Research Article

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Impacts of textile and leather effluent on environment: an assessment through life cycle of fishes and plants

Abstract

The textile and tannery industry in Bangladesh is liable for polluting the soil and water body owing to the discharge of untreated effluents. They use enormous amounts of water, chemicals, and colorants for processing textile and leather products and release a complex mixture of organic and inorganic pollutants and metal contents, which negatively impact the environment. The main objective of this research was to study the deleterious impact of untreated textile and leather effluents on the environment in Bangladesh. For this purpose, textile and leather effluents were collected from industries during discharging after processing. Parameters, such as BOD, COD, pH, TDS, TSS, TH, Turbidity, conductivity, alkalinity, Dissolved Fe, metal contents, etc., were tested to determine the characteristics of the effluents. Moreover, the impact of these effluents on tree plants as well as on fishes was observed over 24 days. The results showed that the effluents contain extremely high values of BOD, COD, TDS, TSS, hardness, conductivity, alkalinity, silica from the recommended discharge limit. It was also observed that leather effluents cause a more harmful effect on the survival of fishes and trees due to the presence of high metal contents than textile effluents. The findings will help address this alarming situation in the ecosystem of Bangladesh and recommend immediate action to save the ecosystem from untreated discharges of industrial effluents.

Keywords: textile effluents, leather effluents, physio-chemical parameters, environmental effect

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Introduction

Due to rapid industrial development during the last three decades in Bangladesh, the disposal of industrial effluents has become a serious problem.[1] Among various types of industries, textile and leather industries consume huge amounts of water daily and consequently generate a large volume of industrial liquid effluents, which contain various organic and inorganic materials and toxic trace elements.[2] These effluents are usually discharged to nearby agricultural fields, lakes, river courses, or directly adjacent landfills without any treatment.[3] Among the two types of industries, the textile industries are one of the largest water consumers in Bangladesh, as it is the second-largest readymade garments manufacturer in the World. Textile effluents are very toxic and carcinogenic, as it contains various types of synthetic dyes, heavy metal salts, and inorganic chemicals.[4–6] The textile effluents are the main causes of water pollution in surface and river water, as most textile industries are not interested in discharging effluent after proper treatment.[7] Department of Environment (DOE) in the country is trying to enforce for establishing the effluent treatment plant (ETP) in every textile industry. As a result, ETP is a prerequisite for getting clearance from DOE for factory establishment in the country. According to the statement of DOE, more than 50% of Bangladesh's existing export-oriented industries have established ETP plants and the rest of the industries have not till now.[8] On the other hand, the smaller industries, including local market-oriented industries, do not afford to install a proper ETP plant. That is why any of those factories directly discharge the effluents to the water body.[9] Though many industries have proper ETP plants, they kept their ETP just for displaying to the buyers and being in a safe position during the supervision of DOE.[10] On another side, many factories (medium to large scale) are practicing state-of-the-art ETP's and are operating those always.[7] The industry managements of those are committed to saving the surrounding environment and fulfilling the DOE regulations. Most of the time, such industries discharge of even better quality than the regulation requires.[11]

On the other hand, the tannery industry belongs to one of the most polluting industrial sectors after textile industries in Bangladesh.[12] Tannery industries rely heavily on chemicals to produce leather via transforming animal hides.[11,13] In Bangladesh, about 90% of tannery industries are engaged in the chrome tanning process, which improves the properties of the leather. So, leather product manufacturing is also a water-consuming procedure that requires huge water and generates the consumed water as effluent.[14,15] These leather effluents carry heavy pollution loads due to an enormous presence of highly colored compounds, heavy metals like Cr, Pb, Cd, Ni, various organic and inorganic substances, toxic metallic compounds, different types of tanning materials and large quantities of suspended matter.[16]

Consequently, both the textile and leather effluents are most hazardous for our environment and for the life of aquatic animals.[17] So, industrial pollution due to effluents is an area of growing environmental concern and one of the main problems presently facing Bangladesh.[15,18] Colorants and chemicals found in industrial effluents are not only carcinogenic to human beings but also observed to be toxic to aquatic life (WHO 2002), causing severe environmental problems as well as posing threats to sustaining aquatic biodiversity.[19] Similarly, the presence of dyes and chemicals in surface and subsurface water makes the fishes and plants' life challenging to survive. Therefore, monitoring the impact of pollution is important for the safety assessment of the environment and its biodiversity. Therefore, the purposes of the study were to observe the effect of industrial effluents (textile and leather) on aquatic life, i.e., fishes and plants in Bangladesh.

