ECO-ENVIRONMENTAL STUDIES OF INDUSTRIAL EFFLUENTS AND IMPACT ON THE SURROUNDING ENVIRONMENT

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Abstract

The study was carried out to investigate the impact of industrial effluents on the surrounding environment of the Dhaka Export Processing Zone (DEPZ). The industrial effluents were collected from different outlets found in the DEPZ area. Other samples such as water, soil and plant samples (*Oryza sativa*) with roots, shoots, grains and husks were collected from the fields adjacent to the DEPZ area. Collected industrial effluents samples were analyzed for physiochemical characteristics like colour, pH, TDS, DO, BOD, COD, EC, turbidity, and salinity. All types of collected samples were analyzed for Cd, Cr, Cu, Ni, Pb and Zn by using Atomic Absorption Spectrophotometer (AAS). The concentration of heavy metals observed in the industrial effluents were in the range of Cd (0.0025 ppm to 0.0094 ppm), Cr (0.42 ppm to2.15ppm), Cu (0.56ppm to 4.55ppm), Ni (0.05ppm to 0.43ppm), Pb (0.04 ppm to 0.32 ppm) and Zn (1.87 ppm to 5.54 ppm). In water samples it ranges Cd (0.0019 ppm to 0.0075 ppm), Cr (0.372 ppm to 0.803 ppm), Cu (0.153 ppm to 0.535 ppm), Ni (0.019 ppm to 0.082 ppm), Pb (BDL to 0.31 ppm) and Zn (0.21 ppm to 0.59 ppm). This study showed that most of the observed physiochemical parameters of the collected samples were higher than the permissible limits. The analysis of the collected samples showed that the heavy metals contributed significantly towards the degradation of the surrounding biotic environment, and is directly attributable to the unbecoming industrial activities occurring nearby.

Key words: *Industrial effluents, Heavy metals, Soil, Plant, Environment*.

Introduction

Large scale urbanization, a consequence of economic development, is leading to production of huge quantities of effluents and pollutants in Bangladesh. This industrial revolution started to spring up slowly in Bangladesh in the early sixties, and is still on-going with the development of new industries throughout the country (Jolly *et al*., 2012). The Dhaka Export Processing Zone (DEPZ) being the 2nd EPZ, and the largest industrial belt of Bangladesh housing 92 industrial units which are categorically the leading creators of pollution. These industrial units include caps/accessories/garments; textile/knitting; plastic goods; footwear/leather goods; metal products; electronic goods; paper products; chemicals and fertilizers and other miscellaneous products.

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Long-term use of industrial or municipal wastewater in irrigation is also known to have a significant contribution on the concentrations of trace and heavy elements such as Cd, Cu, Zn, Cr, Ni, Pb, and Mn in surface soil (Panda and Khan, 2003). Almost all factories discharge their daily generated wastewater directly into nearby water bodies without any pre-treatment. The majority of industrial units have their own effluent treatment plants (ETP), but they don't operate them regularly in an effort to save costs (Mondal *et al.*, 2017). As a result, excessive accumulation of trace elements in agricultural soils through wastewater irrigation may not only result in soil contamination, but also affect food quality and safety (Sharma and Raju*,* 2013). This research will provide a clear idea about the water quality of the DEPZ and its adjacent area, and will help to establish the basis for future research and monitoring activities that aid in preventing water pollution around the DEPZ area. In addition, the data gathered in this study will work towards creating better effluent management strategies for effective management in the treatment of DEPZ discharges in terms of toxicity, and heavy metal concentrations.

Material and Methods

Study Area

The DEPZ is located at about 35 km south-east of Dhaka, the capital city of Bangladesh. This area belongs to Dhamsona Union under Savar Upazila of Dhaka District. The major geomorphic units of the area are: the highlands, the lowlands or floodplains, depressions, marshes, and abandoned channels. Soil found in these tracts from Madhupur Clay Formation, generally reddish brown in colour, contains pre-existing paleosol materials. The Bansi-Daleshwari and Turag River comprise the drainage network of the area Bansi on the west, and Turag River on the east (Rahman *et al.*, 2014).

Sampling

The study area was divided into several selected points within the DEPZ industrial outlets where industrial effluent is available in flowing conditions. The industrial effluents samples were collected for physiochemical and heavy metal analysis from the selected points of DEPZ found in the table below.

Table 1: Geographical location of different sampling sites of industrial effluents.

