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Assessment of the Quality of Industrial Wastewater in Three Metropolitan Cities in Bangladesh

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Abstract

This study was conducted to assess the quality of different industrial wastewater. Some physicochemical parameters viz., pH, EC, TDS, Na^+, K^+, Ca^{++}, Mg^{++}, CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-}, PO_4^{3-} including heavy metal contents like Pb, Cd, Ni, Cr, As, Zn and Cu concentration from collected wastewater samples were analyzed. Atomic Absorption Spectrophotometer was used for analyzing the heavy metals in the wastewater samples. The results revealed that, the values of pH, EC, TDS ranged between 6.44-9.0, 471-4307 µS cm^{-1}, 1952-5209 mg L^{-1}, respectively. The higher mean concentrations of Na^+, K^+, Ca^{++}, Mg^{++}, CO_3^-, HCO_3^-, Cl^-, SO_4^{2-}, PO_4^{3-} were 1407.8, 27.9, 69.9, 76.6, 2.7, 11.7, 1688, 76.6, 6.1 mg L^{-1}, respectively. The mean concentration of Cd, Ni, Cr, Zn, and Cu was 0.17, 0.87, 85.73, 0.80, and 1.56 mg L^{-1}, respectively. Among trace elements Ni and Cd, Zn and Cd, Zn and Cr showed a positive relationship. To avoid the harmful effects of wastewater on environment it is imperative to treat industrial effluents before discharge into open environment.

Key words: Correlation, Heavy metals and Industrial wastewater

Introduction

With the rapid population growth, industrialization and urbanization processes also expand day by day. After 1971, Bangladesh is slowly and steadily turning its attention to develop its economy, through industrial development and moving away from the agricultural sector. The wastewater generated by large population and by industry is a major source of pollution. Even after treatment, wastewater can end up in areas deemed sensitive for the environment or human health. Industrial wastewater not only contains trace elements (Pb, Cd, Ni, Cr, As, Zn, Cu, Hg, Mn) but also bears excess amounts of cation (Ca^{++}, Mg^{++}, K^+, Na^+) and anion (SO_4^{2-}, NO_3^-, PO_4^{3-}, Cl^-, CO_3^{2-},HCO_3^-) which are responsible for polluting water, even it inhibits plant growth. It is reported that among all the trace elements, chromium is the most widely used and discharged to the environment from different sources. Mercury, Pb, Cd, Zn and As are very toxic to living organisms. They can lower reproductive success, prevent proper growth and development; even cause death.

Though the growth of economy and the internal development of a nation depend upon the development of industrial sector but these sectors are responsible to pollute the natural environment due to discharge of untreated solid and liquid waste. As a result, pollution of water and soil environment increased day by day due to rapid industrialization (Anwar *et al.*, 2006).

For example, 270 registered tanneries are located in Hazaribagh; these tanneries generate 7.7 million liters of liquid waste and 88 million tons of solid waste every day (Blacksmith Institute, 2007). The tannery industries are operating and discharging solid and liquid wastes directly to the low-lying areas, river and natural canals without proper treatment. Unfortunately, these discharges destroy the ecosystem of water and soil environment.

Zahir and Ahmeduzzaman (2012) reported that tanneries in the Hazaribagh area discharge some 21,600 cubic meters of liquid waste every day (RPMC, 2008). Another study observed that Tejgaon industrial area alone dispose about 12,000 m^3 untreated industrial wastes per day, which consists variety of industrial units like soap, dyeing, pharmaceuticals, metals etc (Annual bulletin Tejgaon Upazila, 2003). The wastes of this industrial area are directly discharged into the drainage system or canal.

The main objectives of this paper were
i) to examine the physico-chemical constituents (pH, EC, TDS, Na^+, K^+, Ca^{++}, Mg^{++}, Cl^-, SO_4^{2-}, PO_4^{3-}) of different industrial wastewater, and (ii) to study the trace elements (Pb, Cd, Ni, Cr, As, Zn, and Cu) of these samples.

