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Research Article

Impact of the tannery industrial zone on the physicochemical and microbiological quality of the Dhaleshwari river water, Bangladesh

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ABSTRACT

The main aim of this study is to investigate the effect of tannery effluents on the Dhaleshwari River water near Savar, Dhaka. The physicochemical properties analyzed included pH, electrical conductivity (EC), dissolved oxygen (DO), total dissolved solids (TDS), total hardness (TH), chloride ion (Cl^-), sodium ion (Na^+), potassium ion (K^+), chromium (Cr), lead (Pb), and cadmium (Cd) to determine the current pollution status of the river. The pH was 5.50-7.64. The EC was 207.40-258.60 μScm^{-1}, indicating standard ionic species in the water. TDS levels were 149.00-177.00 mgL^{-1}. Na^+ and K^+, determined using a flame photometer, ranged from 28.49-34.48 mgL^{-1} and 2.92-3.94 mgL^{-1}, respectively. Cl^- content, measured by titrimetric method, ranged from 8.50-30.23 mgL^{-1}. Heavy metals were analyzed using an Atomic Absorption Spectrophotometer (AAS), revealing Pb levels below the detection limit (BDL) to 0.07 mgL^{-1} and Cr levels from BDL to 0.015 mgL^{-1}. At the same time, Cd was BDL in all samples. The microbial analysis detected only coliform bacteria, including E. coli and Salmonella sp. The study concludes that the Dhaleshwari River shows evidence of pollution from tannery effluents, particularly in heavy metals and microbial contamination, although some physicochemical properties remain within standard levels.

Introduction

Bangladesh is home to over 230 large and small rivers, crucial in domestic, industrial, agricultural, and aquaculture activities. However, water quality in these rivers is deteriorating due to untreated industrial effluents, municipal wastewater, runoff pollution from chemical fertilizers and pesticides, and oil spillage from sea and river port operations (Akter et al., 2019). The Bangladeshi economy heavily relies on industries, particularly the leather industry, which provides significant employment opportunities and economic growth. Unfortunately, these industries pose substantial environmental health risks due to the discharge of liquid effluents and solid waste in adjacent low-lying areas (Khan, 2014). Water consumption and the daily production rate of different industries can change effluents' amounts and features (Sarker et al., 2013). Compared to other sectors, leather tanning is one of the most polluting activities because of its high water consumption and production of hazardous liquid effluents. The productive cycle of the industry uses chromium (Cr), the most concerned discharged pollutant. These pollutants cause variations in pH and increase TDS (Dixit et al., 2015).

The leather industry in Bangladesh consists of almost 220 tanneries, 3,500 MSMEs, 2500 footwear companies, and more than 90 enterprises. Tanneries were mainly located in Narayanganj at the beginning of the tannery industry in Bangladesh. After that, the central location was Hazaribagh of Dhaka.

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Regrettably, the businesses are struggling; 105 out of 155 tanneries have been relocated to Savar Industrial Park. Before the relocation, the major pollution in the Buriganga River was caused by the untreated liquid from tanneries produced during the treatment of about 60,000 tons of raw hides and skins (Azom et al., 2012). The contamination of rivers also accumulated in common fish species used as local food sources. The tanneries have recently been around the Dhaleshwari River of the Savar district. In central Dhaka, the Dhaleshwari River is one of the primary distributaries in central Dhaka, stretching 160 kilometers in length with an average depth of 37 meters (Raknuzzaman et al., 2016; Ahsan, 2018). The river receives huge amounts of municipal waste, leather industry waste, and directly or indirectly treated sewage water (Mohanta et al., 2019). These pollutants make the aquatic environment unsuitable for living, especially since the water quality parameters are not up to the WHO standard for drinkable water. The contaminants in rivers can cause long and short-term diseases. The physiochemical quality has also deteriorated (Islam et al., 2021a). Physiochemical and microbiological parameters can give overall information on the current state of water of the Dhaleshwari River. Water can taste bitter or contain increased oxygen because of its high pH (Edzwald, 2010).

On the other hand, metals or other substances will be corroded or dissolved in low-pH water (APHA, 2005; Baird et al., 2017). EC is strongly related to water pollution. Pure water is a good conductor of electrical current, increasing with increasing ions (Meride and Ayenew, 2016).

