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Assessing Water and Soil Pollution Due to Uttara EPZ, Nilphamari, Bangladesh

Md. Emdadul Haque*, Moury Shermin, Arifa Yasmin Mukta

Department of Disaster Management, Begum Rokeya University, Rangpur, Bangladesh
Email: *e_haque27@yahoo.com, sherminmoury@gmail.com, arifayasminmukta@gmail.com

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Abstract

The Uttara Export Processing Zone (UEPZ) is being the important industrial belt of the northern region. It is an important issue to find out the environmental impact of UEPZ. Water is the most important source of domestic, irrigation and industrial purpose in both rural and urban regions. The present study was carried out to find out the water and soil quality of UEPZ. Five heavy metals were selected (Fe, Cu, Mn, Pb, Cr) to assess water quality of UEPZ and two indices such as heavy metal pollution index (HPI) and contamination index (C_d) were selected to evaluate the impact on water. The results showed that the concentrations of heavy metals in water samples were within the permissible limits of WHO drinking water quality. HPI of water samples in three sites was 20.57 which was lower than 100 the critical value for drinking water. Both results show the region is moderately or slightly polluted. Pollution risks of heavy metal in the soil were evaluated by method of geological acumination index (I_{geo}) and Pollution load index (PLI) for seven soil samples. The geological evaluation of the cumulative index results showed that the contamination degree of 4 heavy metals follows the sequence of Mn > Zn > Fe > Cu. Then the results of PLI of seven soil sample are 1.474 > 1.398 > 1.372 > 1.308 > 1.302 > 1.290 > 1.289. Both results show the soil sample area were unpolluted to moderately polluted. Finally, an overall impact of UEPZs environment is also discussed in this paper.

Keywords

UEPZ, Environment, Contamination, Mitigation, Impact, Pollution

1. Introduction

UEPZ is the seventh of the eight export processing zone in Bangladesh located at Nilphamari district. It's the only export processing zone of the northern part of Bangladesh. It was established in September 2001 on about 213.66 acres of lands in Sangalshi area in Nilphamari town. It's located in 25˚51'29"North latitude to 88˚51'50"East longitude. About 30,000 workers work here. There are more than 180 industrial plots in this EPZ. Allocation of 138 plots has been completed, 12 plots are running, 33 plots are undeveloped and 09 plots remain empty. The areas Sangalshi have been for many years a verdant region of fertile farmlands with paddy and wheat fields and plantations of various vegetables and mustard. It also provides a good habitat for flora and fauna. However, in recent times, the scenario has been changing rapidly due to its industrial sites in the area. The communities in the region are still involved in farming but rapid changes are creating overall environmental impacts. In the last ten years, this region has witnessed a significant change due to industrial establishments and the area in the periphery of the highway. UEPZ is established with a view to achieving employment, income, and hence reduce poverty through setting up industries and utilizing benefits, but it has an indirect impact on the agricultural land. The Export Processing Zones (EPZs) have become an important factor for economic enclaves particularly in employment generation, export diversification and investment creation. There is a connection between environmental conservation, industrial and neighboring developments which is not in doubt, but developments whether residential, commercial or industrial impact the environment either negatively or positively, but mostly negatively unless they are well planned and appropriate and adequate measures put in place to mitigate against possible and certain negative impacts (Wadud, 2018).

People in this region lead to deplorable life. The adverse impacts caused by industry within the zone need to be identified and assessed urgently to identify the water and soil pollution from the factories. In order to assess the situation, comprehensive information about the existing industries area is needed to be integrated into the conservation and development plan of the region in order to reduce the environmental degradation. In this regard, an environmental impact assessment (EIA) is mandatory for the protection, conservation and sustainable management of the environment. But in this article water and soil pollution assessment have been done to figure out the real picture of UEPZ. The main objectives of the study are summarized as follows:

- ✓ To assess the chemical contamination of water quality of the UEPZ.
- ✓ To determine the chemical contamination of soil quality of agricultural land beside UEPZ.

The concentrations of heavy metals in soils are varied according to the rate of particle sedimentation, the rate of heavy metals deposition, the particle size and the presence or absence of organic matter in the soils. The assessment of sediment enrichment with elements can be carried out in many ways; the most common ones are the index of geo-accumulation (I-geo) and pollution load index (PLI).

Khan et al. (2011) describes in environmental pollution around Dhaka EPZ and its impact on surface and groundwater. Dhaka EPZ since its establishment has altered the fragile environment of the surrounding area. Huge amount of effluents discharged from Dhaka EPZ has been polluting the surface and groundwater. Surface water contamination by industrial effluents released from Dhaka Export Processing Zone (DEPZ) and the ramification to groundwater have been estimated.

Industrial activities are threat to the quality and quantity of surface and ground water resources in many part of the world (Allen et al., 1996). These activities, by their nature consume, divert, and can seriously pollute water resources. There, it may pollute the natural surface drainage and other water resources (Singh et al., 2007). Industrial water can vary greatly in the concentration of contaminants present, and some water discharges can be a potential water resource, where the local water demands for irrigation, and even drinking and domestic uses can be fulfilled by effective utilization (Cidu et al., 2007; Singh et al., 1997).