Sampling Points	Geographical Location	
01	23º57'01.42"N	090º16'10.72"E
02	23º57'04.42"N	090º16'10.72"E
03	23º57'07.42"N	090º16'10.72"E
04	23º57'05.42"N	090º16'10.72"E
05	23º57'05.42"N	090º16'11.72"E
06	23º57'04.42"N	090º16'09.72"E
07	23º57'06.42"N	090º16'11.71"E

Sample collection and preparation

Effluents were collected from 7 different points of main drainage inside the DEPZ industrial area. Geographic locations of sampling points were confirmed by GPS (Model: Garmin GPSMAP 76CSx). High-density PVC bottles were used for sample collection and preservation. Each bottle was cleaned thoroughly by ringing each through with dilute HNO_3, followed by washing with distilled water. The bottles were kept air tight and labelled properly for identification.

Laboratory analysis

During the study, different parameters of effluent samples were analyzed. In this study, different physiochemical parameters and various heavy metals were analyzed using the appropriate instruments necessary. Heavy metals like Chromium (Cr), Lead (Pb), Copper (Cu), Zinc (Zn) and Nickel (Ni) in the collected samples were analyzed by flame atomic absorption spectrophotometer.

Results and Discussion

Physico-chemical Parameters

The results of the physiochemical parameters are presented in figures as determined in the effluent samples collected from industrial effluent channels of the DEPZ, water and soil samples collections originating from adjacent agricultural field. The results of analysis are discussed below by graphical presentation.

pH of the industrial effluents

Measurement of pH is one of the most important and frequently used tests in water chemistry. The results of pH in different samples collected from DEPZ industrial area are discussed below. The pH of the industrial effluents collected from different points is shown in Fig. 01 and ranged from 8.76 to 11.23, with an average of 10.17. Here the sampling point E5 have the lowest pH value (pH = 8.76), and the highest pH value was found in sampling point E7 (pH = 11.23). According to the Royal Government Gazette (1996), standard pH of industrial effluents is 5.5-9.0. Higher values of pH were measured in sites E1, E2, E4, E6 & E7 were, 10.37, 10.25, 10.45, 10.68 & 11.23 respectively. This may be due to different types of dyes used in the dyeing process of different industrial effluents. In textile dyeing industries, H_2O_2 and NaOH are used as bleaching and kier agents. The resulting higher pH values in industrial effluents were attributable to the composition within wastes originating from textile mills including NaOCl, NaOH, Na_2SiO_3, surfactants, and sodium phosphate (Sultana *et al*., 2009). The majority of these samples surpassed the permissible limit which can directly lead to harmful effects for the local aquatic environment.

Electrical conductivity of collected samples

The electrical conductivity (EC) of water is an indicator of a salinity problem. The EC of industrial effluents collected from different sampling points of the DEPZ industrial area are shown in Fig. 02. The EC of industrial effluents ranges from 2354 µS/cm to 3532 µS/cm with an average value of 2697.71 µS/cm. The average values of EC found in the effluents indicate that a large amount of ionic substances were released from the DEPZ industries into the studied area such as sodium, chlorine, etc. The average concentration of EC is higher than the DoE (2003) standard of 1200 µS/cm. Such a high value of EC is not suitable for aquatic life and irrigation purposes.

Total dissolved solid of collected samples

The dissolved minerals in water are commonly referred to as total dissolved solids (TDS). The TDS values of the industrial effluent samples collected from different industries are shown in Fig 03. The TDS values of the sampling points ranges from 2368 mg/l to 4245 mg/l with an average value of 3046.3 mg/l. The highest TDS value 4245 mg/l was observed in sampling site E7. The lowest TDS value 2368 mg/l was found in sampling spot E2. According to Chowdhury *et al.*, 1999, waste discharge quality standard of TDS for industrial units and projects is 2100 mg/l. meaning that the TDS value of all samples higher than the standard value are considered extremely higher given the standard limit of 250 mg/l (Peavy *et al.,* 1985; Davis and Cornwell, 2006).

Dissolved oxygen (DO) of collected samples

Adequate dissolved oxygen (DO) is considered necessary for good water quality. DO in water is essential for aquatic life. Deficiency of DO in water gives rise to odoriferous products of anaerobic decomposition. The average value of DO found in the studied area is shown Fig. 04, which varied from 0.03 to 0.18 mg/L, and was far below the limit of DoE (4.5-8 mg/L). The content of DO in site E7 was very low (0.03 mg/L), which suggested that the local industries were releasing high levels of organic substances, most likely resulting from dyes that are in high oxygen demanding wastes (Emongor *et al.,* 2005). The presence of sufficient DO in water is a positive sign of a healthy body of water, but deficiencies in the concentration of DO is a signal of severe pollution.