Materials and methods

Collection of effluents, tree plants, and fishes

Two types of industry effluents, i.e., textile and its adjacent river in Savar, Dhaka, and tannery and its adjacent river in Savar, Dhaka Bangladesh, were collected from July to September in 2019. Textile effluent samples were collected from individual drainage lines of three industries during the processing of the industries, mainly during dyeing, printing, and finishing processes. Leather effluent samples were also collected in the same way from three industries. In addition, some shrub-type trees were collected from the local nursery of Bangladesh, which was similar in age and size. Furthermore, Anabas fishes were collected from the local market of Dhaka, Bangladesh, for observing the surviving capability of fishes with textile and leather effluents.

Analysis of physio-chemical parameters of the effluents

After collection, the samples were transferred to the laboratory following the guidelines of the American Public Health Association (APHA) at favorable temperatures (< 4˚C). The effluents were then subjected to various physio-chemical analyses to measure wastewater quality using the analytical grade chemicals and reagents throughout the study. Electrical conductivity (EC) and pH of the samples were measured at the sampling site with a conductivity meter (Hach-SensION5) and pH meter (HANNA, USA), respectively. Drying methods were followed in determining the total dissolved solids (TDS). The color was measured using the light transmission characteristics of the filtered sample employing a spectrophotometer. Other parameters such as total hardness (TH), m alkalinity, calcium, magnesium, chloride, sulfate, iron, silica, turbidity, total suspended solids (TSS), dissolved oxygen (DO), biological oxygen demand (BOD), and chemical oxygen demand (COD) were evaluated using the guidelines and procedure suggested by APHA (2005) and BIS (1991). Metal contents were analyzed by the ASTM method as described by N. Rahmanian et al., which was approved by APHA.[20] All the analytical experiments were carried out with the support of the laboratory of Dexterous Engineering Bangladesh.

Observation of the survivability of fishes in textile and leather effluents

The fishes were collected from the local market of Bangladesh. Anabas fishes were selected for this study, which was kept in five different pots by mixing freshwater with different ratios of textile effluent to observe the survivability of fishes in that condition as shown in Figure 1. The ratio of freshwater and wastewater were 80:20 (freshwater 80: textile effluent 20); 70:30 (freshwater 70: textile effluent 30); 60:40 (freshwater 60: textile effluent 40); 50:50 (freshwater 50: textile effluent 50); 100% freshwater in another pot. Keeping the fishes into the pots, sufficient foods were provided every day. The observation was continued up to 24 days, and the changes in fishes were noticed. The survivability of fishes was investigated with the same mixing ratio of leather effluents as the similar pattern of textile effluents.

Figure 1 Cultivation of fishes and plantation of trees with various concentrations of effluents water.

Observation of the survivability of plant trees using textile and leather effluents

Shrub-type trees of similar ages and sizes were implanted in seven separate flowerpots. Three tree plants (A, B, C) were cultivated using the various ratio of textile wastewater, whereas the other three plants (D, E, F) were cultivated using the various ratio of leather wastewater, and another one tree (G) was planted with only 100% fresh water. The flowerpots were kept in proper air circulation and sunlight for proper growth, as shown in Figure 1. The ratio of freshwater and textile wastewater was 80:20 for tree sample A, 70:30 for sample B, and 60:40 for sample C. The ratio of freshwater and leather wastewater was 80:20, 70:30, and 60:40 for trees D, E, and F, respectively. The sample trees were kept over observation for 24 days, and the changes of plants were monitored.

Results and discussion

The results obtained from the analysis of textile and leather effluent collected from several processing industries are shown in Table 1 and Table 2.