From the literature review, it is clear that every EPZ have a bad impact on the environment though it plays a major role in the economy. Most paper has been done on different EPZ of Bangladesh. It shows positive and negative impact of EPZ. But there is no work done on the UEPZ. As every EPZ have impact on environment so it is important to evaluate the negative impacts. So this paper tries to find out the negative impact of UPEZ on water and soil. This study also tries to find out the local people's perceptions and make them aware about the negative impact of UPEZ.

2. Materials and Methods

2.1. Study Area

An EPZ is established in the Shongalshi at Saidpur than a of Nilphamari district in July 01, 2001. This EPZ is known as the Uttara EPZ (henceforth UEPZ). It is situated 10 kilometers away from Nilphamari by road, 18 kilometers away from Saidpur airport, 360 kilometer away from Dhaka and 640 kilometers away from the Chittagong Sea Port. It is connected with Dhaka, and Chittagong seaport by road, rail and air directly and indirectly. This EPZ is established for domestic and foreign investors covering an area of about 230 acres with a view to creation of employment of about 35,000 labourers. It is establish with 213.66 acres of lands in Sangalshi area in Nilphamari town. There are more than 180 industrial plots in this EPZ. Allocation of 138 plots has been completed. 12 plots are running. 33 plots undeveloped and 09 plots are empty. It is at Shongalshi in Nilphamari. Here is a GIS (Geographic Information System) map of the study area executed in ArcMap 10.3 is presented in below (**Figure 1**).

2.2. Soil Sample Collection

Soil sampling is a technique by which a true representative sample of a given area is collected. A one-time sampling of soil representative of the entire catchment area was undertaken and analyzed using standard methods soil samples

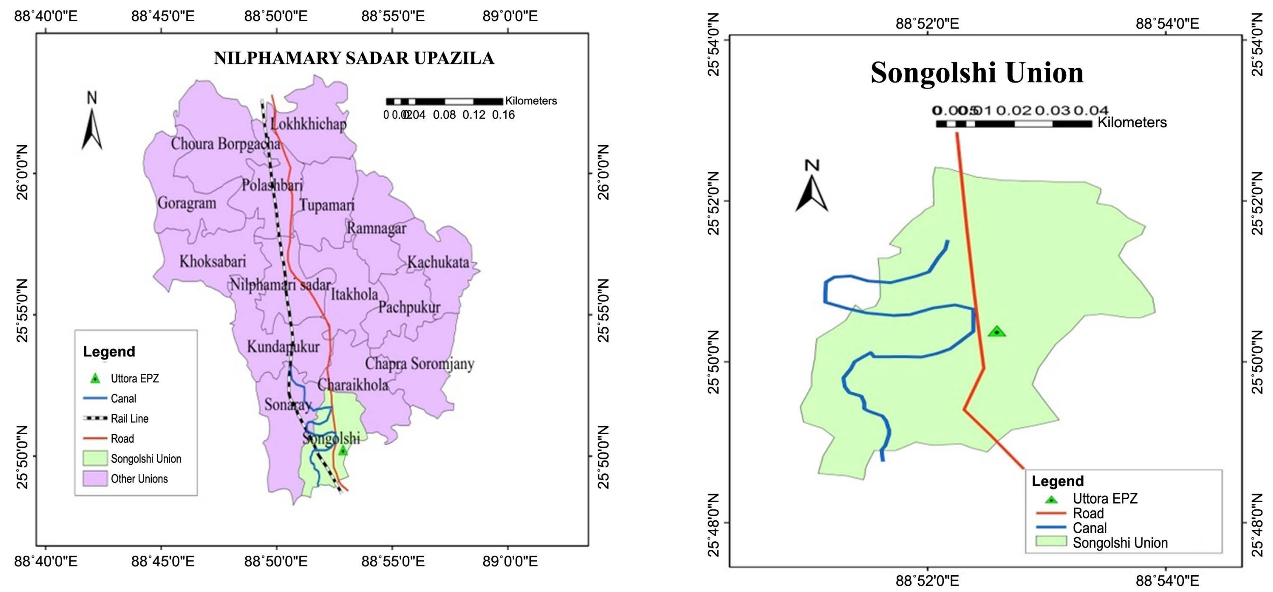

Figure 1. Location of the study area.

were taken every 20 cm from the top soil to a depth of 75 cm. Seven points were selected for collecting soil sample of the study area to investigate certain parameter in which four soil sample were collected from agricultural land adjacent to the UEPZ and another three soil samples were collected from inside of the UEPZ.

2.3. Soil Sample Preparation

Adhering materials were removed with forceps, and all sample materials were dried at ambient temperature. In all steps of soil sample preparation and analysis, care was taken to avoid contamination. Soils are highly heterogeneous; hence it has to be analyzed for various physico-chemical. This also would help in assessing the amount of nutrients or amendments required for a particular soil to increase its productivity. Samples were collected in thick quality plastic pot and immediately transported to the laboratory. They were shade dried at room temperature and stored. The dried soils were then sent to laboratory to test.

2.4. Evaluation of Soil Quality

2.4.1. Geo-Accumulation Index

The index of geo-accumulation (I_{geo}) is used to assess the soil and sediment quality. Geo-accumulation index was enabled to assess the pollution of metal in the soil particles of the selected area Geo-accumulation index was determined by the following equation according to Muller, G. (1969) and described by Boszke et al. (2004). Equation (1) is:

$$I_{geo} = \log 1.5\sqrt{\frac{C_n}{B_n}} \tag{1}$$

where

C_n = is the measured concentration of the element in the pelitic sediment fraction (<2 μm).

