ASSESSMENT OF THE IMPACT OF SUGERMILL WASTEWATER TO THE NEARBY CANAL AND GROUNDWATER

Fariha Nazneen Tisha*[1], Md. Asif Azad[2], Md. Aminur Rahman[3], Md. Mahmudur Rahman[4], Md. Saiful Islam[5], Md. Moynul Islam[6], Md. Tanver Hasan[7]

[1] Undergraduate Student, Bangladesh Army University of Engineering and Technology, Bangladesh, e-mail: *farihanazneen2611@gmail.com*

[2] Undergraduate Student, Bangladesh Army University of Engineering and Technology, Bangladesh, e-mail: *mdasifazad20101022@gmail.com*

[3] Undergraduate Student, Bangladesh Army University of Engineering and Technology, Bangladesh, e-mail: *yoishik@gmail.com*

[4] Associate Professor, Bangladesh Army University of Engineering and Technology, Bangladesh, e-mail: *drmahmudur.rits@gmail.com*

[5] Associate Professor, Bangladesh Army University of Engineering and Technology, Bangladesh, e-mail: *msaifuli2007@gmail.com*

[6] Assistant Professor, Bangladesh Army University of Engineering and Technology, Bangladesh, e-mail: *moynul.acct.ru.44 @gmail.com*

[7] Lecturer, Bangladesh Army University of Engineering and Technology, Bangladesh, e-mail: *tanverbauet152603@gmail.com*

***Corresponding Author**

ABSTRACT

The wastewater from sugar mills has a number of unfavorable properties. The wastewater typically has a medium to high BOD_5, COD loading, a high level of suspended and dissolved particles, and a strong color. The principal connected environmental effect of dumping effluent from a sugar mill into an open body of water is a change in the chemistry of the water. During decomposition, the wastewater creates a noxious odor. The wastewater from North Bengal Sugar Mill discharges into a canal through a untiled drain. The people near the canal use the canal water for showers and other household work, which leads to major health issues. The aim of this study was to assess the impact of sugar mill wastewater, which was discharged in the nearby canal. Also, the impact of sugar mill wastewater on the groundwater was assessed. Water sampling of the canal and groundwater was collected before and after the sugar mill wastewater was discharged. A total of eight station points from the connected drain/canal and four tubewell water station points were selected for sample collection before discharging the sugar mill wastewater during the sugar mill was closed for production as well as after discharging the sugar mill wastewater during the sugar mill opens for production. All samples were analyzed at the laboratory, and data was processed using Microsoft Excel 2021. It was found that the Sugar Mill wastewater increased the concentration of color ($p < 0.01$), turbidity ($p < 0.05$), iron ($p < 0.05$), hardness ($p < 0.01$), alkalinity ($p < 0.01$), chloride ($p < 0.01$), BOD ($p < 0.05$), and COD ($p < 0.01$) in surface water. Also, for groundwater, the concentration of alkalinity ($p < 0.01$) was increased due to Sugar Mill Wastewater.