Table 1 Physio-chemical parameters of textile industry effluents

Parameters	Unit	Concentration			Standard
		Industry 1	Industry 2	Industry 3	(Discharging in Land)
Color	-	Black	Orange	Blue	-
pH	-	12.3	11.5	10.6	9-Jun
Total Hardness	ppm	510	1220	532	180
Calcium Hardness	ppm	306	732	319	100
Magnesium Hardness	ppm	204	488	213	50
TSS	ppm	1720	53	404	500
TDS	ppm	16800	30120	10280	2100
Conductivity	µS/cm	29473	43028	13706	1200
Dissolved Fe	ppm	2.3	3.2	1.1	10
Silica	ppm	820	933	334.5	100
Turbidity	NTU	1230	40	295	-
M-Alkalinity	ppm	2360	5300	720	500
Chloride	ppm	380	520	146	600
Sulfate	ppm	225	190	245	-
DO	ppm	2	2.5	2.3	4.5

Table 2 Physio-chemical parameters of leather effluents

Parameters	Unit	Concentration			Standard
		Industry 1	Industry 2	Industry 3	(Discharging in Land)
Color	-	Black	Grey	Yellow	-
pH	-	7.9	7.7	8.1	9-Jun
Total Hardness	ppm	290	360	622	180
Calcium Hardness	ppm	174	216	373	100
Magnesium Hardness	ppm	116	144	249	50
TSS	ppm	1420	1231	456	500
TDS	ppm	3580	7480	15410	2100
Conductivity	µS/cm	6280	11500	20546	1200
Dissolved Fe	ppm	1.11	1.31	4.1	10
Silica	ppm	210	282	721	100
Turbidity	NTU	1000	872	380	-
M-Alkalinity	ppm	130	190	224	500
Chloride	ppm	4500	4900	3800	600
Sulfate	ppm	1370	1220	1150	-
DO	ppm	1.5	2.4	2.1	4.5

It was observed from Table 1 that the concentration of maximum parameters of textile effluents was very high than the standard of discharging in the land. The effluents were found in black, orange, or blue in color. The effluents were highly alkaline with considerable amounts of hardness, silica, and turbidity. Among the parameters, TDS, conductivity, and alkalinity were found extremely high that can destroy the crops producing capability of the soil. The other parameters of the effluent can also affect the life cycle of animals and plants dependent on water, as they are also found higher than the standard of drinking water and irrigation water.

Table 2 showed the results of leather effluents parameters, which also indicated that the concentration of all the parameters was higher compare to the standard for discharging in the land. The effluents were found in black, grey, and yellow in color. The leather effluents were lower alkaline in nature than textile effluents with considerable amounts of hardness, silica, and turbidity. The scenario is almost similar in every tannery industrial zone in Bangladesh, which is also observed by Jahan M.[21] Nevertheless, the concentration of some parameters of leather effluents was not as high as the textile effluents, including TDS, conductivity, and alkalinity, as shown in Table 1 and Table 2. It may be because leather processing industries required fewer operation sequences compared to textile processing industries. Table 1 and Table 2 showed that the color contained in textile and leather effluents might hinder the penetration of sunlight, indicating that oxygen is decreasing in the effluents.

The concentration of BOD and COD in textile and leather effluents

BOD and COD are considered as the most polluting key parameters in textile and leather effluents. The result of BOD and COD parameters in the textile and leather effluents are shown in Figure 2. The results demonstrated that both types of industries discharged the effluents containing very high BOD and COD than the standard set by DOE (200mg/L for inland surface water and 400 for irrigated land), which are unexpected for fishes and other aquatic life. The investigations also revealed that COD values of all leather effluents were very high (2100-3400mg/L) compared to textile effluents (1050-1300mg/L). COD represents the chemically oxidizable load of receiving water indicating the high strength of organic matter and low DO. So, in the higher COD, aquatic life cannot exist. The investigation also showed that BOD values of leather effluents were higher than the values of textile effluents. The highest values of BOD were found at 3300mg/L and 500 mg/L in the case of leather effluents and textile effluents, respectively. The highest values of BOD in textile and leather effluents were two times and six times higher than the standard value permitted by DOE (250mg/L).

Toxic metal contents in textile and leather effluents

Metals like Chromium, Lead, Cadmium, and Nickel concentrations in textile and leather effluents are shown in Figure 3. The metal contents in the leather effluents were very high compare to textile effluents due to the process variation of leather manufacturing. However, heavy metals like Cr, Pb, Cd, and Ni were found very close to the permissible limit in the textile effluents. Among the toxic elements in leather effluents studied, Cr concentration was found the highest. Moreover, the concentrations of all the other metals were also beyond the standard permissible limits. With respect to the concentrations of the parameters, the metals followed the order: Cr>Cd>Ni>Pd.