Biochemical oxygen demand (BOD) of collected samples

Biological oxygen demand (BOD) is defined as the amount of oxygen required by microorganisms to stabilize biologically decomposable organic matter in a waste under aerobic condition (Trivedi and Gurdeep, 1997). BOD values of the industrial effluents at different sampling points are shown in Fig. 05. BOD of industrial effluents at different sampling points ranges from 383 mg/L to 761 mg/L, with an average of 552 mg/L. The highest BOD value was

761 mg/L found in sampling site E7, and the lowest BOD value was 383 mg/L found in sampling site E4. According to The United Nations World Water Development Report (2017), Industrial effluents standards of BOD value is not to exceed 110-400 mg/l, but here all sampling sites surpass the permissible limit, which means there are potentially many harmful effects that can occur from this untreated effluent discharge.

Chemical oxygen demand (COD) of collected samples

Chemical oxygen demand (COD) testing is commonly used to indirectly measure the amount of organic compounds found within water. Most applications of the COD test determine the amounts of organic pollutants found in surface water (e.g. lakes and rivers) or wastewater, making COD testing an effective measure of water quality. The COD value of the industrial effluents at different sampling points is shown in Fig. 06 which ranges from 473.64 mg/L to 1385.83 mg/L with an average of 850.4 mg/L. The highest COD value (1385.83 mg/L) and the lowest COD value (473.64 mg/L) were represented by the sampling location E2 and E7. According to Royal Government Gazette (1996), discharge quality standards of COD for industrial effluents is not to exceed more than 120 mg/L depending on the source of water used for industry, and under consideration of PCC, but should not exceed 400 mg/L in COD. All industrial effluents in this study surpassed the permissible limit, meaning there could be a direct negative effect from untreated effluent discharge in the surrounding area.

Heavy metal concentration of collected effluents

The most commonly occurring metals at the discharge sites are lead, chromium, arsenic, zinc, cadmium, copper, and mercury. Presence of these metals in the water and soil may cause serious threat to human health and ecological systems (Sundar *et al.*, 2010). The results of this analysis are discussed below by graphical presentation.

Lead concentration of collected samples

The concentration of lead (Pb) in industrial effluents at different sampling points is shown in Fig. 07, ranging from 0.04 ppm to 0.32 ppm with an average concentration of 0.198 ppm. The highest lead concentration was (0.32 ppm) found in the sampling site E7. According to Chowdhury *et al.*, (1999) waste discharge quality standards for industrial units and projects of Pb is 0.1 ppm for inland surface water and irrigation water. Excluding site E4, the concentration of Pb in the remaining sampling points were shown to surpass the permissible limit. According to the Royal Government Gazette (1996), Pb standard concentration for industrial effluents is not to exceed 0.2 mg/l. On the basis of the report, sampling points E3, E5, E6 & E7 surpassed the permissible limit.

Cadmium concentration of collected samples

The Cadmium (Cd) concentration found in collected industrial effluents samples are given below. The results of analysis are discussed below by graphical presentation. The concentration of Cd found in industrial effluents at different sampling points is shown in Fig. 08. Cd concentrations in industrial effluents ranges from 0.0025 ppm to 0.0094 ppm with an average concentration of 0.0056 ppm. The highest Cd concentration was (0.0094 ppm) found in the sampling site E7. The sampling position E1 showed the lowest (0.0025 ppm) Cd concentration. According to Chowdhury *et al.*, (1999) waste discharge quality standards of Cd found within industrial units and projects is limited to 0.05 ppm of Cd for inland surface water and irrigation. The concentrations of Cd observed in all samples of this study are within the permissible limit.

Chromium concentration of collected samples

The results of Chromium (Cr) concentration from collected industrial effluents and waste water samples are discussed below. The concentration of Cr found within industrial effluents at different sampling points is shown in Fig. 09. The Chromium concentration of industrial effluents ranges from 0.421 ppm to 2.154 ppm with an average of 1.13 ppm. The highest Cr concentration of 2.154 ppm was found in the sampling point E7. On the other hand the lowest Cr concentration is 0.421 ppm found in the sampling point E5. According to Royal Government Gazette (1996), Standard value of Cr for industrial effluents is 0.25 mg/L meaning all the samples of industrial effluents in this study surpassed the permissible limit.

