M. Alamgir, S.M.T. Islam and J. A. Saju (Eds.)
ISBN: 978-984-35-4034-8

Proceedings of the Waste Safe 2023 – 8th International Conference on Integrated Solid Waste and Faecal Sludge Management
25-26 February 2023, Khulna, Bangladesh

INVESTIGATION OF INDUSTRIAL EFFLUENT & DRINKING WATER QUALITY NEAR UTTARA EPZ AREA OF NILPHAMARI

Md Motahar Hossain[*], Khondokar Mahbub Hassan[*], Sarmista Nandi Satu[*]

[*]*Department of Civil Engineering, Khulna University of Engineering & Technology, Bangladesh*

ABSTRACT

The standard of drinking water has a significant impact on public health. The Uttara Export Processing Zone (Uttara EPZ) produced effluent and dumped it in a pond. The groundwater may become contaminated by long-term discharge. The purpose of conducting this research was to determine whether the industrial effluent disposal was within the acceptable range and if it had any adverse effect on drinking water sources nearby the Uttara EPZ area in Nilphamari. The ECR 1997 standard is used to compare test results from industrial wastewater samples, whereas some parameters, such as DO (0.3 to 1.4 mg/l), BOD_5 (56 to 202 mg/l), and COD (70 to 269 mg/l), exceed the standard limit and other parameters are within acceptable limits. Some parameters of the drinking water sample, such as TC (0 to 112 N/100 ml), FC (0 to 4 N/100 ml), and Mn (0.6 to 2.4 mg/l), exceed the permitted limit. The DWQI analysis for STW 1 is 180.3462, STW 2 is 158.5436, and STW 3 is 426.2846, indicating that the sources of STW 1 and STW 2 have poor water quality, respectively, while STW 3 is unfit for drinking. The sample of drinking water is unfit for consumption.

INTRODUCTION

The Export Processing Zones (EPZs) of Bangladesh have a significant impact on investment, export, and employment (Islam, 2018). The engines of a nation's economy are exports, investment, and employment. Urbanization and industrialization are growing immensely with the balanced rate of population growth (Dhruba et al., 2022). Industrialization refers to the period of social and economic transformation that turns an agrarian society into an industrial one. In the industrialized world, environmental pollution is a significant problem. Water pollution is one kind of the environment's pollution, which also includes pollution of the air, soil, and water. One of the primary factors contributing to water pollution is industrial waste. Industrial effluent contains nitrogen, phosphate, and metals such as iron, chromium, nickel, cadmium, and manganese. Industrial effluent is being dumped in rivers, ponds, and other bodies of water. But continued dumping of solid waste, home sewage, and industrial effluents contaminates groundwater and creates health risks (Lakshmi & George, 2014).

Water is an essential component of our life support system and plays a significant role in it. Human health, marine and terrestrial ecosystems, and life-sustaining activities all require safe water. In comparison to surface water, groundwater is thought to be relatively cleaner and pollution-free (Lakshmi & George, 2014). In Bangladesh, tube well water is used for drinking and cooking by almost 97% of the population (R Shamsur et al., 2017). The United Nations estimates that nearly one-third of people worldwide consume polluted water. According to the WHO, contaminated drinking water is the main cause of 80% of diseases in developing countries (Hossain & Hassan, 2020). Damage to groundwater quality is far more concerning because it is challenging to regulate, anticipate, address, and define the level of pollution, whereas human exposure is extremely close, which puts people at risk for health problems (Khan et al., 2011).

The Uttara EPZ in the Nilphamari district of Bangladesh is the seventh of the country's eight export processing zones. It stabilized in September 2001 and is the only export processing zone in northern

Bangladesh. It is located at 88 51'50" east latitude and 25 51'29" north latitude. There are about 30,000 employees, most of them women. In this EPZ, there are more than 190 industrial plots. 138 plots have been allotted; 12 are running, 33 are still being developed, and 9 are still unoccupied. There are 22 operating industries in the Uttara EPZ, some of which have wastewater treatment facilities. The industrial effluent was dumped close to a pond. The discharge of industrial effluent percolates through the soil, which may cause contamination of surface water and ground water by long-term discharge.