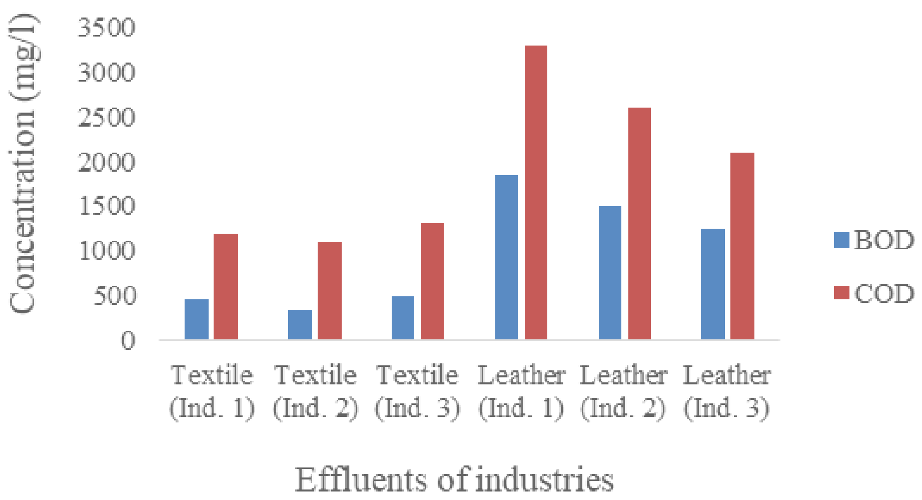

Figure 2 BOD and COD observed in textile and leather effluents.

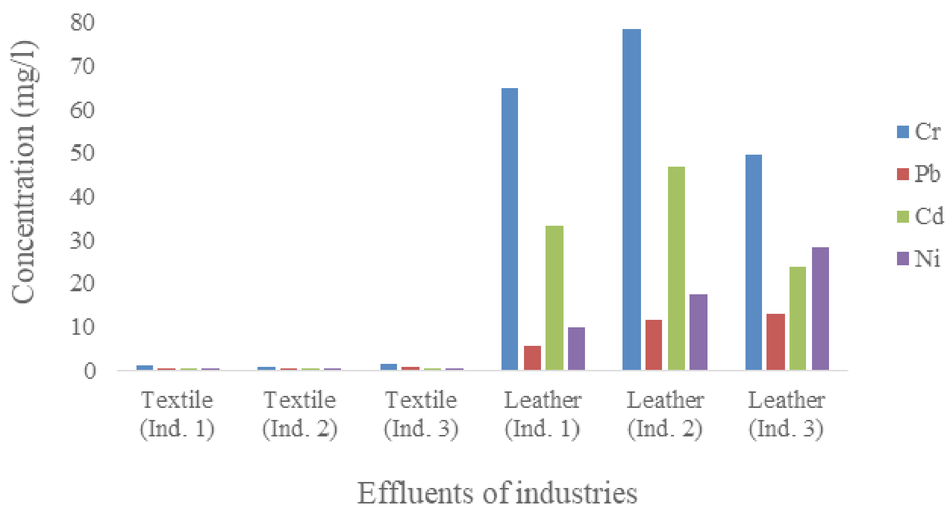

Figure 3 Major metal components found in textile and leather effluents.

Impact of textile and leather effluent on the living condition of fishes

The present findings proved that water quality parameters were deteriorated by various types of effluent concentrations. As indicated by Table 1 and Table 2, the content of dissolved oxygen concentration was lower than the standard, while pH values and conductivity were very high in both the textile and leather effluents. Both the discharged effluents were found of high salinity due to high concentrations of TDS, TSS, Na, chloride, sulfates, and conductivity. The other analyzed parameters such as BOD and COD also highly exceeded the standard permissible limits prescribed by NEQS (2000), ISI (2000), and ISW-BDS-ECR (1997). The result implies that the values of water quality parameters alter based on the nature of the effluents. As a result, the behavioral responses of aquatic organisms were affected negatively and led to reduce aptness to the environment. As some of the pollutants exceeded the hazard level, and survival of fishes and other aquatic species became miserable.[22] When these pollutants were absorbed in cultivated fishes via the bioaccumulation process, they died. In this study, the impact of textile wastewater on the survivability of fishes was observed over 24 days. The fishes were kept by mixing the freshwater with textile effluent in different ratios as 80:20, 70:30, 60:40, and 50:50, and one fish was nurtured only with freshwater. The fishes were cultivated in separate containers. The fish survived more than 24 days, which was cultivated in freshwater, while one fish died on the sixth day with the highest amount of textile waste (50:50 ratios), as shown in Figure 4. The other fishes died on the ninth, thirteenth, and twenty-third days with the effluent ratio of 60:40, 70:30, and 80:20, respectively. It was due to the fishes took various harmful components of the effluent with food such as color, ions, TSS, and TDS.[23] These elements were deposited inside the fishes during the consumption of food. Finally, the fishes died under the influence of harmful substances.