Keywords: *Sugar mill, impact, wastewater, canal, groundwater.*

1. INTRODUCTION

Sugar industry play an important role in national economy and social development by creating job opportunities as well as using lands for farming. Also, the byproduct of sugar mill industry was used in in different in industry as raw material, land farming etc (Salequzzaman *et al.*, 2008). The activities of sugar mills are in need of huge amounts of fresh water for grinding processes and later on releasing bulk effluent into the environment (Qureshi *et al*., 2015). The change of water chemistry is the main environmental impact of the indiscriminate release of sugar mill effluent in an open water body. The effluents cause annoyance odor during their decomposition. Wastewater from sugar mills contains high levels of contaminants such as suspended solids, organic and inorganic matter, and chemicals. The sugar mills wastewater with its high BOD and COD rapidly consumes the available oxygen supply when discharged into water bodies. These effluents jeopardize fish and aquatic life and also create unhygienic septic conditions, creating foul-smelling hydrogen sulphide, which in turn may precipitate iron and any dissolved salts, turning the water black and extremely toxic for aquatic life (Salequzzaman et al., 2008). Sugar factory is basically seasonal which is operate only for 120-180 days in a year (November to April). The sugar mills on an average, create one cubic meter of wastewater per ton of milled sugar cane (Agrawal, undated). Most chemicals used in sugar processing are toxic which make poor quality of water bodies. These effluents not only increase the nutrient level, but also multiply the sufferance limits and hence causes vigorous toxicity (Mishra et al., 1999). The sugar mills' wastewater infiltrates into the subsoil and leaches into the groundwater, forming a contaminated pool by changing the geochemical characteristic of the groundwater. Wastewater discharge from sugar mills contaminates surface water as well as groundwater. The discharge of this wastewater from sugar mills to open water bodies with a high TDS adversely affects aquatic life, renders the receiving water unsuitable for domestic use, damages crop yield if used for irrigation, and intensifies corrosion in water systems and pipes (ETPI, 2001). Effluents with a high temperature can be of concern because high temperatures deplete dissolved oxygen levels in the water body. Effluents also somewhat change the natural pH level of the receiving water body. Such changes can tip the ecological balance of the aquatic system; excessive acidity, particularly, can result in the release of hydrogen sulphide. There are 17 sugar mills in Bangladesh, most of them were established in rural areas (Rahim et al., 2021). 15 of the sugar mills are active. In the Natore district, there are two sugar mills. One is Natore Sugar Mill which locate at Natore Sadar Upazilla. The other is the North Bengal Sugar Mill, which is located at Lalpur Upazilla. The wastewater from North Bengal Sugar Mill discharges into a canal through a untiled drain. The people near the canal use the canal water for showers and other household work. Dermatitis, skin disease, or any other waterborne disease is a major health problem resulting from domestic use of eutrophied water (Nadia & Mahmood, 2006). The objectives of the research are to evaluate the impact of Sugar mill wastewater on nearby canals and groundwater. To investigate this, samples were collected from nearby canals and groundwater before and after Sugar mill wastewater was mixed with it and compared.

2. METHODOLOGY

3. Study Area

North Bengal sugar mill was selected for the present study which was located at Lalpur Upazila in Natore District in Bangladesh. The sugar mill's untreated wastewater passed through a non-tiled open drain, which collected wastewater from the local area, and then fell into the nearby canal. The study map is shown in Figure 1. The North Bengal Sugar Mill only operated for three months a year (November to February).

Figure 1: Surface Water and Ground Water Sample Collection Stations at Study Area.

4. Sample Collection

The sampling method involves purposive or deliberate selection of particular units of sampling area for constituting a sample, which represent the universe (Salequzzaman et al., 2008). A reconnaissance survey was done around the North Bengal Sugar Mill and canal areas for sampling. A total of 8 sampling point was selected from non-tiled drain and canal, which was considered surface water and denoted as (S). For groundwater, 4 tubewells were selected for sampling points (denoted as G) within a 150 m radius of the canal. All the sampling stations' GPS locations were collected by Redmi Note 10S device, as shown in Table 1. Samples were collected in September 2023 to get Sugar Mill wastewater before mix samples and in November 2023 to get after mix samples.

Table 1: Water Sample Collection Stations location

Station No	Location	
	N	E
S1	24°12'49.94"	88°59'45.75"
S2	24°12'46.68"	88°59'37.03"
S3	24°12'46.11"	88°59'36.81"
S4	24°12'38.88"	88°59'30.16"
S5	24°12'35.86"	88°59'32.07"
S6	24°12'27.58"	88°59'43.19"
S7	24°12'13.08"	88°59'57.85"
S8	24°12'8.22"	89°0'15.3"
G1	24°12'47.0"	88°59'44.3"
G2	24°12'31.6"	88°59'32.0"
G3	24°12'27.54"	88°57'0.11"
G4	24°12'11.22"	88°59'49.8"

5. Laboratory Test

To know the water quality of the collected samples, they were brought in the Environmental Engineering Laboratory, Dept. of Civil Engineering, Bangladesh Army University of Engineering and Technology. The analyzed parameters were pH (Lutron Multimeter, WA-2015), Color (Spectrophotometer, HACH DR 3900), Turbidity (Turbidity Meter, TUB-430), EC (Lutron Multimeter, WA-2015), Alkalinity (HI 3812 Hardness Test Kit), Hardness (HI 3821), Chloride (HI 3815), Iron (Spectrophotometer, HACH DR 3900). Also, TSS, TDS, BOD, and COD were carried out according to the APHA (2017) method.