A water source is good for aquatic life if its DO value is higher (Ali and Vijayan, 1986). Lower DO may cause stress and mass mortality in marine animals (Sajid et al., 2024). Higher BOD (Biological Oxygen Demand) of water reduced the DO (Verma and Singh, 2013). Again, low TDS levels in water are not beneficial for thirsty and malnourished people and accelerate kidney problems, heart disease, pregnancy complications, etc. (Peavy et al., 1985). EC is proportional to TDS (Das et al., 2006). Higher hardness refers to highly mineralized water (APHA, 2005). Calcium ion (Ca^{2+}) and Magnesium ion (Mg^{2+}) mainly cause hardness. Though sodium, potassium, and chloride ions are not harmful at normal levels, they cause concern in high concentrations and can cause diseases. High potassium levels in the body result in arrhythmias (Brown et al., 1984). Conversely, excess chlorine levels in rivers that may come from wastewater can cause toxicity symptoms like discoloration and broken vertebrae in fish (Ribeiro et al., 2015). The tannery wastewater can significantly contain chlorides, sulfates, sulfides, and other heavy metals. Excessive contamination of surface water by heavy metals is a global public health concern (Rashid et al., 2023). They can enter the food chain by unrestricted disposal of industrial waste. Lead (Pb) can cause anemia, disturbed reproduction, high blood pressure, and kidney ailments (Jakubowski, 2011). In contrast, a high chromium (Cr) level causes kidney damage, dermatitis, and respiratory problems (Beaumont et al., 2008). Total microbial count (*E. coli*, Total Coliform, Fecal Coliform, and *salmonella*) is another important parameter of water quality. Surface water is more susceptible to bacterial pollution than groundwater as the soil and water through which groundwater flows screen out most of the bacteria (Adesakin et al., 2022). The productive cycle of the industry uses chromium (Cr), the most concerned discharged pollutant (Oludairo and Aiyedun, 2016). Temperature, color, taste, and odor are essential water quality indicators.

As water is vital for our life and environment and because different physicochemical water quality parameters are changing, it is essential to supervise the conditions of rivers, especially those around different industries. The objective of this present work is the quantitative analysis of different physiochemical parameters like pH, EC, TDS, DO, total hardness including sodium, potassium, and chloride ions, and other heavy metal contents (Pb, Cr, and Cd) in the water of Dhaleshwari River. The microbial pollution status in the surface water of this river is another prominent target of this research.

Materials and Methods

Sample collection and pre-treatment

The Dhaleshwari River begins its route from the Jamuna River near the northwestern edge of the district and later merges with the Shitalakshya River in Dhaka-Narayanganj. The merged flow then proceeds southward to join the Meghna River (Islam et al., 2021b). This study's samples were taken from designated locations where the river traverses the industrialized Savar District. The experimental site is situated within the tannery estate in Savar, adjacent to the Dhaleshwari River (Table 1). Exactly 24 surface water samples were collected from the river in Hemayetpur near the tanneries and around 2 km away from the tannery dumping area, and each sample was collected at around 100 m apart. All the samples were collected in HDPE plastic bottles, labeled accordingly, and transported to the laboratory of the Department of Chemistry, University of Dhaka. The samples were kept at –20°C and taken to room temperature before the experiment.

Experimental procedure

A 100 mL beaker filled up to two-thirds with the sample to measure pH. The glass electrode of the pH meter was washed with distilled water and cleaned softly with tissue. Then, it was placed in sample water. The pH value displayed on the screen was recorded. Conductivity was measured using a conductivity meter following the same procedure as pH. A 50.0 mL water sample was taken in a titration flask to determine Chloride Content. 4-7 drops of mixed indicator (Diphenyl carbazone + Bromophenol Blue) were added. The color of the sample became violet, which disappeared by adding 0.2M HNO_3. The color became yellow. After adding 4-5 drops more 0.2M HNO_3, titration was completed using 0.1M $Hg(NO_3)_2$. The volume of the titrant was recorded. Concentration was determined using the given equation: 1 mL of 0.1 M Hg^{2+} = 0.2 mmol Cl^- = 7.10 mg Cl.

For the determination of DO, a bottle was filled with sample water at 6.0 mL, which was less than its volume. 2.0 mL of $MnSO_4$ solution and 2.0 mL of alkali-iodide-azide reagent, which goes well below the surface of the liquid, were added. It was mixed by inverting the bottle several times at 2.0 mL of conc. H_2SO_4 was added.