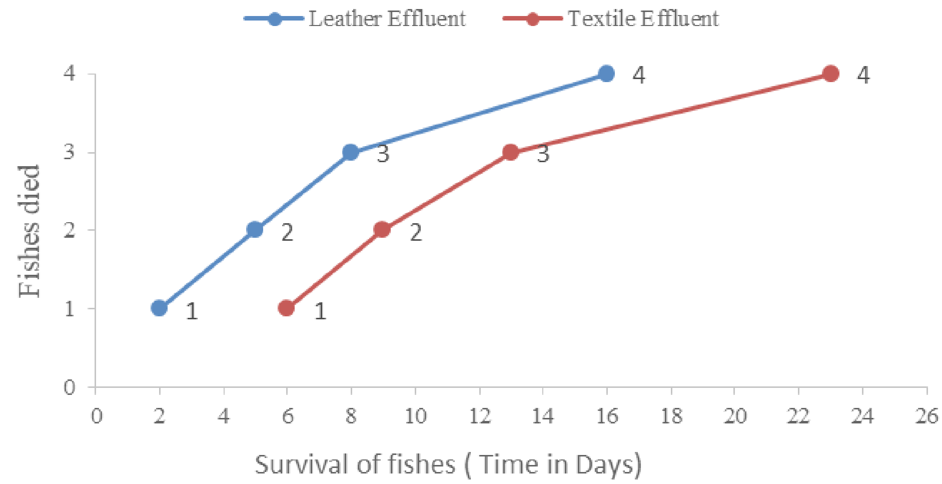

Figure 4 Survival of fishes in textile and leather effluents.

The results of survivability of fishes in leather wastewater were also shown in Figure 4. The fishes were cultivated by mixing the leather wastewater with the freshwater of the same ratio as textile effluent. One fish died just within the second day in the highest amount of leather waste (50:50 ratios), and the other fishes died on the fifth, eighth, and sixteenth day with the effluent ratio of 60:40, 70:30, and 80:20, respectively. The fishes with leather effluents were died earlier than the textile effluents, as tannery effluents contained more heavy metals, like Cr, Cd, Pb, and Ni. These concentrations exceeded the toxic limits, especially in leather effluents. Some algae and fishes have been found to be very sensitive to chromium as well as other metals. Since these wastes contained a significant amount of toxic metals, it poses a severe threat to fishes and other aquatic life.[24] Low levels of chromium, cadmium, lead, and nickel have been reported by recently published studies to cause various severe problems in aquatic life.[25] That is why; leather effluents are more toxic and carcinogenic for the survival of fishes than textile effluents.