6. Data Analysis

Data processing and statistical data analysis were done using Microsoft Office Excel 2021. Bangladesh Environment Conservation Rules (ECR) (2023) and World Health Organization (WHO) (2006) were used to compare results.

7. RESULTS AND DISCUSSION

8. Surface Water

The pH is one of groundwater and surface water's most important physiochemical parameters. According to the ECR 2023 inland surface water standard, the pH value should be 6 to 9. From Figure 2 (a), it was seen that the pH was found within the range of ECR 2023, which indicates pH would not pose any adverse impact to the surface water. Similar results were found by Tabriz *et al.* (2011) in the same area. The maximum value of color was found in S1 in the after mix, which was 1434 Pt-co, and the lowest was found in S8 in the before mix (Figure 2 (b)). After mixing, it was seen that the color was reduced from S1 to S8, which was justified as Sugar Mill wastewater was mixed with existing water and diluted. However, before mixing at S6 and S7, color was slightly increased due to jute retting as Ahmed and Akhter (2001) reported that the degradation process of jute produces smell and change in color of the water used for retting. The color concentration was found to be significantly different ($p < 0.01$) before mixing and after mixing, which indicates that the sugar mill wastewater increased the concentration of the surface water. Before mixing, the turbidity was found to be very small (< 25 NTU), but after mixing, turbidity was increased ($p < 0.05$), which confirms that Sugar Mill wastewater has an impact on surface water, as shown in Figure 2 (c). From Figure 2 (d), it was seen that the TSS was high in after-mix samples compared to before-mix samples except S7. All samples TSS were within the standard limit of ECR (2023).