Table 1. Site description of the sampling area of Dhaleshwari River, Bangladesh.

Sample	Latitude	Longitude
S-1	23.78063 ‘N	90.41932’E
S-2	23.78111’N	90.24043’E
S-3	23.78050’N	90.24024’E
S-4	23.77972’N	90.23995’E
S-5	23.77873’N	90.23975’E
S-6	23.77800’N	90.23951’E
S-7	23.77720’N	90.23918’E
S-8	23.77635’N	90.23890’E
S-9	23.77486’N	90.23965’E
S-10	23.77439’N	90.24110’E
S-11	23.74421’N	90.23790’E
S-12	23.74412’N	90.23800’E
S-13	23.76502’N	90.95906’E
S-14	23.76502’N	90.23937’E
S-15	23.76417’N	90.23977’E
S-16	23.75508’N	90.24806’E
S-17	23.76116’N	90.24084’E
S-18	23.7602’N	90.24087’E
S-19	23.7586’N	90.24168’E
S-20	23.75736’N	90.24240’E
S-21	23.75589’N	90.24428’E
S-22	23.75538’N	90.24555’E
S-23	23.75349’N	90.24772’E
S-24	23.75508’N	90.24806’E

After 10 minutes, the content of the bottle was transferred into a conical flask. Released iodine was titrated with 0.025 M $Na_2S_2O_3$ using the starch indicator. DO was determined using the given equation 1mL 0.0125M $Na_2S_2O_3$ = 0.1 mg DO

$$DO\ (mgL^{-1}) = \frac{\text{mL of titrant} \times 1000 \times 0.1}{\text{Volume of D.O. bottle (mL)}}$$

For the determination of TH, dilute HCl was used to acidify 50.0 mL of sample water and heated for about 1 minute to drive off CO_2. It was cooled and neutralized with Sodium Hydroxide. 1 mL of buffer ammonium buffer solution and 3-4 drops of Erichrome Black T indicator were added. Titration was completed using 0.01M EDTA solution. Hardness was determined using the given equation; 1mL of 0.01M EDTA = 1. 000 mg. $CaCO_3$

A flame photometer was employed to determine the Na^+ and K^+. The flame photometer underwent calibration using standard sodium (Na^+) stock solutions at concentrations of 10, 20, 30, 40, and 50 ppm. Potassium (K^+) calibration utilized standard 1, 2, 3, 4, and 5 ppm solutions. Additional instrumental parameters were adjusted to optimize the flame. Following calibration, water samples were examined by transferring 50 mL from each collected sample into standard laboratory plastic bottles, and readings from the flame photometer were recorded. Concentration was determined using calibration curves.

To determine the bacterial load, samples were initially diluted up to 10^{-2} and cultured by following a technique called pour plate technique. Specifically, 1 mL of each sample was mixed with 9 mL of distilled water to achieve a 1:10 dilution (10^{-1}). Using sterile pipettes, 1 mL from the 10^{-1} dilution was taken to another vial having 9 mL of distilled water, resulting in a 1:100 dilution (10^{-2}). Subsequently, 1.0 mL of each dilution was plated using a sterile pipette covered with a petri dish. Sterile melted media specific to Eosin Methyl Blue Agar (EMB) was poured onto the plates, which were then rotated to ensure the media was even spread. Bacterial colonies grown on the EMB plates were further cultured in LB broth containing yeast extract 0.5%, NaCl 1%, and tryptone 1% at 44.5°C under a laminar flow hood. Colonies were subsequently subcultured on MacConkey agar plates. The colony numbers were counted using a colony counter, and the total plate count was performed by multiplying the colony count by the dilution factor. The mean value of the total plate count for each dilution represented the total bacterial count.

Additionally, water samples were examined for total coliform count using the Most Probable Number (MPN) method and screened for the presence of *E. coli*. The sample incubation was done in LB broth at 44.5°C for enrichment and observed after overnight incubation. Confirmation of the presence of E. coli, a fecal indicator, was based on gas production and color changes in the media. EMB agar was employed as a selective medium for detecting E. coli colonies.