The study's objectives were to determine the characteristics of industrial effluent, examine the standard limit for disposal, assess the drinking water quality near the disposal site, and make suggestions for the discharge of industrial effluent.

MATERIALS AND METHODS

STUDY AREA

Nilphamari District, the northernmost city in Bangladesh, and its area of 1580.85 sq. km. Geographically, it lies between latitudes 25°44' and 26°19' north and longitudes 88°44' and 89°12' east. Uttara EPZ was established in September 2001 in the Shongalshi district of Sadar Nilphamari. It is located 10 kilometers by road from Nilphamari, 16 kilometers from Saidpur airport, 409 kilometers from Dhaka, 682 kilometers from the Chittagong Sea Port, and 568 kilometers from the Mongla Sea Port. It is located in the Shongalshi area of Nilphamari city on 213.66 acres of land. There are 190 industrial plots, with a 2000-square-meter average plot size.

Figure 1: Location of Uttara EPZ

SAMPLING AND COLLECTION OF WATER SAMPLE

There are seven different sampling locations from which samples are collected, which were selected after a thorough reconnaissance assessment. Four samples of industrial effluent and three samples of drinking water, totaling seven samples, were taken.

Table 1: Location of sampling

	Location 1	Location 2	Location 3	Location 4	STW 1	STW 2	STW 3
Latitude	25°51’22.7”	25°51’25.0”	25°51’24.8”	25°51’36.9”	25°51’32.3”	25°51’36.6”	25°51’32.0”
Longitude	88°51’32.3”	88°51’28.9”	88°51’22.2”	88°51’02.1”	88°51’32.1”	88°51’27.4”	88°51’22.8”

ISBN: 978-984-35-4034-8

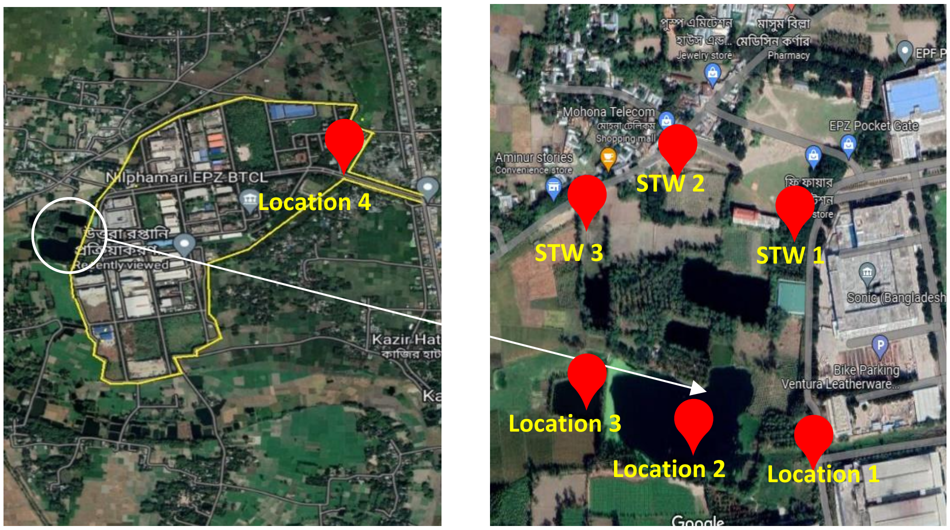

Figure 2: Sample collecting location

LABORATORY MEASUREMENT

The samples of groundwater were taken right away to the lab and placed in the refrigerator for storage. Based on APHA (1999) procedures, the analysis got underway right away in the lab. When it comes to physicochemical properties, pH, Color, Dissolved Oxygen (DO), Electrical Conductivity (EC), and Turbidity were all measured using specific instruments. As opposed to this, titration was used to measure the hardness and chloride levels. The gravimetric method was used to measure TS and TDS. Spectrophotometer tests were performed on As, Fe, Mn, and COD.