Materials and Methods

Study area

Gazipur district located in between 23°53´ and 24°21´ north latitudes and in between 90°09´ and 92°39´ east longitudes, Hazaribagh situated in 90°21´ east longitudes and 23°45´ north latitudes and location of Mymensingh district is in between the latitudes 24°15´ and 25°15´ North and 90°05´ and90°50´ East longitudes (Fig. 1).

Sample collection

Wastewater samples were collected from the drainage system of five types of industries where industrial effluents were discharged. To conduct this research two dyeing, two pharmaceuticals, two leather, two foods, and two plastic industries were considered. Sample size was 30 with three replicates.

Sample preparation

After collection, all water samples were filtered through Whatman No.1 filter paper to remove unwanted solid and suspended material to avoid any undesirable situation during chemical analysis. Five to six drops of liquid toluene were added to control microbial growth. Then the samples were preserved in the laboratory at controlled temperature (-18^{o}C).

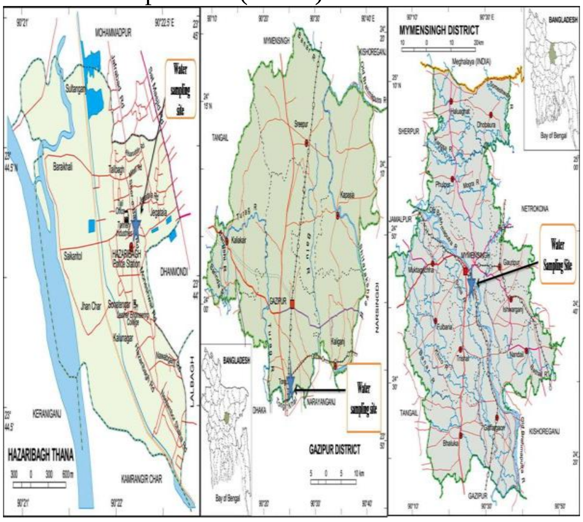

Fig. 1. Map of the study area

Chemical analyses of wastewater

Analyses of the physicochemical properties like pH, EC, TDS, Na^+, K^+, Ca^{++}, Mg^{++}, CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-} and PO_4^{3-} of wastewater samples were conducted in the laboratory of Agricultural Chemistry, BAU. The concentrations of trace elements (Pb, Cd, Ni, Cr, As, Zn, and Cu) in wastewater samples were analyzed by atomic absorption spectrophotometer (Spectr AA-55B) at the Soil Science Division, Bangladesh Agricultural Research Institute (BARI), Joydevpur.

Results and Discussion

pH, EC and TDS values

The mean values of pH, EC and TDS was found in wastewater of different industries are given in Table 1. According to the results, the values of pH, EC, TDS ranged between 6.44-9.0, 471-4307 µS cm^{-1}, 1952-5209 mg L^{-1}, respectively. Among the five different industries, wastewater of dyeing industry contains higher pH values 9.0 and wastewater of leather industry contains higher EC and TDS values of 4307 µS cm^{-1} and 5209 mg L^{-1}, respectively. The use of sodium carbonate and salt in the dyeing process and electrolytes in the bleaching process causes an increase in EC of the wastewater (Mountassir *et al.*, 2013).

Kamal *et al.* (2015) who found almost similar pH value (9.7) like this study in dyeing industry. According to Uddin (2004), the EC value of industrial wastewater was within the range of 288 to 7766 µS cm$^{-`1}$. Kamal *et al.* (2015) also found an excess TDS value (9140.8 mg L^{-1}) in his study.

Cations and anion contents

The data presented in Tables 1 shows that cations were higher, in wastewater of leather and dyeing industries than those of the other industries. In tannery effluent, Na^+, K^+, Ca^{++}, and Mg^{++} varied from 934-1973, 16.6-28, 21.4-83.8 and 48.6-119.9 mg L^{-1} respectively. Whereas in dyeing effluent these cations varied, form 627-1961, 11.3-42.8, 42.0-83.2 and 23.0-65.8 mg L^{-1}, respectively. Higher concentrations of cations were recorded as 1407.8, 27.9, 69.9, 76.6 mg L^{-1}, respectively. Na and K content of tannery and textile effluents were higher than the DoE standard for open water [200 mg L^{-1} for Na, 12.0 mg L^{-1} for K] (DoE, 2003). Inorganic salt cations increase the salinity regime as well as electrical conductivity of water that is revealed in the present investigation. Among anion contents higher mean concentration of Cl^-, SO_4^{2-}, PO_4^{3-} was 1688, 76.6, 6.1 mg L^{-1}, respectively. According to the results of Table 1, wastewater of leather industries contains higher load of Cl^- and SO_4^{2-} measuring 1588 and 76.6 mg L^{-1}, respectively than wastewater of other studied industries. Hussain *et al.* (2004) reported that the Cl^- content of four industries showed a discrepancy of 980 to 2185 mg L^{-1}.