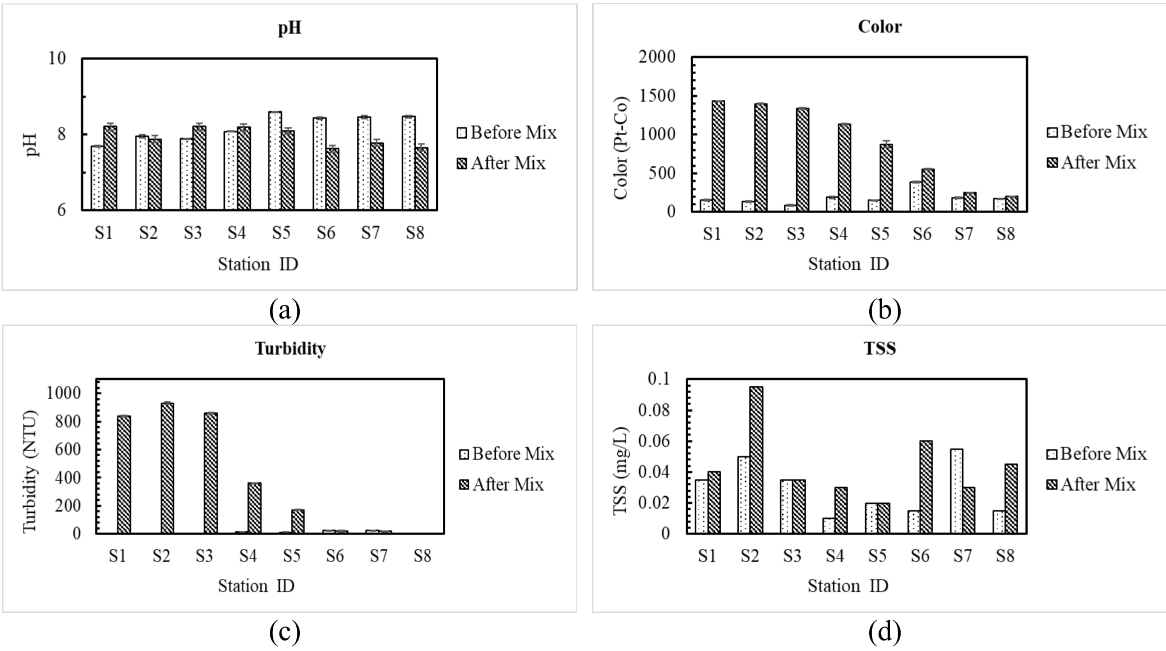


Figure 2: Variations of Before and After Mix of Sugar-Mill Wastewater for surface water (a) pH, (b) Color, (c) Turbidity and (d) TSS.

According to the ECR 2023 inland surface water standard, the iron value should be 3 mg/l. Before starting the manufacturing activity of the sugar mill, the iron value varies from 0.23 mg/L to 0.75 mg/L, which maintains the standard value as shown in Figure 3 (a). After starting the sugar mill's manufacturing activity, the iron value varies from 0.13 to 2.24 mg/L. The iron concentration of before mixing wastewater was found to be significantly different ($p < 0.05$) than after mixing, which indicates that sugar mill wastewater increased the iron concentration. Before starting the sugar mill's manufacturing activity, the hardness value varied from 123 mg/L to 455 mg/L (Figure 3 (b)). After starting the sugar mill's manufacturing activity, the hardness value varies from 202 mg/L to 478 mg/L. The hardness concentration before mixing was also found to be significantly different ($p < 0.01$) than after mixing. As per the ECR 2023 inland surface water standard value for BOD_5 should be 30 mg/l. Before commencing the manufacturing process in sugar mills, the wastewater typically exhibits a BOD range of 1.9 to 74 mg/L, as shown in Figure 3 (c). At S5, the BOD5 value was higher than S4 because at S5, there was jute for the degradation process. The degradation process of jute generates a high level of BOD_5 (Roy & Hassan, 2016). After starting the sugar mill's manufacturing activity, the BOD range was 6 to 84 mg/L, which was significantly different ($p < 0.05$) than before mixing. COD is an important indicator of the deterioration of water quality from the discharge of untreated industrial effluent. According to the ECR 2023 inland surface water standard, the COD value of the effluent should be 200 mg/L. Figure 3 (d) shows that, before starting the manufacturing activity of the sugar mill, the COD range is 50 mg/L to 504 mg/L. The COD varies from 339 mg/L to 504 mg/L in S1 to S4, respectively, and the COD varies from 77 to 46 mg/L in S5 to S8, respectively. The result showed that all of the values of S1 to S4 are greater than the standard value of ECR (2023). The rest of the stations maintain the standard value. After starting the manufacturing activity of the sugar mill, the COD value of the wastewater varied from 1440 mg/L to 1629 mg/L, which was much higher than the standard value and significantly different ($p < 0.01$) than before mixing. Alkalinity is essential for fish and aquatic life because it protects against rapid pH changes large amount of alkalinity imparts bitter test in water. Before starting the manufacturing activity of the sugar mill the alkalinity value varies from 182 mg/L to 427 mg/L (Figure 3(e)). After starting the manufacturing activity of the sugar mill the alkalinity value varies from 346 mg/L to 481 mg/L. The statistical analysis showed that the alkalinity concentration before mixing was found to be significantly different ($p < 0.01$) than after mixing. According to ECR 2023, on inland surface water, the standard value of Cl should be 600 mg/L. Before starting the manufacturing activity of the sugar mill, the Cl varied from 8 mg/L to 31.66 mg/L, which maintains the standard value (Figure 3 (f). After starting the manufacturing activity, the Cl varied from 26.33 mg/L to 64.66 mg/L, which was within the standard limit but was found to be significantly different ($p < 0.01$) than before mixing.

