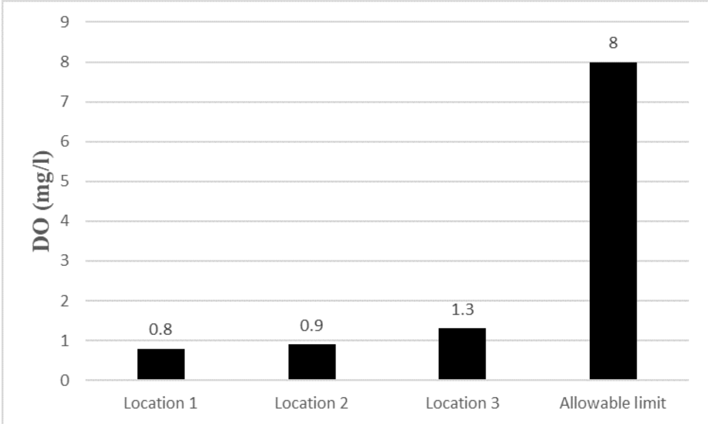

Figure 4: Comparison of DO with standard value (ECR,1997)

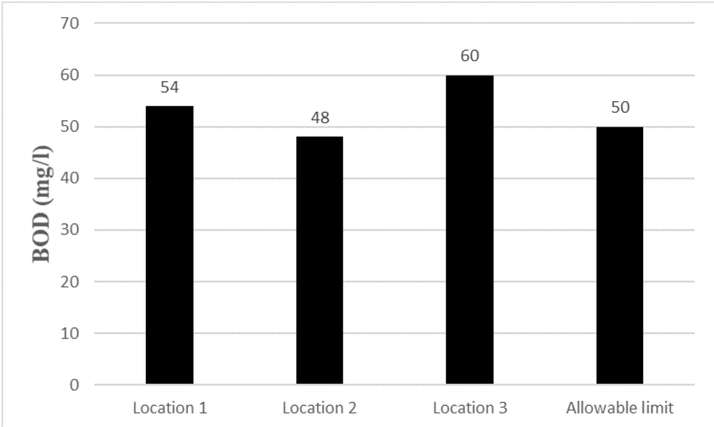

Figure 5: Comparison of BOD_5 with standard value (ECR,1997)

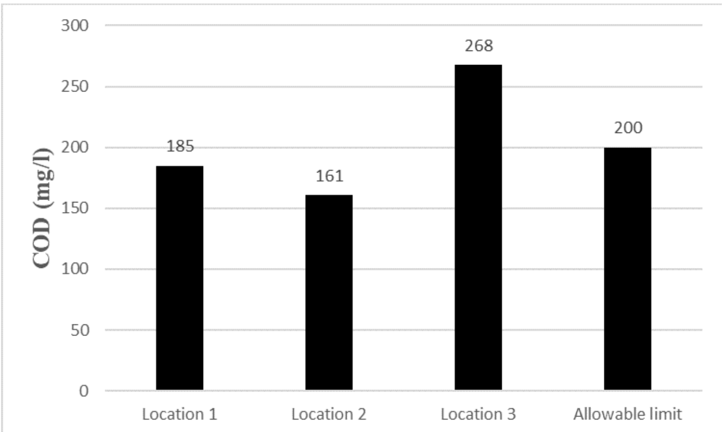

Figure 6: Comparison of COD with standard value (ECR,1997)

13. Suitability Check of Wastewater Disposal

The suitability of a wastewater disposal method can be assessed by comparing it to the allowable limits stipulated in the Environmental Conservation Rules of 1997. If the wastewater meets all the allowable limits, it is considered suitable for disposal without further treatment. The pH values recorded at location 1 (6.60), location 2 (6.90), and location 3 (7.20) all fall well below the allowable limit range of 6 to 9. These results indicate that the pH of the wastewater is suitable for disposal. Turbidity values at all three locations significantly exceed the allowable limit of 10 NTU. Therefore, additional treatment is essential to reduce turbidity before disposal. The hardness values recorded at location 1 (98 mg/l), location 2 (140 mg/l), and location 3 (155 mg/l) are considerably lower than the allowable limit of 500 mg/l. Hence, hardness is within acceptable levels for wastewater disposal. The TS values at all three locations are below the allowable limit of 2100 mg/l, indicating the suitability of TS for disposal. TDS values at all three locations are well below the allowable limit of 2100 mg/l, making TDS suitable for disposal. TSS values at all three locations remain within the allowable limit of 150 mg/l, indicating their suitability for wastewater disposal. DO values at all three locations are considerably lower than the allowable limit of 8 mg/l. Hence, further treatment is necessary to improve DO levels before disposal. BOD_5 values at all three locations exceed the allowable limit of 50 mg/l, implying the presence of organic pollution. Additional treatment is recommended to lower BOD levels. The levels of COD, at all three locations exceed the limit of 200 mg/l. As a result, further treatment is required to address the COD levels. The iron levels at all three locations are significantly lower than the limit of 2 mg/l indicating that they are suitable for disposal. Manganese concentrations at all three sites remain below the threshold of 5 mg/l which means that the manganese content can be safely disposed of in effluent. The arsenic concentrations at all three sites also remain below the threshold of 0.2 mg/l confirming their suitability for disposal. Additionally, the chloride concentrations at all three sites are below the limit of 600 mg/l, thereby establishing chloride compatibility with effluent disposal.