Zinc concentration of collected samples

The concentration of Zinc (Zn) in industrial effluents from different industries ranges from 1.87 ppm to 5.54 ppm and is shown in Fig. 10. The average concentration of Zn was 3.114 ppm. The highest Zn concentration (5.54 ppm) was found at the sampling site E7. The sampling point E4 showed the lowest Zinc concentration (1.87 ppm). According to the Royal Government Gazette (1996), standard of Zn for industrial units is 5.0 ppm for inland surface water and irrigation water, but sampling point W7 surpasses the permissible limit, while other sampling sites are within the permissible limit.

Nickel concentration of collected samples

The concentration of Nickel (Ni) in industrial effluents collected from different industries is shown in Fig. 11. Ni concentrations ranged from 0.05 ppm to 0.43 ppm with an average of 0.24 ppm. The highest Ni concentration (0.43 ppm) was found in the sampling site E7 and the lowest was (0.05 ppm) in the sampling point E5. According to Chowdhury *et al.*, (1999) waste discharge quality standard of Ni for industrial units and projects is 1.0 ppm for inland surface water and irrigation water and here all samples are within the permissible limit in respect to Ni concentration.

Copper (Cu) concentration of collected samples

The concentration of Copper (Cu) in collected industrial effluents and waste water samples are discussed in below. Cu concentration of collected industrial effluents at different sampling points is shown in Fig. 12. Cu conc. of industrial effluents at different sampling points ranges from 0.56 ppm to 4.55 ppm with an average of 1.92 ppm. The highest Cu concentration (4.55 ppm) was found in the sampling site E7. On the other hand the lowest Cu concentration (0.56 ppm) was found in sampling site E3. According to Chowdhury *et al.*, (1999) waste discharge quality standard of Cu for industrial units and projects is 0.5 ppm for inland surface water and irrigation water, but here all observed samples sites surpassed the permissible limit.

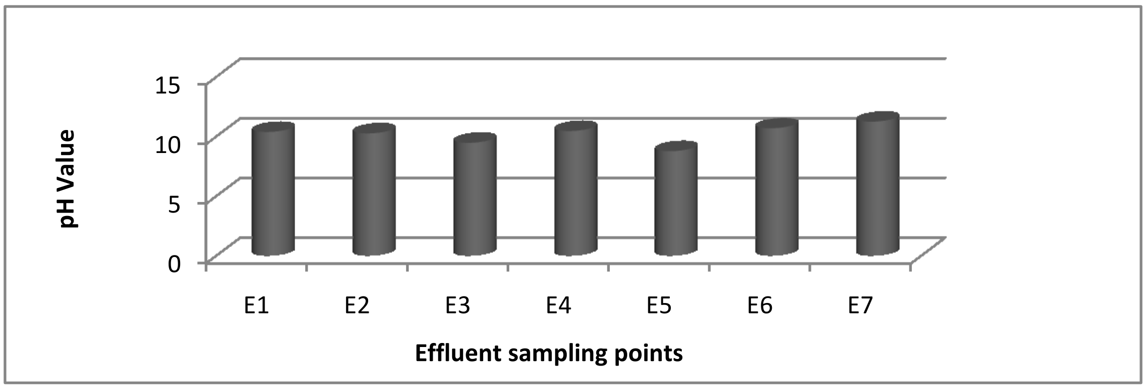

Figure 1. pH of industrial effluents at different sampling points.