STATISTICAL ANALYSIS of WATER QUALITY INDEX (WQI)

WQI, which is frequently used to measure the quality of drinking water, was utilized to assess water quality. The WQI was created by Brown et al. in 1970, and Backman et al. later improved it (1998). The World Health Organization (WHO) reported in 2004 that the WQI will aid in explaining the combined effects of every parameter in addition to all qualitative parameters on drinking water quality (Abbasnia et al., 2018).

$$Wi=\frac{wi}{\sum_{i=1}^{n} wi} \quad (1)$$

Where, Wi = relative significance of each variable, wi = significance of each variable, n = number of variables

Using the 2011 World Health Organization (WHO) guidelines, the concentration of each parameter in each water sample was divided to obtain the quality rating scale, which was then multiplied by 100 using the equation (2)

$$q_i = \left(\frac{c_i}{s_i}\right) \times 100 \quad (2)$$

Where, qi = the grade for quality, Ci = each parameter's concentration (mg/L), Si = Limit (mg/L) established by WHO and published in 2011

$$SIi = wi \times qi \quad (3)$$

$$WQI = \sum_{i=1}^{n} SIi \quad (4)$$

where SIi is the subindex of the parameter, qi is the grade for quality, and n is the total number of variables (Abbasnia et al., 2019). Five grades of water quality can be identified based on the WQI results, as shown in Table 2.

Table 2 divides various types of water into five categories based on their quality.

Table 2: Index for measuring water quality (Abbasnia et al., 2019)

WQI Value	Assessment of Water Quality
<50	Excellent grade water
50-99.99	Good grade water
100-199.99	Poor grade water
200-299.99	Very poor grade water
≥300	Unfit for use as a drinking

Table 3: The weight (wi) and WHO drinking water standard values

Parameter	WHO (mg/l) (Si)	weight (wi)
pH	6.5-8.5	4
TDS	750	4
Cl-	500	3
Turbidity	4	4
Hardness	300	3
Mn	0.1	4
Fe	0.3	4
	sum=	26

RESULTS AND DISCUSSIONS

Laboratory tests were done to determine the water quality parameters using surface water samples and composite effluents from multiple industries. The Environment Conservation Rules (ECR, 1997) standard limits and typical water quality discharged from Uttara EPZ companies are listed in Table 4.

Table 4: Laboratory Test Results of Industrial Effluent Quality

Parameter	pH	Color (PtCo)	Turbidity (NTU)	Hardness (mg/l)	DO (mg/l)	BOD_5 (mg/l)	COD (mg/l)	TS (mg/l)	TDS (mg/l)	TSS (mg/l)	Cl (mg/l)	Fe (mg/l)	Mn (mg/l)	As (mg/l)
Sample 1	7.2	436	51	56	0.5	202	268	570	370	200	28	0.92	4.2	0
Sample 2	7.2	218	9	60	0.5	56	70	610	430	180	20	0.84	1.8	0
Sample 3	7.3	205	25	60	0.3	72	117	290	240	50	18	0.75	2.1	0
Sample 4	7.7	116	10	46	1.4	132	190	190	150	50	13	0.27	0.4	0
Standard value*	6-9	-	10	500	4.5-8	50	200	2100	2100	150	600	2	5	0.2

* Source: Guide to the Environmental Conservation Act of 1995 and Rules of 1997

Analysis of the laboratory results shows that the values for the following parameters are within acceptable limits: pH, hardness, total solids (TS), total dissolved solids (TDS), total suspended solids (TSS), Cl, Fe, Mn, and As. The COD, BOD5, and DO values exceed the allowable limits.