B_n = is the geochemical background value in fossil argillaceous sediment (average shale).

1.5 allows analyzing natural fluctuations which is a given substance in the environment as well as very small anthropogenic influences (Table 1).

2.4.2. Pollution Load Index

The pollution load index (PLI) was proposed by Tomlinson et al. (1980) for detecting pollution which permits a comparison of pollution levels between sites and at different times. Pollution load index (PLI) which was used for identify the soil quality of the study area. The PLI is obtained as Concentration Factors (CF). CF is ratio between the concentration of heavy metals in study area and background level. This index is quickly understood by unskilled personal in order to compare the pollution status of different places and it varies from 0 (unpolluted) to 10 (highly polluted). PLI index is given bellow:

$$C_f = C_m / C_b \tag{2}$$

C_f = C metal/ C Background value, n = number of metals.

Finally, the equation is given bellow

$$\text{PLI} = \sqrt[n]{CF_1 \times CF_2 \times CF_3 \times \cdots \times CF_n} \tag{2.1}$$

PLI value and its contamination level were compared followed by Harikumar et al. (2009).

PLI = 0 indicates concentration of background; PLI ≤ 1 indicates Unpolluted; 1 < PLI ≤ 1indicates moderately to unpolluted; 2 < PLI ≤ 1 indicates moderately polluted; 3 < PLI ≤ 1, indicates moderately to highly polluted; 4 < PLI ≤ 1 indicates highly polluted and finally PLI > 5 indicates very highly polluted.

These PLI values are used to identify the contamination level of soil. It varies from 0 to 5 indicates background concentration soil to very highly polluted.

2.5. Water Quality Assessment

2.5.1. Methods to Qualitative Analysis of Water

Water is a dynamic system and hence its characteristic quality changes with time

Table 1. Index of geo-accumulation (I_{geo}) for contamination levels for soil nutrient.

I_{geo} Class	I_{geo} Class	Contamination level
0	$I_{geo} \leq 0$	Uncontaminated
1	$0 < I_{geo} < 1$	Uncontaminated/moderately contaminated
2	$1 < I_{geo} < 2$	Moderately contaminated
3	$2 < I_{geo} < 3$	Moderately/strongly contaminated
4	$3 < I_{geo} < 4$	Strongly contaminated
5	$4 < I_{geo} < 5$	Strongly/extremely contaminated
6	$5 < I_{geo}$	Extremely contaminated

(Source: Muller, 1969).

and place. Water quality is therefore measured with a variety of physical, chemical and biological variables which may be qualitative (indices or ratings of environmental risk and health) or quantitative (measurements or amounts of specific indicators or parameters). 7 water samples were collected from ETP of UEPZ. Plastic bottle containers were used for collecting and storing the samples in the laboratory. The following procedure was followed while sampling. Before being filled with the sample, the container was first rinsed with the sample. The samples were collected by directly immersing the container in the soil, and it was closed properly using appropriate stoppers. Water samples were collected at irregular intervals to identify their characteristics and the changes in their quality. A total of 7 composite water samples were collected from various locations encompassing the entire catchment area. Precautions were taken while handling the collected samples to ensure its integrity. Composite water samplings were completed from these points to evaluate the chemical composition immediately transported to the laboratory for further physico-chemical analysis. To get the result at first the water should be digested by following the given steps.

2.5.2. Digestion of Water for Metal Analysis and Equipment Used

Conical flask, Test tube, White man filter paper, Burner, Burner stand, Beaker, HNO_3, HCL, Distilled water, Match. Firstly we rinsed all the equipment with distil water. Then took 100 ml sample water in the beaker and then 3 ml HCL and 2 ml HNO_3 (65% concentrated) mixed with it. Then keep the beaker on the burner stand for boiling until it came in 25 ml in volume. Followed samples were allowed to cool at room temperature. After that the boiled water was filtered into the conical flask using white man filter paper. Then 75 ml distil water mixed with it and the volume came in 100 ml. finally this 100 ml water poured in a bottle which was rinsed with distil water. Then send to laboratory to test.

2.6. Evaluation of Water Quality

Two documented methods evaluated in this study are the Contamination index (C_d) developed by Backman et al. (1998) and the Heavy Metal pollution index (HPI) proposed by Mohan et al. (1996).

2.6.1. The Contamination Index (C_d)

One of the approaches to calculate contamination of water bodies is through Contamination Index (C_d), which takes into consideration both the number of parameters exceeding the upper permissible limits or guide values of the potentially harmful elements (Backman et al., 1998). Calculation of the contamination degree (C_d) was carried out separately for each analyzed sample of water, as a sum of the contamination factors of individual components exceeding the upper permissible values. Hence, the contamination index summarizes the combined effects of several qualities according to Backman et al. (1998), the calculation scheme of Contamination Index (C_d) is as follows:

$$C_d = \sum_{i=1}^{n} C_{fi} \quad (3)$$

where, C_{fi} = Contamination factor for the i-th component, C_{Ai} = Analytical value of the i-th component, C_{Ni} = Upper permissible concentration of the i-th component (N denotes the "normative value").