Initially, standard solutions for all the heavy metals being studied were prepared at various concentrations, ranging from three to five, by diluting a stock standard solution with a concentration of 1000 ppm. Water samples under study were filtered first using Whattman Fitter paper no. 42. Cr, Cd, and Pb concentrations were measured using AAS. Standard operation parameters were set. The hollow cathode lamp for Cr, Cd, and Pb was used as a radiation source, and air acetylene was used as fuel.

Results and Discussion

pH of the twenty-four sample waters is given in Fig. 1. The highest frequency value was pH 7.64, followed by pH 7.62 and pH 7.60. pH values are between 5.50-7.64, indicating that some samples are slightly acidic and some are somewhat basic. Twelve of the samples are slightly below the recommended level. In contrast, other samples are within the standard level (Fig. 1). Low pH may be due to industrial pollution, chemical dumps, power plants, etc. This will lead to a bad impact on aquatic organisms (Norton et al., 2008). Sample S-19 has the lowest pH, and S-1 has the highest pH. A previous study of the Dhaleshwari River showed that pH was between 7.68-8.03. pH was basic, which differed from our study (Islam et al., 2021a). The electrical conductivity implies overall ionic species in water (Nancarrow et al., 2021). Higher EC indicates higher ions and moderate EC indicates a good number of ions in water (Uddin et al., 2014). The specific conductance of most natural water ranges from 50-1500 µScm^{-1}. From Fig. 1, the EC of sample waters ranges from 207.4-258.6 µScm^{-1}, which is lying within the standard level of EC (Islam et al., 2021a). Most of the samples are within the range of 230-250 µScm^{-1}. Previous studies showed that EC was in the range of 140-395 µScm^{-1} (Rikta et al., 2016), which agrees with this study. Oxygen is the single most important gas for most aquatic organisms. Fishes will have no support if the DO level is less than 1 mgL^{-1}. For the fish population 5.0-8.5 mgL^{-1} DO is

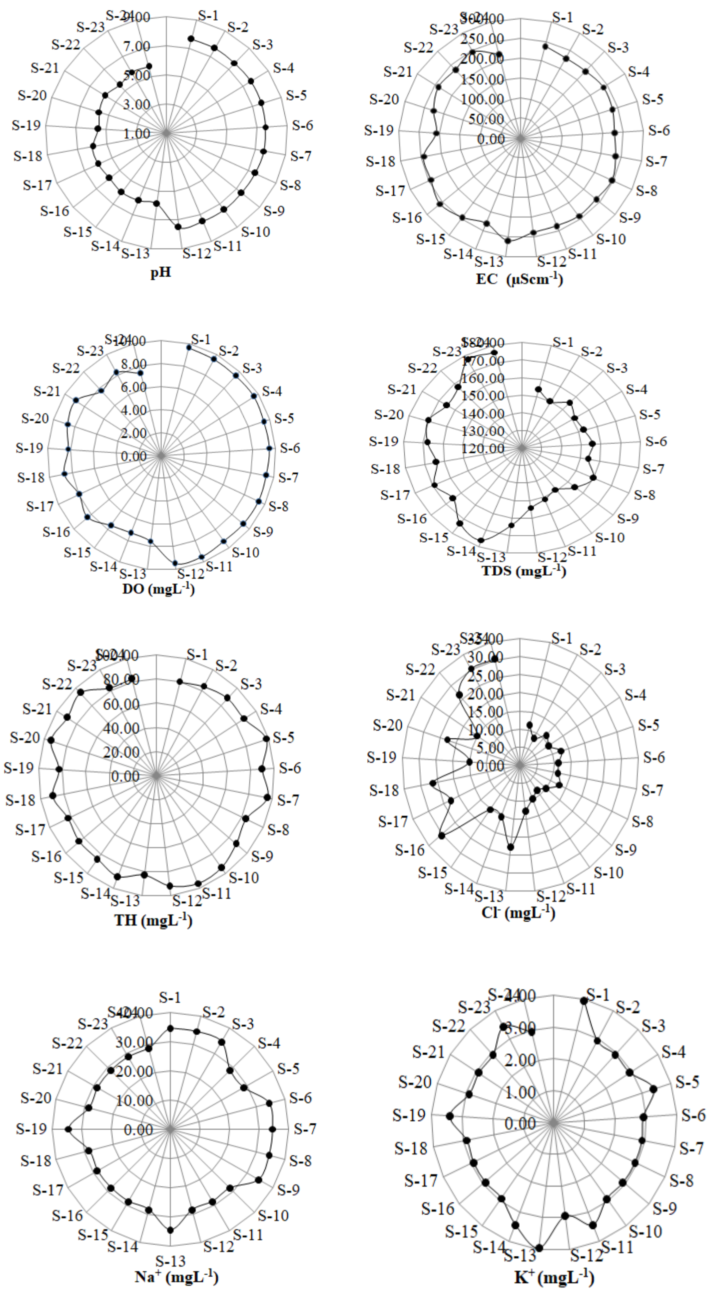

Fig. 1. Spatial variation of water quality parameters of Dhaleshwari River water.