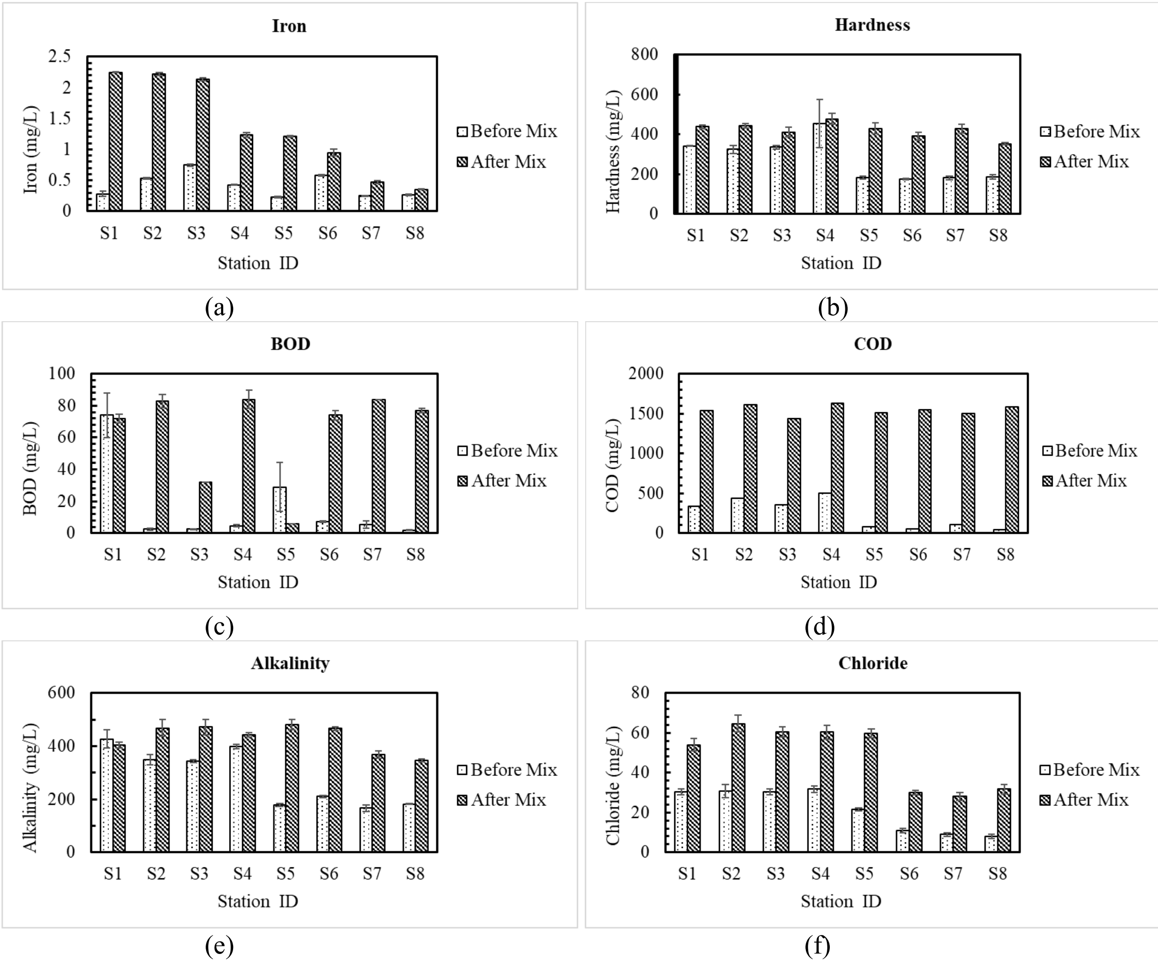
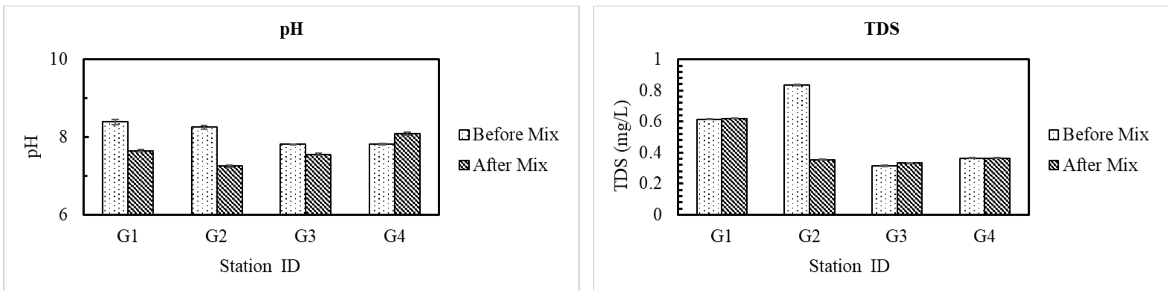