Trace elements

The mean concentration of Cd, Ni, Cr, Zn, and Cu was 0.17, 0.87, 85.7, 0.80, and 1.56 mg L^{-1}, respectively (Fig. 2 and 3). Among the trace elements, higher concentration of Cd, Ni, and Cu was found in wastewater samples of dyeing industries where as the higher concentration of Cr was found in wastewater samples of leather industries. Heavy metals particularly, lead (Pb), chromium (Cr), Cadmium (Cd), Copper (Cu) and Nickel (Ni) are widely used for the production of color pigments of textile dyes (Bhardwaj *et al.*, 2014).

On the other hand, nearly 90% of all leather produced is tanned using Cr salts. Generally, 8% of the basic chromium sulphate salt is used for conventional tanning (Stein and Schwedt, 1994). This is the main reason for the higher concentration of trace elements (Cd, Ni, Cu, and Cr) in the effluents of dyeing and leather industry. Average contents of Cd and Ni in wastewater of different industries varied from 0.07 to 0.17 and 0.03 to 0.87 mg L^{-1}, respectively (Fig. 2).

Wastewater samples of dyeing industries contained higher value of Cu concentration (1.56 mg L^{-1}) from other industries (Fig. 3). Nazir *et al.* (2015) determined Cd concentration in dyeing industries was 0.129 mg L^{-1} which also exceeds the permissible limit like the present study. Among seven studied heavy metals, concentration of Ni and Cu slightly but Cr exceeded seriously the DoE recommended discharge standard in Bangladesh. Another trace element, Cr was found in wastewater of dyeing and leather industries at a higher concentration of 27.64 and 85.73 mg L^{-1}, respectively (Table 1). Like this study, Husain *et al.* (2013) also found similar concentration of Cu in dyeing industries ranged from 0.15 to 1.08 mg L^{-1}.

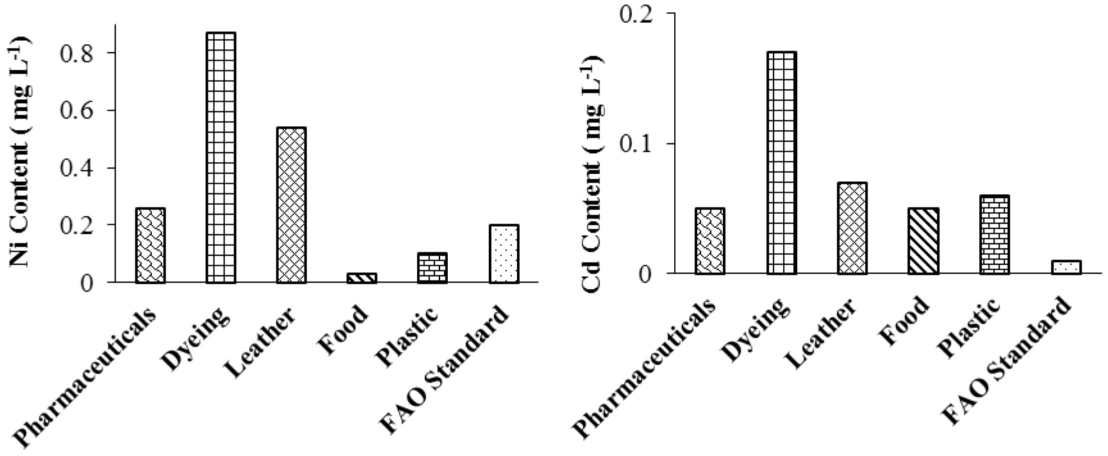

Fig. 2. Average Cd and Ni contents of different industrial wastewater

Table 1. pH, EC, TDS, Cations and anion content of different industrial wastewater