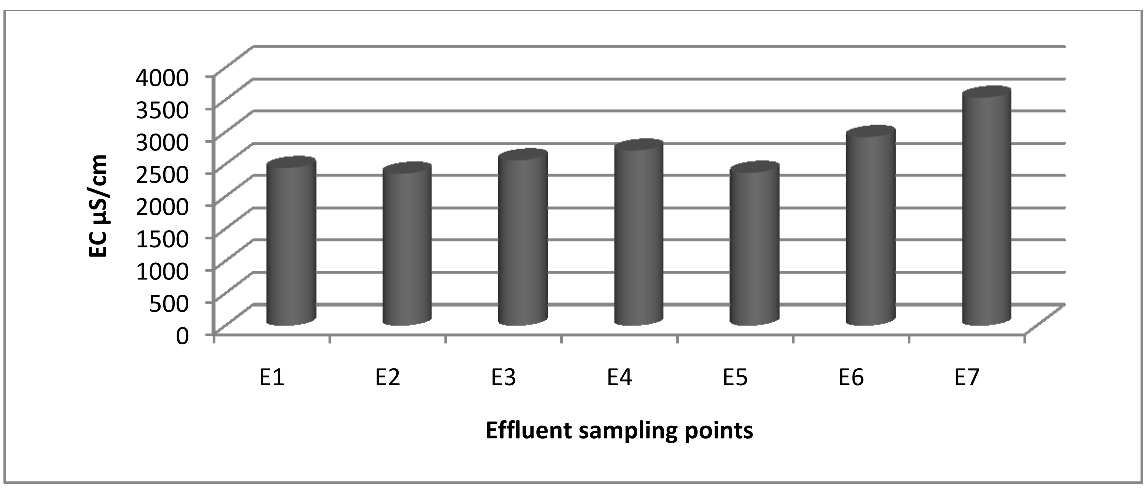

Figure 2. EC of industrial effluents at different sampling points.

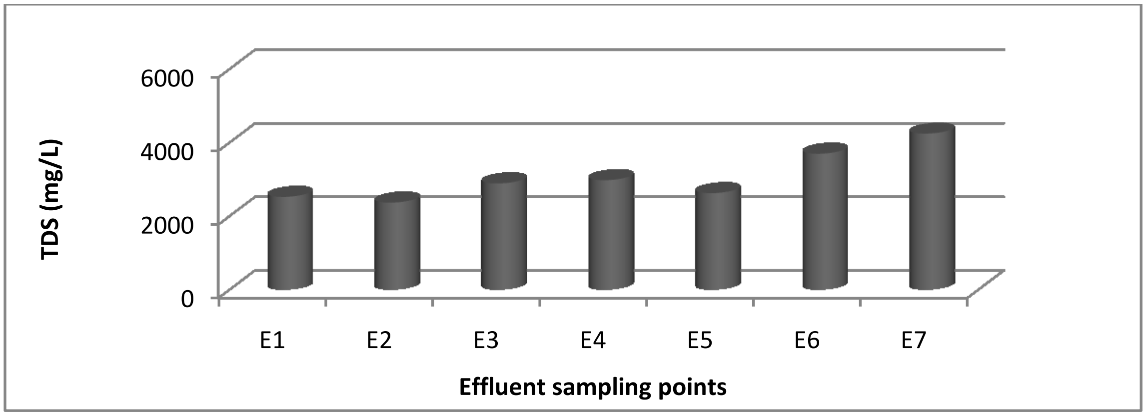

Figure 3. TDS of industrial effluents at different sampling points.

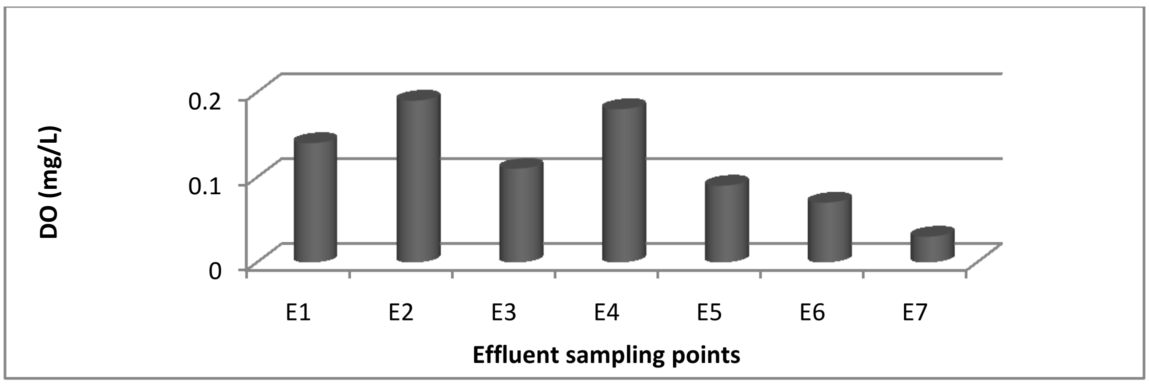

Figure 4. DO of industrial effluents at different sampling points.