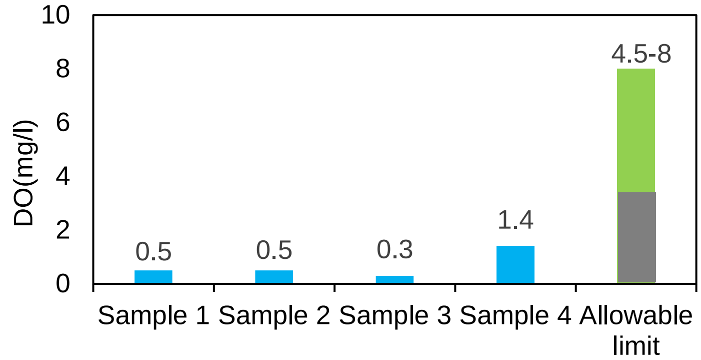

Figure 3: DO in Wastewater Sample

For aquatic life, dissolved oxygen (DO) is a crucial water quality indicator. The dissolve oxygen (DO) values ranged from 0.3 to 1.4 mg/l, while the standard value for Bangladesh is 4.5 to 8 mg/l. Low DO would be a sign of poor water quality, which would make it impossible to support a lot of delicate aquatic life.

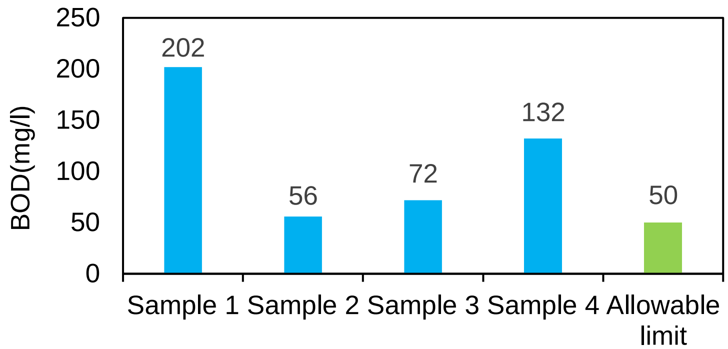

Figure 4: BOD_5 in Wastewater Sample

The biochemical oxygen demand (BOD) values ranged from 56 to 202 mg/l, while the standard value for Bangladesh is 50 mg/l. This value is a critical determinant of the level of environmental pollution that wastewater represents. A higher BOD needs more oxygen, so there is less food for organisms that need oxygen, and the water quality gets worse.

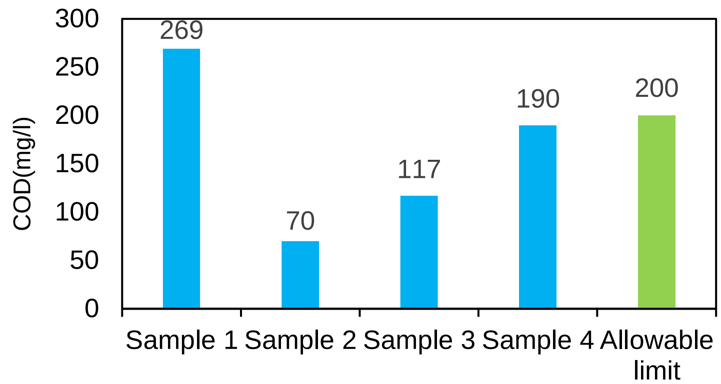

Figure 5: COD in Wastewater Sample

The chemical oxygen demand (COD) values varied from 70 to 269 mg/l, while the standard value for Bangladesh is 200 mg/l. Except for one, the COD readings are within an acceptable range.

The concentration of drinking water quality parameters was measured in the lab and compared to the groundwater sample's allowed limit as recommended by ECR (1997). Table 5 displays the information

Table 5: Laboratory Test Results for Drinking Water Quality

Parameter	pH	Turbidity (NTU)	Color (PtCo)	Hardness (mg/l)	TDS (mg/l)	TC (N/100ml)	FC (N/100ml)	Cl (mg/l)	Fe (mg/l)	Mn (mg/l)
STW 1	7.5	3.23	12	116	230	112	4	13	0.28	0.9
STW 2	7.6	3.28	32	56	240	11	2	8	0.6	0.6
STW 3	6.7	6.69	26	278	670	0	0	83	0.13	2.4
Standard value*	6.5-8.5	10	15	200-500	1000	0	0	150-600	0.3-1.0	0.1