	Parameters		**Name of industries**					FAO Standard
			Pharmaceuticals	Dyeing	Leather	Food	Plastic	
	pH	Mean	**7.57**	**9**	**8.22**	**6.4**	**8.2**	
		Range	7.3-7.8	8.7-9.3	7.4-8.8	6-7.2	8.0-8.4	
	EC ($\mu S\ cm^{-1}$)	Mean	**1896**	**4076**	**4307**	**471**	**733**	
		Range	434-3620	1517-6547	2140-7210	301-560	460-987	
	TDS ($mg\ L^{-1}$)	Mean	**2200**	**5055**	**5209**	**1952**	**2892**	
		Range	1637-2617	4023-7033	1213-8810	1867-2092	1980-3843	
	Na^+	Mean	**984**	**1190.9**	**1407.8**	**214.4**	**329.3**	
		Range	737-1358	627-1961	934-1973	187-228	199-481	
Cations	K^+	Mean	**25.3**	**27.9**	**20.6**	**9.2**	**10.9**	
		Range	20.1-30.7	11.3-42.8	16.6-28	8.7-9.8	6.1-16.6	
	Ca^{++}	Mean	**62.6**	**69.9**	**56.9**	**39.9**	**34.7**	
		Range	50.8-70.9	42.1-83.3	21.4-83.8	29.7-50.3	30.6-36.2	
	Mg^{++}	Mean	**31.4**	**39**	**76.6**	**17.8**	**27.7**	
		Range	22.6-34.7	23.1-65.8	48.6-119.9	15.1-23.6	16.8-36.8	
	Cl^-	Mean	**593**	**973.4**	**1588**	**49.0**	**44.6**	
		Range	130-1335	144-1938	524-2986.9	42.0-55.7	36.9-53.9	
Anion	SO_4^{2-}	Mean	**31**	**39**	**76.6**	**45.5**	**32.3**	
		Range	87-188.5	77.2-274.3	12.9-243.1	100.8-120	71.2-186.7	
	PO_4^{3-}	Mean	**2.4**	**3.5**	**2.5**	**5**	**6.1**	
		Range	1.6-3.5	2.8-4.8	1.4-5.3	4.7-6.7	5.8-7.8	
	Cr ($mg\ L^{-1}$)	Mean	**1.2**	**27.6**	**85.7**	**0.16**	**0.22**	**0.1**

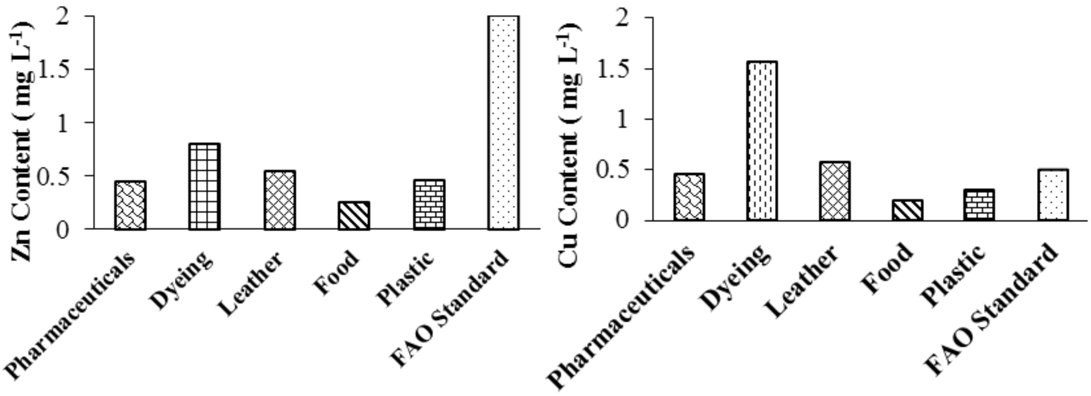

Fig. 3. Average Zn and Cu contents of different industrial wastewater

Correlation analyses of trace elements

Interrelationship studies between different water quality parameter are very helpful in understanding the geochemistry of the study area. The regression equation for the parameter having significant correlation of other constitutes. The regression analysis has been done to find whether the relatioships among trace element parameters are linear or not (Fig. 4).