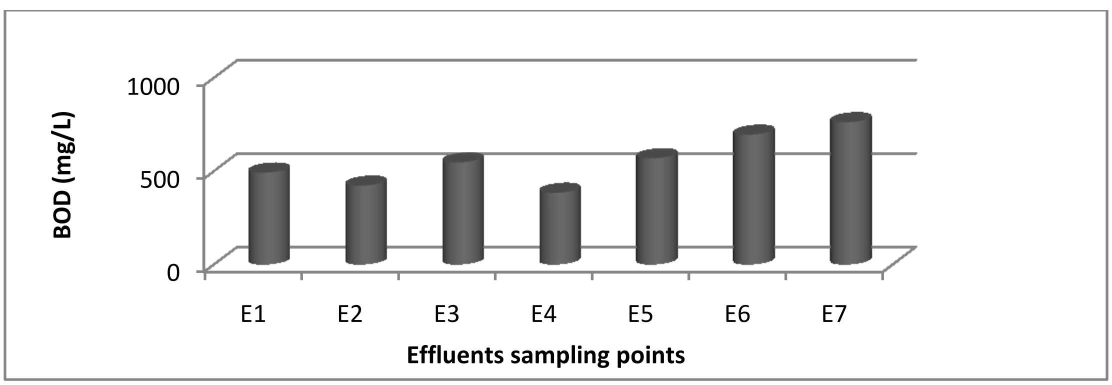

Figure 5. BOD of collected industrial effluents at different sampling points.

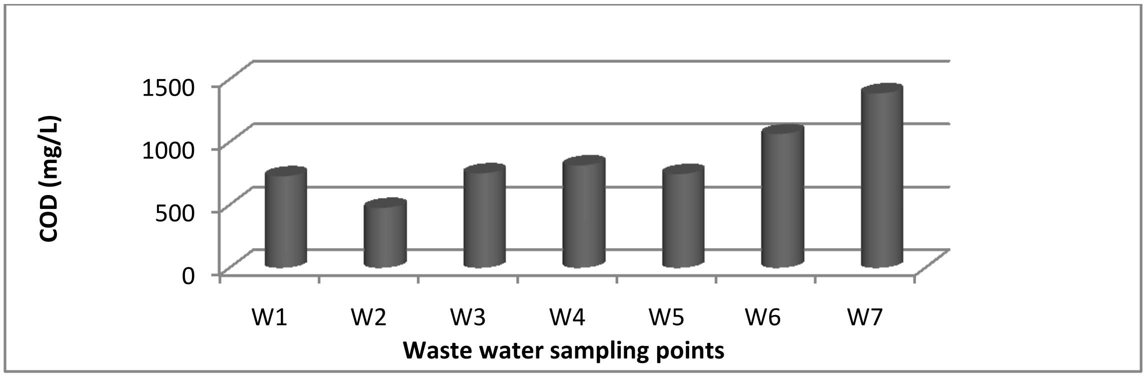

Figure 6. COD of industrial effluents at different sampling points.

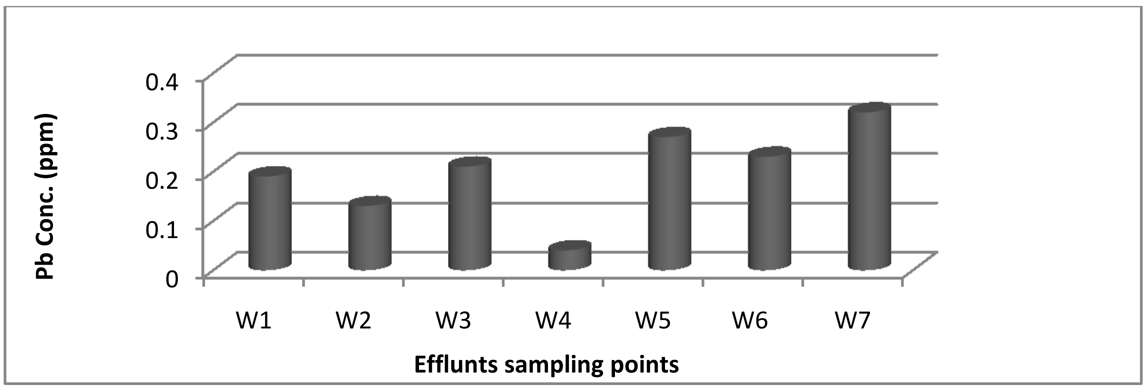

Figure 7. Pb concentration of industrial effluents at different sampling points.