required (Ali et al., 2022). Fig. 1 shows DO value of collected samples where DO is between 7.24-9.67 mgL^{-1}. This indicates that DO is within and, for some samples, is slightly higher than the permissible limit. Sample S-1 has the highest DO, and sample S-14 has the lowest DO. A previous report shows that DO has increased as their result indicated an average DO of 5.0 mgL^{-1} (Rikta et al., 2016). In natural water, dissolved solids primarily consist of Na^+, K^+, Ca^{2+}, Mg^{2+}, and ions such as Cl^-, SO_4^{2-}, PO_4^{3-}, $H_4SiO_4^{2-}$, and HCO_3^-. High levels of dissolved substances make water unsuitable for general use (Afrad et al., 2020). TDS in sample waters is decreasing in the series S-23> S-14 = S-24 > S-15 > S-20 > S-17 > S-19 > S-22 > S-21 = S-16 >S-13= S-18 > S-8 > S-6 > S-3 = S-9 >S-01 = S-12 = S-07 > S-05 > S-04 >S-11 > S-02 > S-10. It varies from 149 to 177 mgL^{-1} (Fig. 1). It is within the standard value. TDS value changed a lot from 2016 as it was between 634-1265 mgL^{-1} before (Rikta et al., 2016). The overall condition, given TDS, has improved. Hardness measures the concentration of dissolved calcium and magnesium in water. The ideal drinking water for most consumers typically contains approximately 10.00-100.00 mgL^{-1} of TH as $CaCO_3$ (Islam et al., 2016). The hardness of water samples is 80.00-94.08 mgL^{-1}. In this study, all the values fall within the accepted limits as per the WHO standards (Prosun et al., 2018). The water samples are moderately hard (Fig. 1). Chloride indicates salinity in water. Na content can also be high if the amount of chloride in water is high. Cl^- is primarily a stable parameter and can indicate pollution in natural freshwater environments (Dugan et al., 2017). The chloride concentration in the study is given in Fig. 1. Chloride content of samples ranges from 8.50-30.23 mgL^{-1}. The comparison between the average and standard values of chloride indicates slight deviations, both higher and lower. It may refer to a little impurity in river water. S-16, S-23, and S-24 have the highest Chloride, and S-2 and S-10 have the lowest Chloride content. Na^+ content was 28.49 mgL^{-1} and 34.48 mgL^{-1}. Fifteen of the samples have the same Na^+ content. The other nine samples have equal content. K^+ content in water is in the range 2.92-3.94 mgL^{-1}. Fig. 1 shows that eight of the samples (S-15, S-16, S-17, S-18, S-20, S-21, S-22 and S-24) have same K^+ content (2.92 mgL^{-1}). S-5, S-11, S-14, S-19 and S-23 have same K^+ content (3.43 mgL^{-1}). Again S-1 and S-13 have equal K^+ content (3.94 mgL^{-1}).

The findings show that the Na^+ and K^+ content in all water samples are within the allowable limits set by the World Health Organization (Banerjee and Prasad, 2020). The amount of Na^+ and K^+ are found in the order Na^+> K^+ ion. The analysis of Dhaleshwari River water indicates significant variability in water quality parameters. The pH values range from 5.50 to 7.64, with an average of 6.68, which is within the acceptable guideline of 6.50-8.50, indicating relatively neutral water. EC ranges from 207.40 to 258.60 μScm^{-1}, averaging 236.43 μScm^{-1}, well below the 700 μScm^{-1} guidelines, reflecting low salinity. DO levels, crucial for aquatic life, range from 7.24 to 9.67 mgL^{-1}, with an average of 8.75 mgL^{-1}, exceeding the minimum guideline of 6.00 mgL^{-1}, indicating good water quality. TDS and TH are also well within permissible limits, indicating low mineral content. Chloride (Cl^-), sodium (Na^+), and potassium (K^+) levels are significantly lower than their respective guidelines, highlighting minimal pollution from industrial and domestic effluents (Table 2). These results collectively suggest that the Dhaleshwari River maintains a generally healthy water quality standard despite the industrial activities in the Savar District.