Figure 3: Variations of Before and After Mix of Sugar-Mill Wastewater for surface water (a) Iron, (b) Hardness, (c) BOD, (d) COD, (e) Alkalinity and (f) Chloride

9. Ground Water

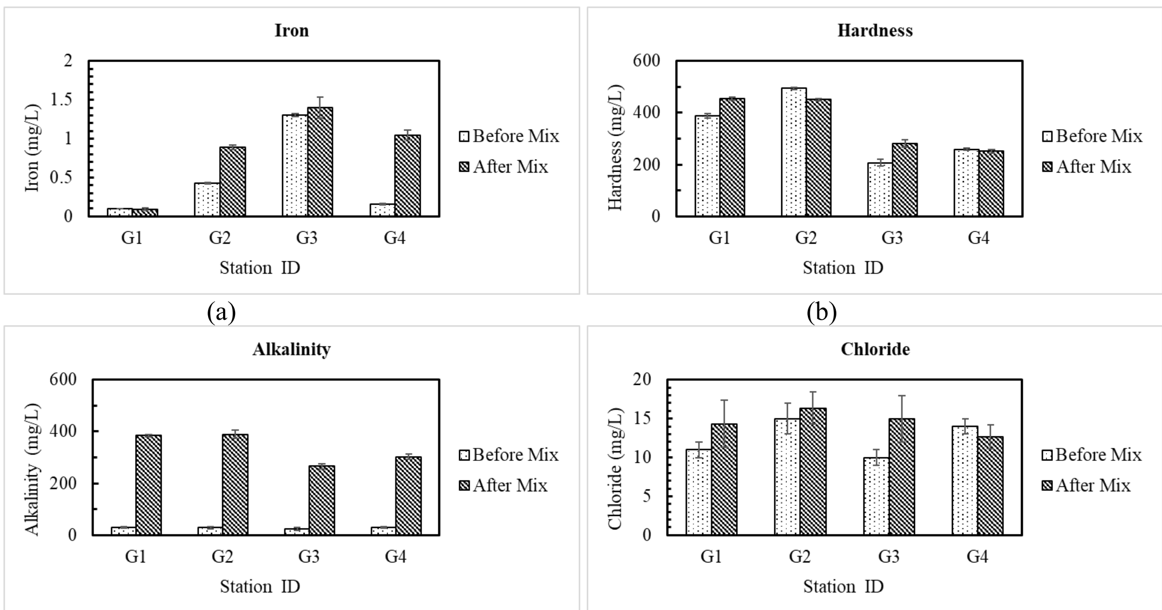
The pH is one of groundwater and surface water's most important physiochemical parameters. As per the ECR 2023 standard value of the pH range for drinking water should be 6.5 to 8.5. From Figure 4(a), it was seen that before starting the manufacturing activity of the sugar mill, the pH range was 7.8 to 8.3, which does maintain the standard value. After starting the manufacturing activity of the sugar mill, the pH range is 7.25 to 8.08, which is usable. According to the ECR 2023, the standard value of TDS for drinking water should be 1000 mg/L. Before starting the manufacturing activity of the sugar mill, the TDS value varies from 0.315 mg/L to 0.835 mg/L, which maintains the standard value as shown in Figure 4(b). After starting the sugar mill's manufacturing activity, the TDS value varies from 0.33 mg/L to 0.62 mg/L.