*Source: Guide to the Environmental Conservation Act of 1995 and Rules of 1997

Table 6: Results of drinking water quality index (DWQI) for STW 1

Parameter	Concentration (mg/l) (Ci)	WHO (mg/l) (Si)	weight (wi)	Relative Weight (Wi)	qi=(Ci/Si)*100	SIi=Wi*qi
pH	7.5	6.5-8.5	4	0.153846154	101.3333333	15.38462
TDS	230	750	4	0.153846154	32	4.717949
Cl-	13	500	3	0.115384615	1.6	0.3
Turbidity	3.23	4	4	0.153846154	82	4.969231
Hardness	56	300	3	0.115384615	18.66666667	2.153846
Mn	0.9	0.1	4	0.153846154	600	138.4615
Fe	0.28	0.3	4	0.153846154	200	14.35897
		sum=	26		WQI=	180.3462

Table 7: Results of drinking water quality index (DWQI) for STW 2

Parameter	Concentration (mg/l) (Ci)	WHO (mg/l) (Si)	weight (wi)	Relative Weight (Wi)	qi=(Ci/Si)*100	Sii=Wi*qi

pH	7.6	6.5-8.5	4	0.153846154	101.3333333	15.58974
TDS	240	750	4	0.153846154	32	4.923077
Cl-	8	500	3	0.115384615	1.6	0.184615
Turbidity	3.28	4	4	0.153846154	82	12.61538
Hardness	56	300	3	0.115384615	18.66666667	2.153846
Mn	0.6	0.1	4	0.153846154	600	92.30769
Fe	0.6	0.3	4	0.153846154	200	30.76923
		sum=	26		WQI=	158.5436

Table 8: Results of drinking water quality index (DWQI) for STW 3

Parameter	Concentration (mg/l) (Ci)	WHO (mg/l) (Si)	weight (wi)	Relative Weight (Wi)	qi=(Ci/Si)*100	Sii=Wi*qi
pH	6.7	6.5-8.5	4	0.153846154	89.33333333	13.74359
TDS	670	750	4	0.153846154	89.33333333	13.74359
Cl-	83	500	3	0.115384615	16.6	1.915385
Turbidity	6.69	10	4	0.153846154	66.9	10.29231
Hardness	278	300	3	0.115384615	92.66666667	10.69231
Mn	2.4	0.1	4	0.153846154	2400	369.2308
Fe	0.13	0.3	4	0.153846154	43.33333333	6.666667
		sum=	26		WQI=	426.2846

The drinking water quality index for STW 1 is 180.3462, STW 2 is 158.5436, and STW 3 is 426.2846 from tables 5, 6, and 7, respectively. Given that STW 1 and STW 2 have DWQI values between 100 and 199.99, it can be said that the water quality in this area is poor (Table 3). Since STW 3's DWQI rating is higher than 300, it is believed that the water in this area is not fit for human consumption (Table 3).

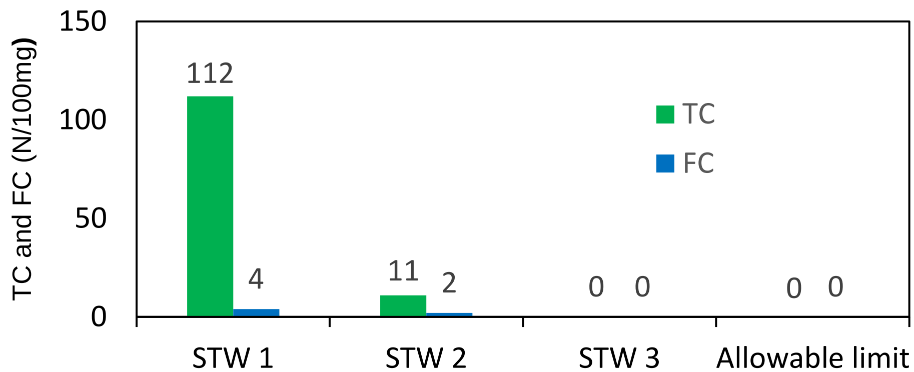

Figure 6: TC and FC in drinking water sample

When analyzing the microbiological quality of water, the coliform group is extremely important. According to ECR 1997, the coliform group's standard value is zero. Figure 3 shows that the total coliform and fecal coliform concentrations in SWT1 and SWT2 are 112, 4, and 11,2, respectively, while SWT3 has no TC FC concentration. The STW1 and STW2 drinking water sources are unsuitable for drinking purposes, and STW3 is suitable.