The Pearson correlation analysis (Table 3) of Dhaleshwari River water quality parameters reveals several significant relationships. The pH strongly correlates with dissolved oxygen (DO) (r = 0.866), indicating that higher pH levels are associated with higher DO concentrations. A strong negative correlation exists between pH and total dissolved solids (TDS) (r = -0.890), suggesting that increased TDS levels correspond to lower pH values. The chloride (Cl^-) concentration negatively correlates with pH (r = -0.808) and DO (r = -0.689), implying that higher Cl^- levels reduce both pH and DO. Sodium (Na^+) has a moderate positive correlation with pH (r = 0.415) and DO (r = 0.348), while showing a negative relationship with Cl^- (r = -0.431). Total hardness (TH) shows a weak positive correlation with pH (r = 0.268) and DO (r = 0.305) but a weak negative correlation with TDS (r = -0.372). Potassium (K^+) does not show strong correlations with other parameters, indicating minimal influence on overall water chemistry.

The microbial qualities of the collected water at the consumer level were examined. Total Coliform Count (TCC), Fecal Coliform Count (FCC), and *E.coli* were examined quantitatively whereas *Salmonella sp.* was examined qualitatively. Total Coliform and Fecal Coliform are indications of pathogenic organisms (Korajkic et al., 2018). In the examined water samples, the TCC value ranges from 0 to 1.5×10^2 $CFUml^{-1}$ in the original concentration and from 0 to 3×10^2 in 10^{-1} dilution (Table 4). Values were excessively above the WHO guideline. So, TCC values are above the permissible limit (0.0 $CFUml^{-1}$) according to Bangladeshi standards for drinking water.

Table 2. Statistical parameters with standard guideline values of water quality parameters.

Parameters	**pH**	**EC (μScm^{-1})**	**DO (mgL^{-1})**	**TDS (mgL^{-1})**	**TH (mgL^{-1})**	**Cl^- (mgL^{-1})**	**Na^+ (mgL^{-1})**	**K^+ (mgL^{-1})**
Minimum	5.50	207.40	7.24	149.00	80.00	8.50	28.49	2.92
Maximum	7.64	258.60	9.67	177.00	98.00	30.23	34.48	3.94
Average	6.68	236.43	8.75	161.54	88.32	16.77	30.74	3.12
±SD	0.90	11.21	0.83	9.04	5.14	7.49	2.96	0.33
Guideline value	6.50-8.50	700	6.00	1000	500	150-600	200	12
References	(DPHE, DoE, Bangladesh standard) Yr.						WHO, 2003	EC (European,1986 Community), 1986

Table 3. Pearson correlation analysis of Dhaleshwari River water quality parameters.

	pH	**EC**	**DO**	**TDS**	**TH**	**Cl^-**	**Na^+**	**K^+**
pH	1.000							
EC	0.016	1.000						
DO	0.866	-0.028	1.000					
TDS	-0.890	-0.052	-0.880	1.000				
TH	0.268	-0.124	0.305	-0.372	1.000			
Cl^-	-0.808	0.208	-0.689	0.755	-0.273	1.000		
Na^+	0.415	-0.144	0.348	-0.370	-0.326	-0.431	1.000	
K^+	-0.040	0.112	-0.131	0.043	-0.258	-0.007	0.230	1.000

The samples are not suitable for drinking purposes (Voulvoulis, 2018). But they can be used for household work. All the samples were free from Fecal Coliform and *Salmonella sp*., and according to BD standards and WHO standards are acceptable for drinking. All the sample waters were acceptable for regular use.

Table 4. Microbial parameters and heavy metals content in different water samples.

