IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 10, Issue 11 Ver. III (Nov. 2016), PP 43-46
www.iosrjournals.org

Assessment of Toxicity Index of Different Heavy Metals from Industrial Discharge

Md. Khorshed Ali[1], Atik Sarraz[2], Preetom Kishore Roy[2],
Roky Mallick[3], Sagar Das[3]

[1]*Assistant Professor in Chemistry, Department of Electrical and Electronics Engineering, University of Information Technology & Sciences (UITS), Bangladesh*
[2]*Assistant Professor, Department of Civil Engineering, University of Information Technology & Sciences (UITS), Bangladesh*
[3]*Undergraduate Research Student, Department of Civil Engineering, University of Information Technology & Sciences (UITS), Bangladesh*

Abstract: *This work is aimed at assessing the toxicity index (TI) of heavy metals found in the wastewater of different garment industries of Chittagong city. The study finds the toxicity index of 9 toxic heavy metals found in the industrial effluent. This has been determined by sampling wastewater and subjecting the samples to a comprehensive chemical analyses. In calculating the TI, the toxic metals considered are: arsenic, chromium, cadmium, copper, lead, manganese, nickel, silver, and zinc. The TI for these 9 heavy metals ranges from 22.68 to 620.32. The high values of TI were found mainly from the higher values of manganese, lead, chromium, and nickel in wastewater. Although these metals have less toxic effect, they are significant in the industrial discharges mainly because of their bulk amount presence in water samples. The analysis reveals that the wastewater of the different industries need extensive treatments for toxicity before discharging in a water body.*

Keywords: *Garment Industry, Heavy Metals, Industrial Discharge, Toxicity Index, Wastewater*

I. Introduction

Human are interfering nature since the dawn of civilization. The rapid increase in population and the increased demand for industrial establishment in order to meet human requirements have created problems on environment such as overexploitation of available resources and pollution of the land, air and water.Industrial pollution is one of the problems presently facing Bangladesh. Chittagong is the fastest rising industrial city in Bangladesh located on the banks of the Karnaphuli River in the south-eastern region of the country. Most of the industries discharged their untreated waste on the environment directly which disturbed the ecological balance slowly & continuously. According to the WHO, about 80% of the diseases in human beings are caused by water. It is therefore becomes imperative to regularly monitor the quality of effluent from different industries in order to protect the Karnaphuli river. The paper investigates the toxic heavy metals of raw wastewater in various industrial discharges and finds the toxicity index of 9 different toxic metals found in the samples.Toxicity index is one of the most effective tools [1-6] to communicate information on the quality of wastewater to the concerned citizen and policy makers. It, thus becomes an important parameter for the assessment of effluent. TI is defined as a rating reflecting the composite influence of different toxic metals. It is calculated from the point of view of the ecotoxicology of the environment in regard to surface water pollution. The object of the present work is to discuss the quality of effluent discharged in the Karnaphuli River based on computed toxicity index.

Study Area

Chittagong City Corporation is located in the southeastern part of Bangladesh between the 22° 21′ North latitude and 91°50′ East longitude. It covers an area of 185 Sq. km (60 Sq. Miles) with a population [7] of 5, 56,451 (2011). The main source of employment is business. The major industries established inside and outside the city are – Fertilizer, Chemical, Cement clinker, Steel mill, Garments, Paper, and Jute etc. which engage almost 80% of the workforce. Our main study area was located on the Oxygen & Baizid industrial zone. The effluents of 10 different industries mainly of garments, textiles, accessories, food, and steel etc. were collected for a thorough chemical analyses for heavy metal detection. A total of 12 parameters are brought to investigate their toxicity which have direct or indirect impact on human health. There are eight industries which are related to clothing (S1, S2, S3, S4, S6, S7, S8, and S9), one steel factory (S5), and one food industry (S10). The garments and clothing industries are - KDS Fashion Ltd. (S1), KDS Garments Ltd. (S2), Clifton Textile & Apparels Ltd. (S3), KDS Accessories Ltd. (S4), Mars Apparels Ltd. (S6), Hoque Industrial Enterprise Ltd. (S7), The Heliads Fashion Ltd. (S8), Quality Garments Ltd. (S9). The rest of the two industries are Jakir Hossain Re-rolling Mills Ltd. (S5) and Fulkoli Food Products Ltd. (S10). The respective coordinates for these industries are listed in Table 1.