In this study, for uniformity sake all analytical values were considered irrespective whether above or below upper permissible concentration value. Secondly, the values were not normalized since this is the first ever study in the area. The upper permissible concentration value (C_{Ni}) was taken as the maximum admissible concentration (MAC). The components considered include Cu, Fe, Pb and Mn.

2.6.2. Heavy Metal Pollution Index (HPI)

The HPI represent the total quality of water with respect to heavy metals. The HPI is based on weighted arithmetic quality mean method. In computing the HPI, Prasad and Bose (2001) considered unit weightage (W_i) as a value inversely proportional to the recommended standard (S_i) of the corresponding parameter as proposed by Reddy (1995).

The HPI model (Mohan et al., 1996) is given by

$$\text{HPI} = \frac{\sum_{i=1}^{n} W_i Q_i}{\sum_{i=1}^{n} W_i} \quad (4)$$

where, Q_i = The sub index of the i^{th} parameter, W_i = The unit weightage of i^{th} parameter and n = The number of parameters considered.

Weighted arithmetic index method has been used for calculation of HPI. The unit weight (W_i) has been found out by using formula

$$W_i = \frac{K}{S_i} \quad (4.1)$$

where, K = proportionality constant, S_i = standard permissible value of ith parameter.

The sub index (Q_i) of the parameter is calculated by

$$Q_i = \sum_{i=1}^{n} \frac{|M_i - I_i|}{(S_i - I_i)} \times 100 \quad (4.2)$$

where, M_i = The monitored value of heavy metal of ith parameter, I_i = The ideal value of the ith parameter and S_i = The standard value of the ith parameter. The sign (−) indicates numerical difference of the two values, ignoring the algebraic sign. The critical pollution index of HPI value for drinking water (as given by Prasad & Bose, 2001) is 100.

3. Results and Discussion

3.1. Soil Quality Assessment

3.1.1. The Geo-Accumulation Index ($I_{\text{-geo}}$)

Geo-accumulation index was determined followed by Equation (1).

Table 2 represents geo accumulation index with its value in the study area. Mainly from 12 parameter, Cu, Fe, Mn heavy metals are selected. The concentration is varying from 0 to 1 which makes the area slightly to moderately polluted. The I_{geo} grades for the study area sediments vary from metal to metal and site to site (across metals and sites). The I_{geo} classes for Cu vary from 0.18 to 0.76, which remain in class 2, which means the study area uncontaminated to moderately pollute. Sample number 1, 2, 4 carry a little much concentration of Cu, situated beside UEPZ.

In Table 2, I_{geo} classes for Fe vary from 0.1o to 0.18, which also remain in class 2, represented the uncontaminated to moderately pollute, which means the study area uncontaminated to moderately pollute of the study area. From Table 2, I_{geo} classes for Mn vary from 0.41 to 1.108. Concentration of Mn are fall into class 2 and 3 which indicates uncontaminated to moderately polluted, which means the study area uncontaminated to moderately polluted and moderately contaminated. The concentrations of heavy metals in sediments are varied according to the rate of particle sedimentation, the rate of heavy metals deposition, the particle size and the presence or absence of organic matter in the sediment.

The I_{geo} showed grade 3 for Mn and other all heavy metals are in grade 3, this suggests that the sediments of the area are having background concentrations for Mn, Cu, and Fe, and these elements are practically changed by anthropogenic influences, while the concentration of the metals exceeded the average shale value. These dangerous metals may be derived from industrial waste and chemical used, in the factories of UEPZ. These elements may also be derived through corrosion of the numerous abandoned launches along agricultural activities of the land of study area.

Figures 2(a)-(d) represent the geo-accumulation values of Fe, Cu, Mn, and Zn. From the graph, 4 no area namely mocha para are moderately polluted. The concentration of heavy metal of mocha para are Mn > Zn > Fe > Cu. The soil sample 1, 2, 3, 5, 6, 7 are in class 2 and soil sample 4 are in grade 3, which is moderately contaminated by Manganese. Among the index, the concentration of

Table 2. Heavy metal (Cu, Fe, Mn, and Zn) concentration (µgm/gm) for geo accumulation index.

Sample No	I_{geo} Cu	Sample No	I_{geo} Fe	Sample No	I_{geo} Mn	Sample No	I_{geo} Zn
1	0.769368	1	0.111817	1	0.420922	1	0.455139
2	0.456489	2	0.160219	2	0.534693	2	0.370615
3	0.185006	3	0.108527	3	0.411244	3	0.115855
4	0.247805	4	0.151898	4	1.108218	4	0.569145
5	0.210461	5	0.15563	5	0.448704	5	0.089741
6	0.20316	6	0.184078	6	0.774584	6	0.250275
7	0.269223	7	0.172911	7	0.571107	7	0.079144