Sample ID	Total Coliform Count CFUml^{-1}			Fecal Coliform Count CFUml^{-1}	*Salmonella sp.* CFUml^{-1}	Heavy Metals (mgL^{-1})		
	Original	10^{-1} dilution	10^{-2} dilution			Cd	Pb	Cr
S-1	Absent	Absent	Absent	Absent	Absent	BDL	0.05	BDL
S-2	Absent	Absent	Absent	Absent	Absent	BDL	0.04	0.007
S-3	Absent	Absent	Absent	Absent	Absent	BDL	0.05	0.012
S-4	Absent	Absent	Absent	Absent	Absent	BDL	0.06	0.015
S-5	Absent	Absent	Absent	Absent	Absent	BDL	0.05	BDL
S-6	Absent	Absent	Absent	Absent	Absent	BDL	0.07	0.012
S-7	Absent	Absent	Absent	Absent	Absent	BDL	0.07	0.008
S-8	Absent	Absent	Absent	Absent	Absent	BDL	0.04	0.012
S-9	Absent	Absent	Absent	Absent	Absent	BDL	0.05	BDL
S-10	Absent	Absent	Absent	Absent	Absent	BDL	0.03	0.01
S-11	Absent	Absent	Absent	Absent	Absent	BDL	0.04	0.008
S-12	Absent	Absent	Absent	Absent	Absent	BDL	0.05	BDL
S-13	2.7×10^{1}	1.5×10^{2}	Absent	Absent	Absent	BDL	0.06	0.012
S-14	Absent	Absent	Absent	Absent	Absent	BDL	0.04	0.004
S-15	4×10^{1}	1×10^{2}	Absent	Absent	Absent	BDL	0.06	0.014
S-16	3.5×10^{1}	Absent	Absent	Absent	Absent	BDL	0.05	0.003
S-17	1.5×10^{2}	3×10^{1}	Absent	Absent	Absent	BDL	0.04	BDL
S-18	3×10^{1}	1×10^{2}	Absent	Absent	Absent	BDL	BDL	0.008
S-19	Absent	Absent	Absent	Absent	Absent	BDL	BDL	0.009
S-20	1.5×10^{2}	3×10^{2}	Absent	Absent	Absent	BDL	BDL	0.004
S-21	Absent	Absent	Absent	Absent	Absent	BDL	0.02	0.009
S-22	Absent	Absent	Absent	Absent	Absent	BDL	BDL	0.014
S-23	8.5×10^{1}	3×10^{2}	Absent	Absent	Absent	BDL	BDL	0.01
S-24	3.5×10^{1}	2×10^{2}	Absent	Absent	Absent	BDL	BDL	BDL

The collected water samples were analyzed for Cr, Pb, and Cd. The Cd content was below the detection limit for all the samples. The range for Pb was below the detection limit of 0.07 mgL^{-1}. The range for Cr was below the detection limit of 0.015 mgL^{-1} (Table 4). According to the Maximum Contamination Limit (MCL) standard, Cadmium concentration should not exceed 0.005 mgL^{-1}, Lead should not exceed 0.015 mgL^{-1} and for Chromium 0.1 mgL^{-1}.

All the measured values are within permissible limits, which will show no adverse impact on the Dhaleshwari River water system. The exceptionally low concentration could be attributed to the river water's continuous flow, resulting in a high dilution factor.

Conclusion

The degradation of water quality in Bangladesh's rivers, particularly the Dhaleshwari River, underscores the pressing need for rigorous environmental monitoring and management. Despite their critical role in the nation's economic activities, industries, especially the leather sector, have significantly contributed to pollution through untreated effluents. This has led to detrimental impacts on the aquatic ecosystem and human health. The study reveals that while parameters such as pH, EC, DO, TDS, and TH are within acceptable limits, heavy metals and microbial contamination pose serious concerns. Effective regulatory measures, advanced waste treatment technologies, and strict enforcement of environmental standards are essential to mitigate these issues. Sustainable industrial practices and continuous monitoring are crucial to preserving the health of the Dhaleshwari River and ensuring the well-being of communities relying on its resources.

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Author Contributions

Tasnum Rahman: Formal analysis, visualization, writing– review & editing; Aporupa Abeazom Zom Urmi: Formal analysis, visualization, writing– review & editing; Md. Mazharul Islam: Conceptualization, data curation, investigation, methodology, software, supervision, visualization and writing-original draft; Md. Iqbal Rouf Mamun: Supervision, data curation, funding acquisition, project administration, resources, writing – review & editing; and Mohammad Shoeb: Data curation, funding acquisition, project administration, resources, writing – review & editing.

Declaration of conflicting interests

The authors declare that they have no financial and any other competing interest.

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