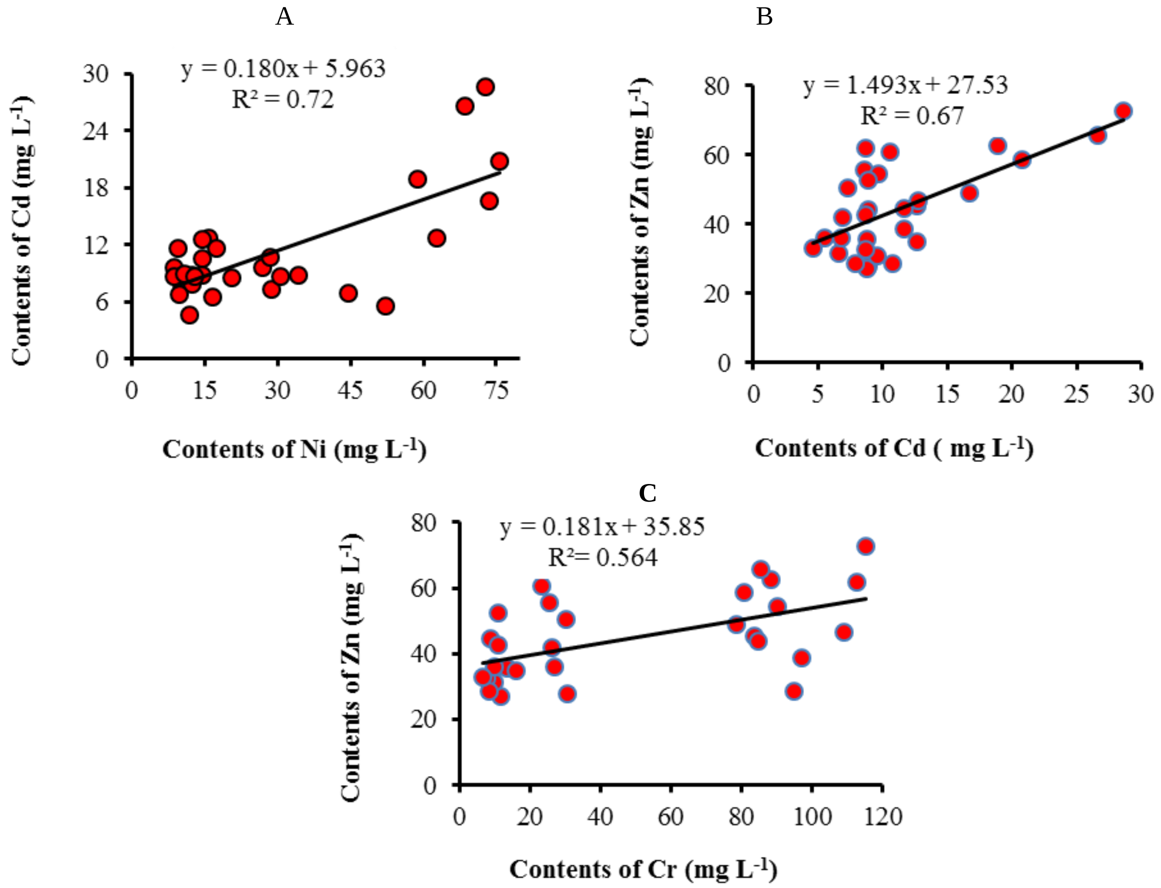

Fig. 4. Scatter plots between contents of Ni and Cd (A), Zn and Cd (B), Zn and Cr (C) of different industrial wastewater

Conclusions

This study concludes that wastewater of leather and dyeing industries contained excess EC, TDS, cations, anions, Ni, Cr, and Cu compared to other industrial wastewater. Higher concentration of trace elements in dyeing and leather industries, indicates that the wastewater of those industries could be more dangerous for the environment. Discharge of wastewater into environment without treatment should be strictly prohibited to avoid any unexpected hazards to protect the environment.

Acknowledgements

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