Humans suffer no harmful effects from drinking water containing iron. According to the ECR 2023, the standard value of the Iron for drinking water should be 0.3 mg/L to 1 mg/L. It was found that, before starting the sugar mill's manufacturing activity, the iron value maintained the standard value except S3 (which is 1.3 mg/L), as shown in Figure 5(a). After starting the sugar mill's manufacturing activity, the iron value varies from 0.09 mg/L to 1.40 mg/L. According to WHO standards in drinking water, hardness is in the range of 10–500 mg of calcium carbonate per liter. Before starting the manufacturing activity of the sugar mill, the hardness value maintains the standard value, which varies from 207 mg/L to 494 mg/L. After starting the manufacturing activity of the sugar mill, the hardness value varies from 251 mg/L to 456 mg/L (Figure 5(b)). According to WHO, the total alkalinity of drinking water should be 200 mg/L. Figure 5 (c) shows that before starting the manufacturing activity of the sugar mills, the alkalinity value varies from 25 mg/L to 30 mg/L. After starting the manufacturing activity of the sugar mill, the value of alkalinity varied from 266 mg/L to 389 mg/L, which was higher than the alkalinity value before starting the manufacturing activity of the sugar mills ($p < 0.01$) and exceeded the standard limit. Anoop and Renu (2014) stated that the presence of large amounts of carbonate ions in Sugar Mill wastewater was responsible for high alkalinity in groundwater. According to the ECR 2023, the standard value of chloride for drinking water should be 250 mg/L. It was found that before starting the manufacturing activity of the sugar mill, the chloride range was 10 to 15 mg/L, which does maintain the standard value. After starting the manufacturing activity of the sugar mill, the chloride range is 12.66 to 16.33 mg/L (Figure 5(d)). As per WHO, for drinking water, the BOD limit is 5.0 mg/L. At this limit, BOD will not cause any harmful impacts on the human body. Before starting the manufacturing activity of the sugar mill, the BOD value varies from 0.7 mg/L to 2.3 mg/L (Figure 5(e)). After starting the manufacturing activity of the sugar mill, the BOD value varies from 0.3 mg/L to 1.4 mg/L.

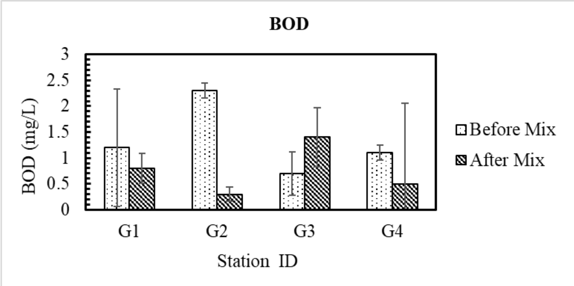


(a) (b)

Figure 4: Variations of Before and After Mix of Sugar-Mill Wastewater for ground water (a) pH, (b) TDS.



(c) (d)



(e)

Figure 5: Variations of Before and After Mix of Sugar-Mill Wastewater for groundwater (a) Iron, (b) Hardness, (c) Alkalinity, (d) Chloride, and (e) BOD

10.CONCLUSIONS

Experimental research had been performed before and after Sugar Mill wastewater mixing to know about assessable wastewater contamination of the North Bengal Sugar mill. It was found that -

- In the surface water sample, the maximum value of color was found in S1 in the after mix, which was 1434 Pt-co, and the lowest was found in S8 in the before mix. Also, before mixing at S6 and S7, the color was slightly increased due to jute retting.
- The turbidity before mixing was found to be very small (<25 NTU), but after mixing, turbidity was found to be increased for surface water.
- TSS was found high in after-mix surface water samples compared to before-mix samples except S7.
- The sugar mill wastewater increased the concentration of color, hardness, alkalinity, chloride, and COD of the surface water as the before-mixing and after-mixing concentrations were found to be significantly different ($p < 0.01$), and for turbidity, iron, and BOD significant level was $p < 0.05$.
- The groundwater samples show that pH, TDS, chloride, and BOD concentrations were found within the standard limit of drinking water. The sugar mill wastewater impact was found only in alkalinity concentration ($p < 0.01$).