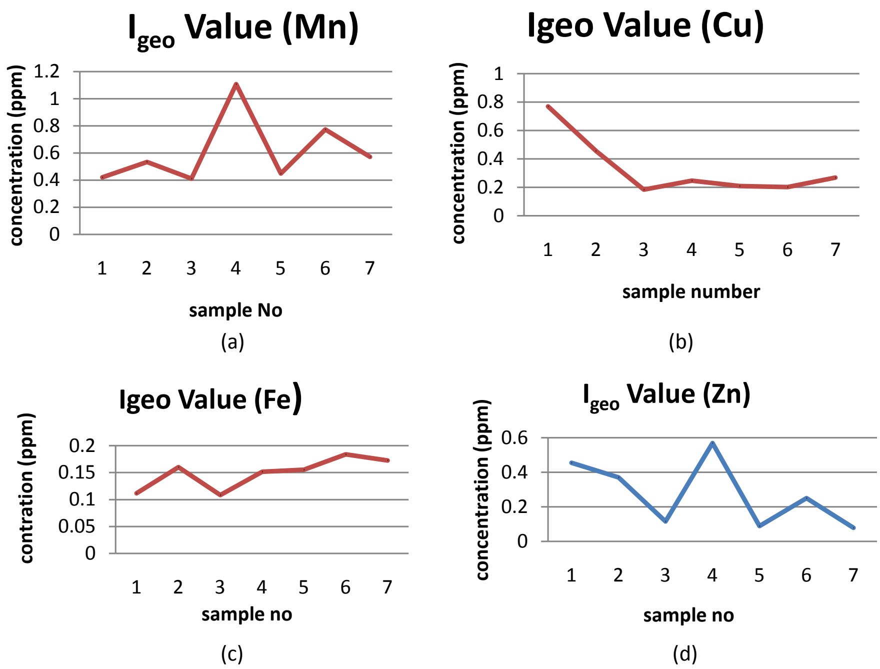

Figure 2. (a) I_{geo} value for Mn; (b) I_{geo} value for Cu; (c) I_{geo} value for Fe; (d) I_{geo} value for Zn.

Mn are found mostly then other heavy metal. This situation can be originated from inflow of Mn form UEPZ which mainly run from agricultural land. Now the situation creates moderately contaminated, but it will brings adverse effect on agricultural land.

Other metal also mixed up with soil by chemical use in UEPZ. Zn, Cu are also from point source of contamination so that excessive use of chemical in UEPZ increases the concentration of heavy metal in further day which has adverse effect on agricultural land of Sangalshi area.

3.1.2. Contamination Factor (C_f)

It refers the specific rate of contamination of different chemical. Form the lab test, we get 13 chemical from which we find chemical contamination of P, K, Zn, Ca, Mg, Cu, Fe, and Mn. When the value of C_f is less than 1 it describes unpolluted or no pollution. But when it is increased or the rate increased, the rate of C_f value is also increased. The following **Table 3** shows the C_f concentration of 10 chemical.

3.1.3. Pollution Load Index

The Pollution Load Index (PLI) is obtained as contamination Factors (C_f), this C_f is the quotient obtained by dividing the concentration of each metal with its control value. The PLI of the place are calculated by obtaining the n-root from the n-C_fs that was obtained for all the metals. This index find the comparison and description about the pollution level of the study area, this index is achieved for provide the combined result of the chemical which find in soil. From the study of C_f contamination, it shows that the selected area is moderately polluted to unpolluted. Here the PLI value find in class 2 which indicates this class, the pollution

Table 3. C_f concentration of chemical parameter.

No	C_{fp}	Cf_k	C_{fs}	Cf_{zn}	Cf_b	Cf_{ca}	Cf_{mg}	Cf_{cu}	Cf_{fe}	Cf_{mn}	PLI value
1	3.618	0.486	3.4	3.429	1.6	0.485	0.786	9.8	0.207	2.933	1.289
2	1.287	0.804	8.051	2.274	1.222	0.471	0.943	3.45	0.425	4.733	1.372
3	0.591	0.619	5.147	0.222	0.355	1.764	1.797	0.566	0.195	2.8	1.302
4	5.106	5.309	4.409	5.362	1.555	2.039	3.056	1.016	0.382	20.333	1.474
5	1.95	0.973	3.225	0.133	0.955	0.378	0.696	0.733	0.401	3.33	1.29
6	4.486	3.584	3.044	1.03	1.93	1.221	2.224	0.683	0.561	9.933	1.398
7	0.062	0.929	3.343	0.103	0.9111	0.732	1.483	1.2	0.495	5.4	1.308

rate is increased when the PLI value is increased. Here the value varies from 1.2 up to 1.3 for the seven soil samples. Here the C_f concentration of 7 soil samples (**Table 4**).

The below **Figure 3** shows that sample 4 is mostly polluted according to the PLI index. 4 no sample indicates mocha para, and its concentration vary from other chemical. It helps to find about pollution level of soil sample point.

3.1.4. Comparison between Geo Accumulation Index and Pollution Load Index

From the overall study, it will be find that site 4 is polluted zone among all them. The two methods indicate that the selected area refers to moderately polluted and unpolluted to moderately polluted. Here **Table 5** describes the comparison between them.

3.1.5. pH Analysis of Soil Sample

pH has its great influence on the chemical and biological properties of liquids, hence its determination is very important. It is one of the important parameters in water chemistry and is defined as −log [H+] and measured as intensity of acidity or alkalinity on a logarithmic scale ranging from 0 to 14 (Ramachandra et al., 2012). According to SRDI, the soil pH value of Bangladesh is given bellow in **Table 6**.