Impact of textile and leather effluents on the living condition of plants

Untreated effluents are becoming a threat to vegetation, plant, and other aquatic organisms due to higher pH, BOD, COD, EC, and various types of metals in the effluents. Textile and leather industries are major sources of these effluents due to the nature of their operations which requires a high volume of water that eventually results in high wastewater generation. The industrial effluents also possessed various organic and inorganic chemical compounds, as shown in Table 1 and Table 2. The presence of these chemicals showed detrimental effects on the development of plants, the germination process, and the growth of the seedlings. If textile and leather effluents were used for plantation purposes, it raised the soil pH, EC, and sodium adsorption ratio values. The soil turned to saline, reducing the plant's ability to absorb nutrients needed for vegetative growth.[24] Consequently, it turns to reduce the growth rate, resulting in smaller leaves, shorter height, fewer leaves, and sometimes burn leaves. The impact of textile and leather wastewater on the plantation of trees was observed over 24 days, as shown in Figure 5. The trees were planted by using freshwater with the textile and leather effluent in the ratio of 80:20, 70:30, 60:40, and one plant only with freshwater. The tree planted only with freshwater survived without any abnormality during the observation period, while the leaves of the tree planted with leather effluent (60:40 ratios) turned into light yellow color on the very first day (Figure 5). However, similar light-yellow leaves were observed using the textile effluent (60:40 ratios) after four days. The leaves of the trees started to shrink by applying leather and textile effluents (70:30 ratios) after eight days and 16 days, respectively. The trees were almost dead just after 20 days and 24 days by using the leather and textile effluents with a ratio of 80:20. The tree plants took various harmful components of the waste with food such as color, ions (Mg, Ca, Fe, chloride), TSS, TDS, heavy metals, etc. These elements were deposited inside the plants during the consumption of nutrients.[13] Finally, the plants were destroyed under the influence of harmful substances. The plants survived more times in textile effluent with different ratios than leather effluents with different ratios, as shown in Table 3. So, leather effluents are more harmful than textile effluents for plants. Physio-chemical analysis of textile and leather wastewater was carried out in this present study, and it was evident that different heavy metals like Cr, Cd, Pb, and Ni were present in higher concentrations in leather effluent than the textile effluent. These heavy metals created more obstruction and restricted various plant physiological and growth processes in case of using the leather effluents.[25] That is why leather effluent's impact on the plantation of trees was observed more severe than the plantation of trees with textile effluents.[13] The decreased and unsatisfactory growth using contaminated wastewater was also reported in sunflower (*Helianthus annuus* L.). Results indicated that the major adverse effect on plant growth emerged due to high pH, EC, BOD, COD, as well as higher amounts of metal contents. Adverse and toxic impacts of municipal effluents on the growth performance and yield of certain vegetables, i.e., spinach, carrot, lettuce, radish, and sugar beet, were also investigated by Tamoutsidis et al. Ahmad et al. also confirmed that wastewater containing heavy metals were responsible to retard plant growth and development and adversely affect the yield. Hossain L et al. also observed that tannery waste liquid decreased the growth of sunflower parameters along with other important parameters like protein, chlorophyll content, and carbohydrate content, etc.[15] The decreased shoot and root biomass of the plants might be due to interference of Pb along with other metals. Lead phytotoxicity involves inhibition of enzyme activities, disturbed mineral nutrition, water imbalance, change in hormonal status, and alteration in membrane permeability. These disorders upset normal physiological activities of the plant resulting in the devastation of the plant trees.

Table 3 Impact of leather and textile effluents on the survivability of tree plants

Effluent/ Change	First day	After 04 days	After 08 days	After 12 days	After 16 days	After 20 days	After 24 days
Freshwater	Normal	No Change	No Change	No Change	No Change	No Change	No Change
Textile waste (80:20 ratio)	Normal	No Change	Light Yellow Leaves	Yellow Leaves	Shrink the Leaves	Leaves Fall	Destroy
Textile waste (70:30 ratio)	Normal	No Change	Light Yellow Leaves	Yellow Leaves	Shrink the Leaves	Leaves Fall	Destroy
Textile waste (60:40 ratio)	Normal	Light Yellow Leaves	Yellow Leaves	Shrink the Leaves	Leaves Fall	Destroy	
Leather waste (80:20)	Normal	Light Yellow Leaves	Yellow Leaves	Shrink the Leaves	Leaves Fall	Destroy	
Leather waste (70:30 ratio)	Normal	Light Yellow Leaves	Shrink the Leaves	Leaves Fall	Destroy		
Leather waste (60:40 ratio)	Light Yellow Leaves	Shrink the Leaves	Leaves Fall	Destroy			

Figure 5 Effect of textile effluent on the plantation.

Conclusion

The pollution due to toxic and hazardous leather and textile effluents in Bangladesh is a major environmental and social concern. The results of the study showed extremely high values of pH, TSS, TDS, EC, chloride, sulfate, BOD, COD in the effluents collected from various textile and leather industries. The values of all the effluent parameters were exceeded the standard permissible limits for ISW-BDS-ECR (1997), ISI (2000), and NEQS (2000). The results also showed that the toxic metal contents such as Cr, Cd, Pb, and Ni exceeded far above the standard, especially in the leather effluents. The study observed that aquatic life, i.e., fishes or any tree plants, could not survive in the textile or leather effluents. The survivability would be more difficult in the case of leather effluents due to the presence of toxic metal contents. It has been recommended that untreated industrial effluents generated from textile and leather industries should not be discharged either into surface water or the surrounding lands. Such activities pose threats to humans, aquatic life, and the entire ecosystem. Therefore, industrial effluents should be treated properly before discharging into the water body so that the pollutants may not enter the environment.

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Conflicts of interest

The authors have no conflict of interest regarding this paper.

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