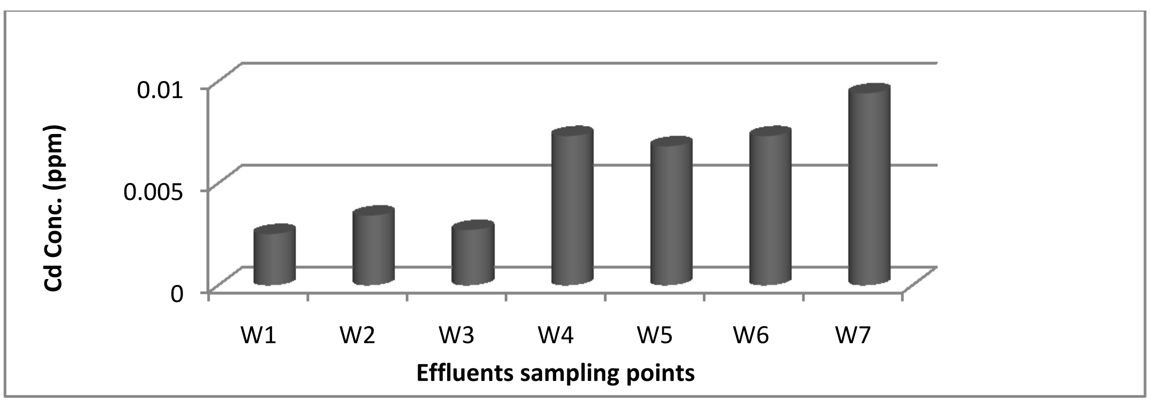

Figure 8. Cd concentration of industrial effluents at different sampling points.

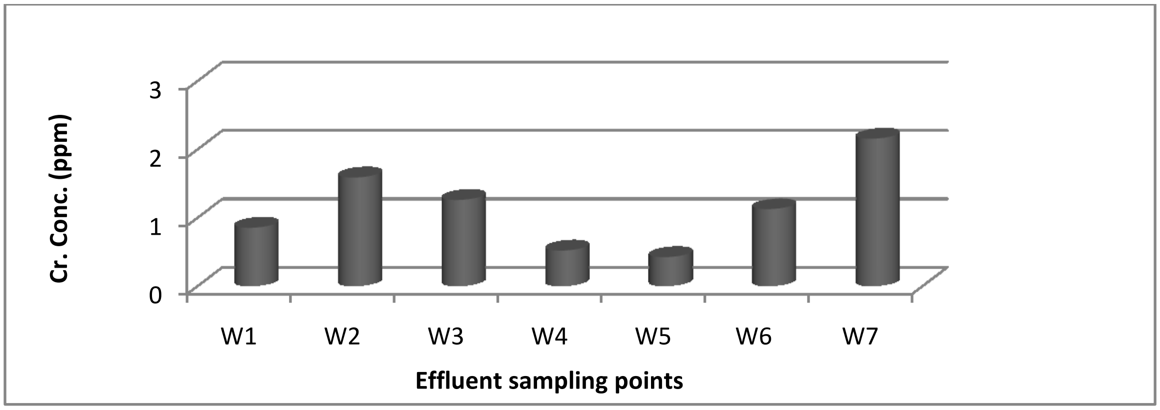

Figure 9. Cr concentration of industrial effluents at different sampling points.

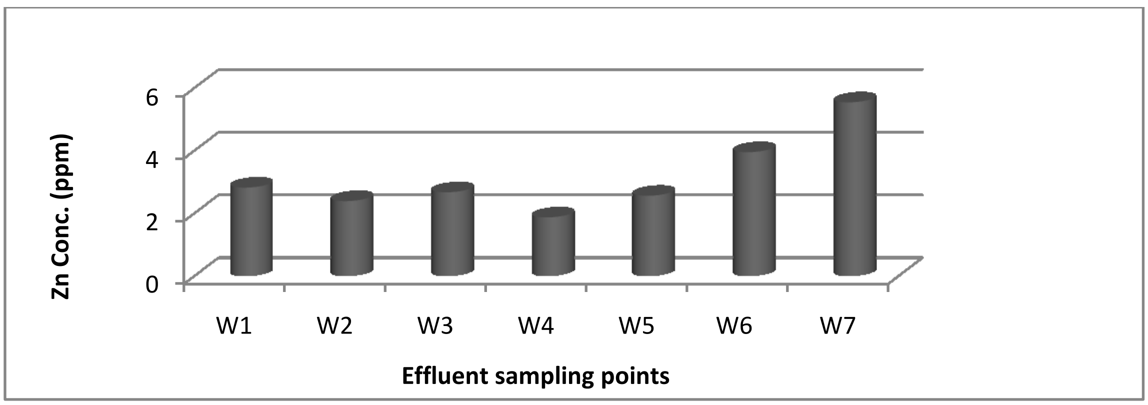

Figure 10. Zn concentration of industrial effluents at different sampling points.