From the lab test, the concentration of pH for 7 soil samples varies from 5.1 to 7.5, which indicates strongly acidic to slightly alkaline. The concentration of PH value of seven soil sample location wise are 3 > 4 > 5 > 1 > 7 > 6 > 2 No sample. Anthropogenically impacted and control soils of the study area were assessed using contamination factors and pollution load index for Cu, Fe, Mn and Zn. The contamination factors were observed generally to indicate low to moderate contamination by heavy metals across the grid points and depths; the background soil was higher than that of the study area for some of the element and grid points which could be attributed to industrial waste and deposit. The measure of degree of overall contamination at the sampled area indicate strong signs of pollution deterioration by the different material which confirm that the study area is facing probable environmental pollution especially with dangerous

Table 4. Values of pollution load index with identify the classification level.

Sample no	PLI value	Pollution level
1	1.289	Moderately to unpolluted
2	1.372	Moderately to unpolluted
3	1.302	Moderately to unpolluted
4	1.474	Moderately to unpolluted
5	1.29	Moderately to unpolluted
6	1.398	Moderately to unpolluted
7	1.308	Moderately to unpolluted

Table 5. Comparison between two methods.

Sample number	Pollution load index	Geo accumulation index
1	Moderately to unpolluted	Uncontaminated to moderately contaminated
2	Moderately to unpolluted	Uncontaminated to moderately contaminated
3	Moderately to unpolluted	Uncontaminated to moderately contaminated
4	Moderately to unpolluted	Moderately contaminated
5	Moderately to unpolluted	Uncontaminated to moderately contaminated
6	Moderately to unpolluted	Uncontaminated to moderately contaminated
7	Moderately to unpolluted	Uncontaminated to moderately contaminated

Table 6. Soil pH according to SRDI.

pH value	Classification
Very strongly acidic	<4.5
Strongly acidic	4.6 to 5.5
Slightly acidic	5.6 to 6.5
Neutral	6.6 to 7.3
Slightly alkaline	7.4 to 8.4
Strongly alkaline	8.5 to 9.0

(Source: SRDI, 2018).

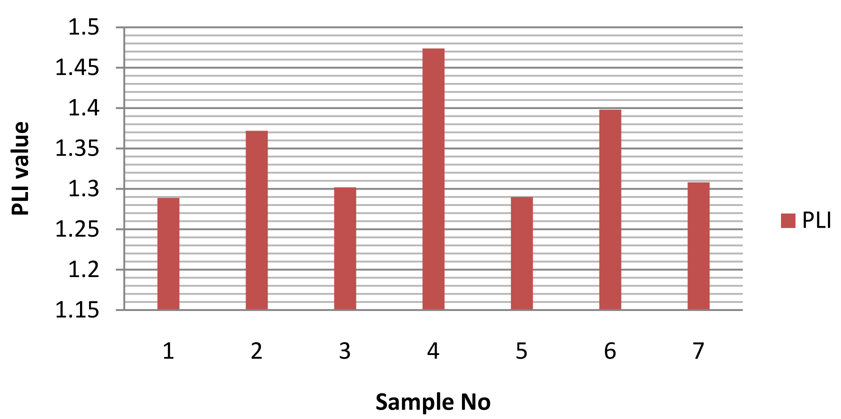

Figure 3. PLI concentration of seven sample points.

heavy metals which result from increased rate of non-treated industrial waste discharged into the cannel.

3.2. Qualitative Analysis for Assessing the Impacts on Water

3.2.1. Water Pollution by Industrial Activities

Discharge industrial organic waste water and source of heavy metal ingredient may be caused water pollution. Therefore to get an idea about the intensity of heavy metal pollution the heavy metal pollution index of the selected study area was calculated. Water samples were taken for study to calculate heavy metal pollution index before treatment after treatment and channel water where the water are finally discharged. The six plant water and cannel water sample sites were selected for the determination of selected heavy metal ingredients.

Heavy metal varies from location wise due to industrial activities. Though the water collect from the ETP, the lowest concentration was found 0.0068 ppm and highest concentration was found 2.17 ppm (**Table 7**).

Here, bellow **Table 8** shows that the analyzed average value of Cu, Pb and Cr has exceeded the standard and concentration of other two heavy metals remain below the standard. Laboratory analysis data of water, samples has comprised with standard value given SWR, WHO and. It has observed that most of the area's water chemical parameters analyzed values fall in the standard limit range and some in exceed or lower.

3.2.2. Contamination Index Calculation (C_d)

Degree of water contamination is classified into three grades (Backman et al., 1998) (**Table 9**).

By using contamination index (Backman et al., 1998) method the C_d was calculated. For calculating C_d, contamination factors for components (C_{fi}), analytical values of five heavy metals (C_{Ai}) and upper permissible concentration of five heavy metals were used. **Table 10** which show analytical value (C_{Ai}), contamination

Table 7. Chemical concentration of water sample.