Table 1: Latitude-Longitude Co-ordinates of Different Industries

Sl No.	Industry	N-E
1	KDS Fashion Ltd.	22°23'33.9"N 91°49'13.5"E
2	KDS Garments Ltd.	22°23'35.0"N 91°49'10.3"E
3	Clifton Textile & Apparels Ltd.	22°23'24.7"N 91°48'44.4"E
4	KDS Accessories Ltd.	22°23'20.6"N 91°48'46.4"E
5	Jakir Hossain Re-rolling Mills Ltd.	22°23'19.1"N 91°48'41.5"E
6	Mars Apparels Ltd.	22°23'00.0"N 91°48'44.7"E
7	Hoque Industrial Enterprise Ltd.	22°23'17.1"N 91°48'29.4"E
8	The Heliads Fashion Ltd.	22°23'16.4"N 91°48'26.6"E
9	Quality Garments Ltd.	22°23'06.1"N 91°48'40.7"E
10	Fulkoli Food Products Ltd.	22°19'43.4"N 91°47'20.6"E

Methodology

Wastewater samples were collected from 10 industrial effluents during pre-monsoon season (March 2015). Each wastewater samples were analyzed for 12 chemical parameters such as iron, manganese, lithium, chromium, cobalt, nickel, copper, zinc, arsenic, silver, cadmium, and lead using standard procedures recommended by APHA-AWWA-WEF [8].

II. Results and Discussion

The chemical analyses of the wastewater and BECR [9] (Bangladesh Environmental Conservation Rules-1997) and WHO [10] (World Health Organization) standards are summarized in Table 2.

Table 2: Wastewater Sample Test Results

Sl.	Metals	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
1	Fe	1.33	4.27	11.22	0.89	6.71	1.24	0.27	4.44	0.951	1.12
2	Mn	0.13	0.09	0.34	BDL	0.01	0.23	BDL	1.24	5.424	0.29
3	Li	0.1114	0.0144	0.3834	0.0926	0.054	0.0365	0.0315	0.0264	0.0864	0.0134
4	Cr	0.0244	0.0017	BDL	0.1086	0.0458	0.0047	0.0530	0.1126	0.0063	0.1116
5	Co	0.0211	0.0052	0.0062	0.0031	0.0168	0.0289	BDL	0.0001	0.0085	0.0026
6	Ni	0.1741	0.0691	0.0720	0.0421	0.1421	0.0710	0.0132	0.0283	0.1401	0.0328
7	Cu	0.0507	BDL	0.1427	0.2327	BDL	0.3517	BDL	0.0717	BDL	0.0447
8	Zn	3.41	1.21	2.02	1.86	3.11	1.72	4.39	3.55	8.77	3.35
9	As	0.0209	BDL	0.0146	0.0418	0.0109	0.0191	BDL	BDL	0.0147	BDL
10	Ag	0.0033	0.0008	0.0036	0.0237	0.010	BDL	0.0043	0.0259	0.0235	0.0183
11	Cd	BDL	BDL	BDL	BDL	0.0002	0.0023	BDL	BDL	0.0044	BDL
12	Pb	0.0111	0.0029	0.0231	0.0348	0.0325	0.0887	0.0312	0.0312	0.0234	0.0593

*BDL = Below Detection Level

Iron, lithium, and cobalt are excluded from index calculation because of nontoxic, light metal, and insignificant, respectively. For computing TI, three steps are followed. In the first step, each of the 9 parameters have been assigned a weight (w_i) according to its relative toxicity in human health (Table 3). The maximum weight of 5 has been assigned to the parameter arsenic due to its major carcinogenic effect on the body as well as its availability. Zinc and silver which are given the minimum value of 1 as they themselves may not be harmful. In the second step, the relative weight (W_i) is computed from the following equation

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i} \qquad (1)$$

Where, W_i is the relative weight, w_i is the weight of each parameter and n is the number of parameters. Calculated relative weight (W_i) values of each parameter are also given in Table 3.

Table 3: Relative weight of chemical parameters

Chemical parameters	Bangladesh Standards	Weight (w_i)	Relative weight (W_i)
Mn	0.1	2	0.08
Cr	0.05	3	0.12
Ni	0.1	3	0.12
Cu	1	2	0.08
Zn	5	1	0.04
As	0.05	5	0.20
Ag	0.02	1	0.04
Cd	0.005	4	0.16
Pb	0.05	4	0.16
		$\sum w_i = 25$	$\sum W_i = 1.00$

In the third step, a quality rating scale (q_i) for each parameter is assigned by dividing its concentration in each water sample by its representation standard according to the guide-lines in BECR and results are multiplied by 100.