From the above discussion, it is clear that the surface water becomes polluted due to sugar mill wastewater surrounding the canal area. Without proper treatment, the wastewater may cause serious health issues to people near the canal by using contaminated canal water. The fish of the canal are under menaces due to water contamination. Also, groundwater was slightly polluted by sugar mill wastewater. However, more groundwater and surface water station samples around the canal will be investigated to gain a deeper understanding and bacteria test will be conducted for groundwater. Also, a questionnaire survey will be conducted in the area to find the health effects of using sugar mill wastewater mixed with surface or groundwater.

ACKNOWLEDGEMENTS

This research was funded by Bangladesh Army University of Engineering and Technology (BAUET) Qadirabad, Dayarampur, Natore-6431, Bangladesh, by an interdisciplinary research program under allocation for science, engineering, and technology innovation (2023 -2024).

REFERENCES

Agrawal, G.D. undated. Waste management and pollution control for Bangladesh sugar factories and distilleries. Unpublished lecture note to Bangladesh Sugarcane Research Institute (BSRI), Ishurdi.

Ahmed Z. and Akhter F. (2001). Jute retting: An overview. *Journal of Biological Sciences*, 1(7), 685-688. https://doi.org/10.3923/jbs.2001.685.688.

Anoop, Y., and Renu, D. (2014). Effect of Sugar mill on Physico-Chemical Characteristics of Groundwater of Surrounding Area. *International Research Journal of Environment Sciences*, 3(6), 62-66. https://www.isca.in/IJENS/

APHA (American Public Health Association) (2017). Standard methods for the examination of water and wastewater (23rd edition). American Public Health Association, American Water Works Association, Water Environment Federation.

ECR (2023) The Environment Conservation Rules. Government of the People's Republic of Bangladesh. Ministry of Environment and Forest

ETPI. 2001. Environmental Technology Program for Industry "Environmental Report on Sugar Sector" Monthly Environmental News 5, Issue 7, pp. 11-27.

Mishra, S., Tiwari, T.N., Mishra, P.C. 1999. Bioaccumulation and bioconcentration of metals in water and sediment of river Brahmani at Rourkela. In: Modern Trends in Environmental Pollution and Ecoplanning, A. Kumar (ed.), pp. 21-28, ABD Publication, Jaipur, India.

Nadia M A. and Mahmood A K. (2006). Study on Effluent from Selected Sugar Mill in Pakistan: Potential Environmental, Health, and Economic Consequences of an Excessive Pollution Load, Sustainable Development Policy Institute (SPDI).

Qureshi, A. L., Mahessar, A. A., Leghari, M. E., Lashari, B. K., & Mari, F. M. (2015). Impact of releasing wastewater of sugar industries into drainage system of LBOD, Sindh, Pakistan. *International Journal of Environmental Science and Development*, 6(5), 381-386. https://doi.org/10.7763/ijesd.2015.v6.622.

Rahim, M.A., Mostafa. M.G. (2021). Impact of sugar mills effluent on environment around mills area. *Journal of AIMS Environmental Science*, 8(1): 86–99.

Roy S., Hassan K.M., (2016). *Scenario water pollution by retting of jute and its impact on aquatic lives*. Journal of the 3rd International Conference on Civil Engineering for Sustainable Development. pp. 164-169.

Salequzzaman, M., Tariqul-Islam, S.M., Tasnuva, A., Kashem, M.A., Mahedi Al Masud, M. (2008). Environmental impact of sugar industry – A case study on Kushtia Sugar Mills in Bangladesh. *Journal of Innovation and Development Strategy*, 2: 31-35.

Tabriz, S., Mojid, M., & Wyseure, G. (2011). Irrigation suitability of north Bengal sugar Mill's effluent and its impact on soil properties. *Journal of the Bangladesh Agricultural University*, 9(2), 283-290. https://doi.org/10.3329/jbau.v9i2.11042

WHO (World Health Organization). 2006. Guidelines for the safe use of wastewater, excreta and grey water: wastewater use in agriculture, Volume L. Geneva: World Health Organization.