14. Drinking Water Quality Evaluation

Table 4: Results of water quality parameters in drinking water

Parameters	Location 4	Location 5	Location 6	Standard value (WHO)
pH	6.9	7.2	6.6	6.5 – 8.5
Turbidity (NTU)	2.8	3.52	4.15	5
Hardness (mg/l)	282	72	138	200 -500
TDS (mg/l)	750	295	250	500
Fe (mg/l)	0.25	0.74	0.45	0.3
Mn (mg/l)	2.32	0.93	1.2	0.1
As (mg/l)	0	0	0	0.01
Cl^- (mg/l)	105	17	22	250

The wastewater produced by Uttara EPZ has the potential to affect the quality of water reservoirs used for drinking purposes. These effects depend on parameters falling within or, outside the recommended ranges set by the WHO. The concentration of Total Dissolved Solids (TDS) ranging from 250 to 750 mg/l exceeds the WHO guideline of 500 mg/l. This suggests that the taste of water might be altered and there could be a risk, for issues. High levels of Total Dissolved Solids (TDS) frequently suggest the existence of salts and minerals a few of which can be unsafe when present, in amounts. The concentration of Iron (Fe) in the wastewater ranges from 0.25, to 0.74 mg/l surpassing the recommended guideline set by the WHO in instances, which's 0.3 mg/l. Excessive amounts of iron, in drinking water can result in changes, to its color and a metallic flavor. It might encourage the development of iron bacteria subsequently causing concerns regarding the quality of water. The manganese (Mn) levels, in the range of 0.93 to 2.32 mg/l, are considerably higher than the recommended limit set by the World Health Organization (WHO), which's 0.1 mg/l. Excessive manganese in water can lead to neurological issues and is associated with off-tastes and colorings that can make water unpalatable. Arsenic (As) was not detected in the wastewater, which is favorable considering the WHO guideline of 0.01 mg/l. The issue of contamination is a problem in Bangladesh, so it's encouraging to see that there is no trace of it in the wastewater. Lastly, chloride (Cl^-) levels span from 17 to 105 mg/l, well within the WHO guideline of 250 mg/l. While chloride itself at these levels does not pose a direct health risk, it can contribute to the overall salinity of the water, affecting taste and potentially causing corrosion in distribution systems.

15. Suitability Check of Drinking Water

The pH levels recorded at all three sites fall within the range of 6.5 to 8.5, indicating that water's acidity levels are safe for consumption. The measurements of water clarity (turbidity) from all three sites indicate values below the accepted limit of 5 NTU implying that the water is clear and suitable to drink in terms of turbidity. However, it should be noted that the hardness values measured at Locations 4 and 6 surpass the recommended range of 200 to 500 mg/l for drinking purposes. The water in these locations may need to meet hardness standards before it can be considered suitable for consumption. On a note, the water hardness at location 5 falls within the range. Furthermore, it has been observed that location 4 exhibits a concentration of dissolved solids (TDS) than the recommended upper limit of 500 mg/l. Consequently, drinking water from this location may not be safe due to its elevated content of TDS. Nevertheless, locations 5 and 6 consistently demonstrate TDS concentrations within a range as outlined by regulations. The iron levels at all sites are lower than the threshold of 0.3 mg/L indicating that the water is safe for consumption, in terms of its iron content. The concentrations of manganese (Mn) consistently remain below the established threshold of 0.5 mg/l at all sampling sites, suggesting that the water is suitable for consumption regarding manganese content. The arsenic (As) amounts at all sites examined are below the rigorous threshold of 0.01 mg/l, indicating that the water samples satisfy the safety standards for arsenic content. In addition, it can be seen that the chloride ion (Cl^-) levels at all sampling sites are much below the permissible threshold of 250 mg/l, thus affirming the potability of the water in terms of chloride ion concentration.

16. Water Quality Index (WQI) Assessment

Table 5: Results of water quality index (WQI)

Locations	WQI	Rating of water quality	Grading
Location 4	206.77	Unsuitable for drinking purpose	E
Location 5	89.29	Very poor water quality	D
Location 6	110.23	Unsuitable for drinking purpose	E

Location 4 has a Water Quality Index (WQI) of 206.77 which falls within the "E" grade. This suggests that the water quality is not suitable, for drinking. This indicates that there are significant issues with the water quality in location 4, which could pose health risks to those consuming it. The WQI of 89.29 for location 5 places it in the "D" grade, signifying very poor water quality. Although it is not as severe as Location 4, the water quality in location 5 is still far from suitable for drinking. The WQI of 110.23 for location 6 also falls into the "E" grade, indicating unsuitability for drinking. Although it is not as severe as location 4, it is still not safe for consumption.

17.CONCLUSIONS

According to the observations of the final result of the water quality parameters, some values are found in the permissible range, and some are found to exceed or be less than the standard range, which is quite alarming. The tested results of water quality parameters in wastewater from location 1, location 2, and location 3 indicate that the wastewater is suitable for disposal from a pH, hardness, TS, TDS, Fe, Mn, As, and Cl perspectives. However, it is unsuitable for disposal from turbidity, TSS, DO, BOD_5, and COD perspectives. This shows that Uttara EPZ's industrial wastewater treatment facility generally does a good job of removing or treating these contaminants before release. To ensure that the treatment plant is working correctly and the quantities of contaminants are below the acceptable limits, it is essential to check the wastewater discharge from the EPZ regularly. An evaluation of drinking water quality based on water quality parameters and the Water Quality Index (WQI) underscored the challenges faced by the local population. Locations 4, 5, and 6 exhibited varying unsuitability for drinking purposes, with issues such as elevated total dissolved solids (TDS) and hardness levels combined with high WQI values, indicating inferior water quality. Pollution, the presence of dangerous chemicals, or inadequate treatment facilities are some of the factors that can contribute to poor water quality. To provide people with safe and clean drinking water, prompt and effective action must be taken to enhance the water quality in these areas.

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