Sample ID	Cu (ppm)	Fe (ppm)	Mn (ppm)	Cr (ppm)	Pb (ppm)
1	0.095	0.0562	0.0391	0.159	0.2149
2	0.1837	0.0076	0.0452	0.1396	0.1317
3	0.0995	0.076	0.0339	0.1389	0.1109
4	0.0226	0.0068	0.0426	0.5965	0.0971
5	0.0624	0.1505	0.0122	0.1468	0.0728
6	0.0172	0.3428	0.033	0.1181	0.0693
7	0.086	0.0281	0.119	0.1131	0.0312
Mean	**0.080914**	**0.095429**	**0.046429**	**0.201714**	**0.103986**
Median	**0.086**	**0.0562**	**0.0391**	**0.1396**	**0.0971**
St Dev	**0.05618**	**0.119892**	**0.033777**	**0.174806**	**0.1639**

(Source: SRDI, 2018).

Table 8. Water quality of the study area.

Elements (ppm)	Average concentration	Surface water quality standard (SWR, 1989)	WHO standard
Fe	0.095429	1	0.3
Cu	0.080914	1.5	2.0
Mn	0.046429	0.3	0.4
Cr	0.201714	0.05	-
Pb		0.05	-

(Source: SWR, 1989; WHO, 2013).

Table 9. Classification of contamination index value.

C_d	Class
$d < 1$	Low Contamination
1 - 3	Medium Contamination
$d > 3$	High Contamination

Note: C_d = Contamination Index (Source: Backman et al., 1998).

Table 10. Contamination index calculation.

	Fe		Cu		Mn		Cr		Pb		C_d
	CAi (ppm)	C_{fi}	CAi (ppm)	C_{fi}	CAi (ppm)	C_{fi}	CAi (ppm)	C_{fi}	CAi (ppm)	C_{fi}	
Plant 1	0.0562	−0.813	0.095	−0.953	0.04	−0.922	0.159	2.180	0.21	20.490	19.983
Plant 2	0.0076	−0.975	0.1837	−0.908	0.05	−0.910	0.1396	1.792	0.13	12.170	11.170
Plant 3	0.076	−0.747	0.0995	−0.950	0.03	−0.932	0.1389	1.778	0.11	10.090	9.239
Plant 4	0.0068	−0.977	0.0226	−0.989	0.04	−0.915	0.5965	10.930	0.1	8.710	16.759
Plant 5	0.1505	−0.498	0.0624	−0.969	0.01	−0.976	0.1468	1.936	0.07	6.280	5.773
Cannel water	0.3428	0.143	0.0172	−0.991	0.03	−0.934	0.1181	1.362	0.07	5.930	5.509
ETP treated water	0.0281	−0.906	0.086	−0.957	0.12	−0.762	0.1131	1.262	0.03	2.120	0.757

factor (C_{fi}) and contamination Index (C_d) of water sample. WHO drinking water standard was taken maximum admissible concentration/upper permissible limit. Calculated values of contamination index for water samples are shown in bellow (Table 10).

The table represents the C_d level of heavy metal which varies from 0.0757 to19.983 indicates highly contaminated by chemical. According to classification of Contamination Index (Backman et al., 1998) of selected parameters are given bellow in Table 11.

The above seven water sample, first six sample show highly contamination level ($C_d > 3$) ranging between 5.509 up to 19.983 ppm (Table 11), one sample show low contamination level ($C_d < 1$) which ranging value 0.757. Mainly first five samples were collected from different plant of UEPZ. The five sample organic waste water, heavy metal water (1), Grading water, heavy metal water (2),

Table 11. C_d classification of the sample water.

Sample name	C_d value (ppm)	C_d classification	Remarks
Plant 1	19.983	Highly contaminated	Before treated
Plant 2	11.170	Highly contaminated	Before treated
Plant 3	9.239	Highly contaminated	Before treated
Plant 4	16.759	Highly contaminated	Before treated
Plant 5	5.773	Highly contaminated	Before treated
Cannel water 6	5.509	Highly contaminated	Discharge water
ETP treatment water	0.757	Low contaminated	After treated

and thick liquid water. Other two sample water namely ETP treated water and cannel water. The five plant waste water and sample water are treated in ETP for reused indicate low contaminated. And finally the amounts of water which discharge in the cannel are also highly contaminated. The C_d value for canal is 5.509 indicate highly contaminated. It will be noted that, the daily amount of treatment water 148 m^3/day and the daily discharge water 120 m^3/day. The discharge water mainly dump into cannel has a great impact on the environment and the agricultural land.

3.2.3. Heavy Metal Pollution Index Calculation (HPI)

For calculation of HPI, the specific 5 chemical parameters (metals) were selected which have great importance and they might extend the pollution index. The HPI, represent the total quality of water with respect to heavy metals. The results were summarized in (Table 12).

Heavy metal ingredients in soil, surface water and ground water resources evolved from various sources. Therefore to get an idea about the intensity of heavy metal pollution the heavy metal pollution index was calculated for study area. After completion of the result, the concentration of each pollutants of each pollutant converted into HPI. The higher HPI value causes the greater the damage to the health. Generally, the critical heavy metal pollution index value is 100.

The results of the sample water were analyzed and presented by way of Figures and Tables. The calculated HPI value for the sample parameter was 39.97 which found to be good and with result within contamination index. The HPI of each sampling point was also calculated in Table 13. This enabled to comparison of quality of water at each sample water with respect to the determined heavy metals to identify the metal contamination of five chemical namely Cu, Fe, Mn, Cr and Pb among seven sample water. The HPI value Cu, Fe, Mn, Cr and Pb are 0.150 < 1.17 < 1.3 < 2.71 < 3.83 < 8.26 < 22.42 ppm accordingly plant, ETP treatment water < cannel water < plant 6 sample water < plant 3 sample water < plant 2 sample water < plant1 sample water < plant 4 sample water seven sampling point, the HPI of the groundwater was below the critical index value of 100, though the HPI values for seven sample 39.97, it indicate that the water quality was good represented better quality of water with respect to the heavy

Table 12. Heavy metal pollution index.