$$q_i = \frac{C_i}{S_i} \times 100 \qquad (2)$$

Where q_i is the quality rating, C_i is the concentration of each chemical parameter in each water sample in mgL^{-1}, and S_i is the water quality standard of Bangladesh for each chemical parameter in mgL^{-1} according to the guidelines of BECR, 1997. For computing the TI, the SI is first determined for each chemical parameter, which is then used to determine the TI as per the following equation

$$SI_i = W_i \cdot q_i \qquad (3)$$

$$TI = \sum SI_i \qquad (4)$$

SI_i is the sub-index of the parameter; q_i is the rating based on concentration of i^{th} parameter and n is the number of parameters. The computed TI values are classified into five types, "less toxic" to "extreme toxic".Wastewater in the effluent contains major portion of iron. A total number of seven industries discharge iron content which are beyond Bangladesh standard (≤1 mgL-1). But, iron is not itself a toxic metal. Iron poisoning is an iron overload caused by a large excess of iron intake and usually refers to an acute overload rather than a gradual one [11]. The toxicity of lithium and cobalt are not considered in our study because of their unavailability of guideline values in BECR and WHO standards.In this study, the computed TI values ranges from 22.68 to 620.32 and therefore, can be categorized into five types "less toxic" to "extreme toxic". Table 3 shows the number of industrial wastewater samples that fall under different quality. The high value of TI at these stations has been found to be mainly from the higher values of chromium, manganese, nickel and lead in the effluent.

Table 4: Water quality classification based on TI value

TI value	Toxicity	Number of parameters	Parameter names
<50	Less toxic	5	Cu, Zn, As, Ag, Cd
50-100	Moderate toxic	1	Ni
100-200	Toxic	2	Cr, Pb
200-300	Very toxic	0	-
>300	Extreme toxic	1	Mn

From the Table 4, we found that arsenic, copper, zinc, silver, and cadmium fall in the group of "less toxic" heavy metals. The findings are logical with the metals silver and zinc as they have been given minimum weight (1). Moderate weight-age was given to copper but falls in the "less toxic" group. But, the main anomaly is found for arsenic and cadmium. Although they have been given highest weightage (5 for Arsenic and 4 for Cobalt), they are found to be less toxic here. This leads to the fact that the availability of metal ions has major impact on the toxicity of wastewater. Opposite case was found in manganese detection. Manganese was given moderate toxicity weightage but it was found to be extreme toxic by the toxicity index. This also draws the same conclusion that expo-sure to huge amount of toxic heavy metals can cause severe damage to human health. Nickel, chromium, and lead also had moderate toxicity in the wastewater samples of different industries.

III. Conclusion

The TI for 10 samples ranges from 22.68 to 620.32. Eight heavy metals out of nine were in between toxic to less toxic range because of less amount present in the raw wastewater. The low value of TI at these industrial discharges has been found to be mainly from the lower values of copper, zinc, arsenic, silver, and cadmium. There are 6 industries which discharge manganese higher than Bangladesh standard values. Thus, manganese was found to be extreme toxic due to its huge amount presence in wastewater. On the other hand, arsenic and cadmium fell in the less toxic category which established the same outcome of unavailability in effluent. The analysis reveals that the wastewater of the industrial effluents needs some degree of treatment before discharge on to Karnaphuli River, and it needs to be maintained in order to keep the river free from heavy metal pollution.

Acknowledgment

This work was conducted by the final semester students of University of Information Technology and Sciences for their fulfilment of Bachelor of Science (B.Sc.) in Civil Engineering.

Reference

[1]. M. al hadithi, Application of Water Quality Index to Assess Suitability of Groundwater Quality for Drinking Purposes in Ratmao-Pathri Rao Watershed, Haridwar District, India, *American Journal of Science and Industrial Research*, 3(6), 2012, 395-402.

[2]. R. Reza and G. Singh, Assessment of Groundwater Quality Status by Using Water Quality index Method in Orissa, India, *World Applied Science Journal*, 9(12), 2010, 1392-1397.

[3]. P. C. Mishra and R. K. Patel, Study of the pollution load in the drinking water of Rairangpur, a small tribal dominated town of North Orissa, *Indian Journal of Environmental Ecoplan*, 5(2), 2001, 293-298.

[4]. S. Naik and K. M. Purohit, Studies on water quality of river Brahmani in Sundargarh district, Orissa, *Indian Journal of Environmental Ecoplan*, 5(2), 2001, 397-402.

[5]. D. F. Singh, Studies on the water quality index of some major rivers of Pune, Maharashtra, *Proc. Acad. Environ. Biol.*, 1(1), 1992, 61-66.

[6]. T. N. Tiwari and M. A. Mishra, A preliminary assignment of water quality index of major Indian rivers, *Indian J Environ. Proc*., 5, 1985, 276-279.

[7]. http://www.ccc.org.bd/media_brief, 2014.

[8]. APHA–AWWA–WEF, Standard Methods for the Examination of Water and Wastewater, *19th ed*., Washington, DC, 1992.

[9]. http://www.dphe.gov.bd/index.php?option=com_content&view=article&id=125&Itemid=133

[10]. WHO (World Health Organization), Guidelines for drinking water quality, *2nd Ed*., 1, 1993, 188.

[11]. https://en.wikipedia.org/wiki/Iron_poisoning