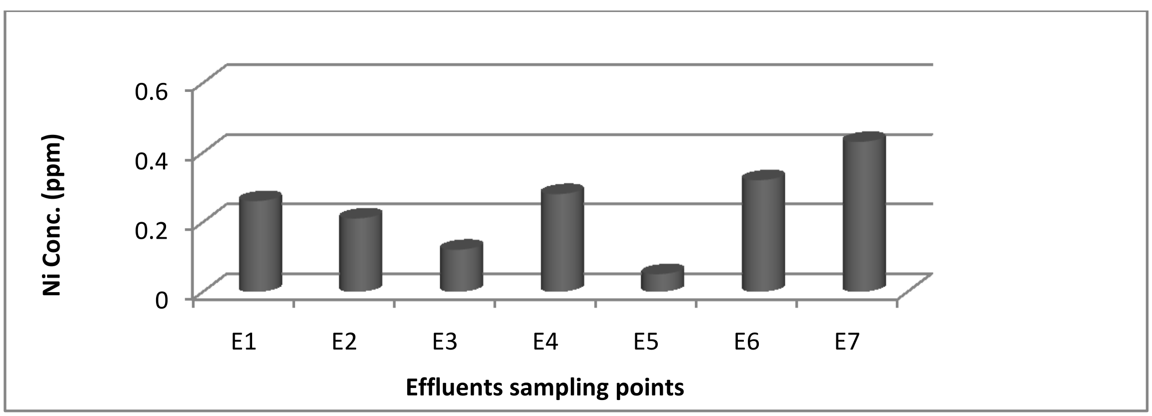

Figure 11. Ni concentration of industrial effluents at different sampling points.

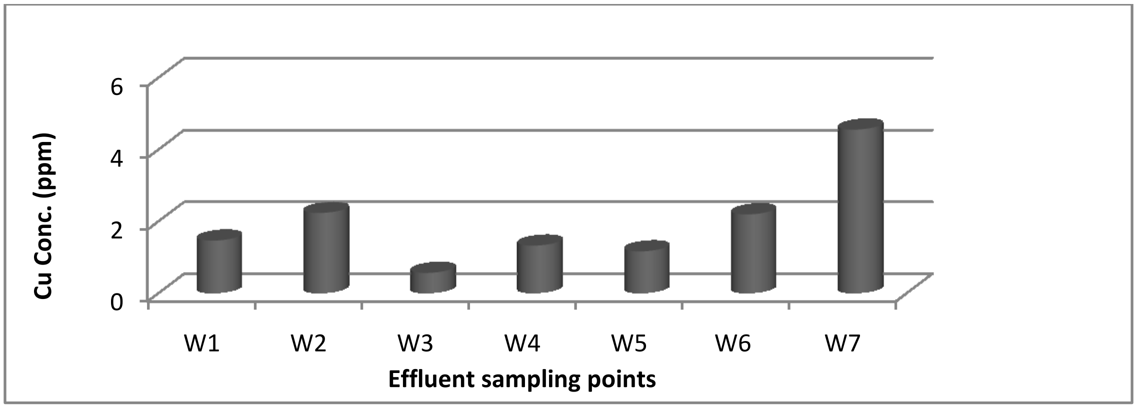

Figure 12. Cu concentration of industrial effluents at different sampling points.

Conclusion

Overall, studies have shown that all the physicochemical and heavy metal parameters of collected water samples (pH, EC, TDS, DO, COD, BOD, Pb, Co, Ni, and Cu) surpassed the permissible limits. The results suggest that the effluents being discharged into the local streams have considerable negative effects on the water quality in the receiving streams. Usage of the stream for agricultural purposes such as irrigation and aquaculture will have adverse effects on crop and animal health, as well as the general ecological environment. Although the values in some cases were lower than the maximum allowable limits, the continued discharge of untreated effluents in the stream may result in severe accumulation of damaging contaminants. Heavy metals parameters (Pb, Co, Cu, Ni and Zn) from all the collected samples surpassed the permissible limits. If the contaminated water used for agricultural purposes continues, the hazardous elements will accumulate within the plants or cereals, and will also affect aquatic animals like fish. If people receive these contaminated cereals or fish, they can potentially suffer from carcinogenic diseases. Thus the present work concludes that the effluents from the industries causes the pollution problems in the surrounding environment. In such conditions only feasible options that could be followed are to control water contamination, legislative measures must be taken, legally binding the individual industries, and forbidding the discharge of untreated or poorly treated industrial effluents. Central ETP of DEPZ should be proper used to protect the environment. Waste water discharged from DEPZ could be recycled for the remediation of pollution in a sustainable and eco-specific way. Moreover different remediation measures should be taking promptly to remove excising metal contamination.

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