Parameters	Mean concentration, ppm (M_i)	Height permitted value for surface water (S_i), ppm (SWR, 1989)	Desirable maximum value (I_i) for surface water, ppm	Unit weightage (W_i) Ppm	Sub index (Q_i)	$W_i \times Q_i$	HPI value
Fe	0.095429	1	1	1	91.05	91.05	
Cu	008914	1.5	0.05	0.666	2.593	1.72	
Mn	0.046429	0.3	0.3	3.33	26.76	89.2	39.97
Cr	0.201714	0.05	0.05	0.2	3.560	71.2	
Pb	0.103986	0.05	0.05	0.2	3.050	61	

Table 13. Status categories of HPI.

HPI	Quality of water
0 - 25	Very good
26 - 50	Good
51 - 75	Poor
Above 75	Very poor (unsuitable for drinking)

(Source: Sirajudeen et al., 2014).

metals. This is not surprising but the result could be increased if the waste water dumping into the nearest cannel. Bellow **Figure 4** shows comparison between Cd and HPI.

Above the comparison show that sample 4 is unpolluted to moderately pollute. From the personal observation sample four water bear the heavy metal water. Untreated waste water discharge into cannel which flows beside mocha para of UEPZ. Though the result of water quality good, but it may result polluted after time go.

3.3. People Perception-Based Discussion

The issue of industrial impacts on soil was also discussed with the local communities. As per the local people's perception, most of the factories produced the organic waste which may be generated by the UEPZs manufacturing work consists primarily of alkaline particulates from the raw and finished products. Furthermore, during the field visit, it was observed the UEPZs beside agricultural land with according to the locals, they said as a result of an industrial work the local environment, crop cultivation near the industrial areas were decreased. Qualitative analysis of I_{geo} index, pollution load index assessed by calculation of the analysis with the graphical presentation. The result showed that the agricultural lands are unpolluted to moderately polluted. But the people had little knowledge about the soil-land pollution due to industrial activities in the region.

4. Conclusion

The environmental impact assessment of UEPZ has been adversely affected to

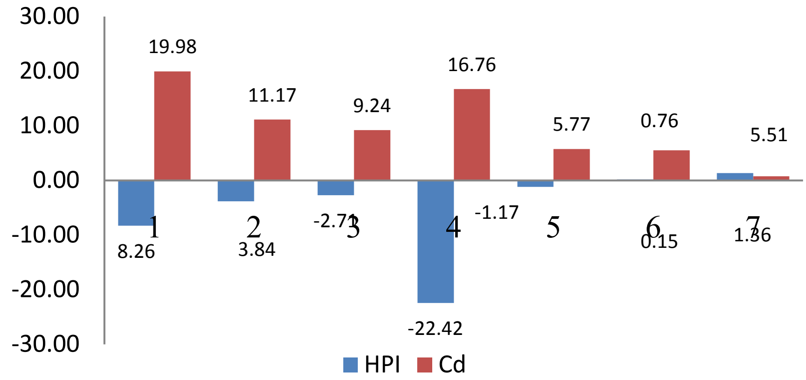

Figure 4. Comparison between HPI index and C_d index for seven water sample.

the region due to industrial activities. As a result, the consequences of such adverse impacts have also been observed in different sectors especially in socio-economic, culture and health. In this regard, the questionnaires regarding the industrial impacts on soil, noise, economic and cultural environment were provided to the local communities to determine their perception about the impacts. This also works as an awareness program that helps to know the local people about the negative impact of the UPEZ on soil and water. Furthermore, the qualitative information obtained from the local people was assessed using different water, soil pollution index modeling. For water, the result of contamination index ranges from 19.983 > 16.759 > 11.170 > 9.239 > 5.773 > 5.757 > 5.509 resulting in unpolluted to moderately polluted and the heavy metal pollution index carrying 39.97 resulting in good water quality. The result for soil shows moderately polluted. However local communities have benefitted by improved road access, community forests, enhanced local service facilities such as water supplies, education and healthcare, etc. People get income opportunities because of the expansion of the local market of local commodities due to industrial activities in the region. According to the respondents, local people were attracted to financial benefits offered by the industries. At the same time, the land use pattern has gradually changed from agricultural use to industrial activities as local people sell off their productive agricultural land. Thus, socio-economic and cultural environmental issues and impacts were discussed during the field visits.

However, UEPZ has also contributed much in the Bangladesh economy with respect to employment generation opportunities, exporting goods and services and investment volume as well for the economic growth of the country. This paper will help the authority to take proper steps for minimizing the soil and water pollution. The legal agreements and laws should be stronger to save the environment. The environment comes first, so sustainable development is mandatory. The authority of UEPZ should think about the environment protection along with their internal developments. They should take measures to protect their worker's safety. UEPZ also create noise pollution and it has an impact on worker's health, so future work can be done on this issue.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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