CONCLUSIONS

The Uttara EPZ in the Nilphamari region discharges wastewater containing a variety of physicochemical contaminants, some of which are above the standard value, such as DO (0.3 to 1.4 mg/l), BOD_5 (56 to 202 mg/l), and COD (70 to 269 mg/l). Most of the tested parameters are within the industrial wastewater allowable limit, such as pH, color, turbidity, Cl, TS, TDS, Fe, Mn, and As. However, if industrial waste is continuously dumped in a pond, the groundwater will be affected. The discharge of industrial effluent percolates through the soil, which may cause contamination of ground water by long-term discharge. Some parameters of drinkable water, such as TC (0 to 112 N/100 ml), FC (0 to 4 N/100 ml), and Mn (0.6 to 2.4 mg/l), exceed the permitted limit. Other metrics, including pH (6.7 to 7.6), turbidity (3.23 to 6.69 mg/l), hardness (56 to 278 mg/l), TDS (230 to 670 mg/l), Cl (8 to 83 mg/l), Fe (0.13 to 0.6 mg/l), and As (not detected), are within the permitted range. The DWQI analysis for STW 1 is 180.3462, STW 2 is 158.5436, and STW 3 is 426.2846, indicating that the sources of STW 1 and STW 2 have low-quality water, respectively, while STW 3 is unfit for drinking. All the drinking water sources are not suitable for drinking purposes. However, industrial waste is not put in those ponds; rather, it is disposed of at another location.

ACKNOWLEDGEMENT

We would like to express our appreciation to Khulna University of Engineering & Technology for supporting this research project with funds and lab space for the B.Sc. Engineering (Civil) thesis work.

REFERENCES

Abbasnia, A., Yousefi, N., Mahvi, A. H., Nabizadeh, R., Radfard, M., Yousefi, M., & Alimohammadi, M. (2019). Evaluation of groundwater quality using water quality index and its suitability for assessing water for drinking and irrigation purposes: case study of Sistan and Baluchistan province (Iran). Human and Ecological Risk Assessment: An International Journal, 25(4), 988-1005. https://doi.org/10.1080/10807039.2018.1458596

Shamsur, R., Muhammad, A. A., Azharul, M. I., Sayema, T. F. K., & Mohammod, L. K. (2017). Assessment of Drinking Water Quality and Hygienic Conditions of the People Living around the Dingaputha Haor Area of Netrokona District, Bangladesh. Research & Reviews: Journal of Ecology and Environmental Sciences, 5(1). https://www.researchgate.net/publication/321716345

Dhruba, A. R., Alam, K. N., Khan, M., Saha, S., Khan, M. M., Baz, M., ... & AlZain, M. A. (2022). IoT-Based Water Quality Assessment System for Industrial Waste WaterHealthcare Perspective. Journal of Healthcare Engineering, 2022.

Hossain, M. R., & Hassan, K. M. (2020). Statistical and gis based analysis of physicochemical parameters of ground water samples around rajbandh dumping site. https://www.researchgate.net/publication/339684275

Islam, N. (2018). *Impact of EPZ on National Economy of Bangladesh*. *20*(9), 23–35. https://doi.org/10.9790/487X-2009032335

Khan, M. K. A., Alam, M., Islam, M. S., Hassan, M. Q., & Al-Mansur, M. A. (2011). Environmental pollution around Dhaka EPZ and its impact on surface and groundwater. Bangladesh Journal of Scientific and Industrial Research, 46(2), 153-162.

Lakshmi, D., & George, J. (2014). Fluoride Adsorption View project Microbial Risk Assessment View project Assessment of Physico-Chemical and Microbiological Characteristics of Water Samples in Suttur Village, Nanjangud Taluk, Mysore, Karnataka, India. In *Int. Res. J. Environment Sci. International Science Congress Association* (Vol. 3, Issue 7). www.isca.me