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Research Article

Effect of Industrial Wastewater on Local Soil Quality and Vegetables in Industrial Estate Hattar, Pakistan

Hafeez Ullah[1*], **Zeeshan Ul Haq**[2]

[1]Department of Chemical and Materials Engineering, National University of Sciences and Technology, Islamabad, Pakistan;[2]Department of Process System Engineering, National University of Science and Technology, Islamabad, Pakistan

ABSTRACT

The concept of demand and supply increases the growth of industrialization. With the rapid increase in population, the number of industries and production rate also increases. These industries discharge tons of wastewater daily, which causes wastewater pollution. Pollution affects various parts of our society like agriculture, human life, animal, and plants. Specifically effect on human life is very drastic and polluting vegetables play a very important role. Current research work is carried out to evaluate and investigate the effect of industrial wastewater irrigation on soil quality and vegetables (onion, pumpkin, lady finger). The investigation is done through the use of a wet digestion method for sample preparation and equipment (Atomic absorption spectrophotometer) for heavy metals determination. The concentration of heavy metals in industrial wastewater as compared to tube well water follows the order: Fe>Zn>Ni>Mn>Cu>Cr. Zinc accumulation is the highest in wastewater-irrigated soil. For the pumpkin, Zn, Fe, and Mn show the highest transfer factor. Heavy metals accumulation for onion follows the trend in order: Mn>Zn>Fe>Cu>Cr>Co>Ni. The investigation shows that Zn, Fe, and Mn have the dominant effect on soil and vegetables. The vegetables show resistance to other heavy metals (Co, Ni, and Cr). This study will help the local farmers to study their land and cultivate proper crops in this area (Industrial Estate Hattar, Haripur). This will also create awareness among the masses to select appropriate vegetables for daily use.

Keywords: Transfer factor; Heavy metal; Industrial wastewater; Chemicals

INTRODUCTION

Reuse of wastewater for irrigation purpose has become a common practice globally because of the scarcity of clean water. These effluents are a rich source of Organic Matter (OM), plant nutrients, and hazardous contaminants, which creates both potential and challenges for agricultural development [1]. The rapid growth of industrialization produces huge volume of untreated industrial wastewater increases the rate of health risks. That causes soil contamination which is now a serious problem on global scale because local farmers use industrial wastewater for irrigation purposes thus contaminating and disturbing the whole ecosystem [2]. Wastewater from industrial zones contains harmful compounds including heavy metals, refractory organics, and other contaminants that can accumulate in food crops and endanger human life. These endanger water resources, agriculture, ecosystems, and people (Figure 1) [3].

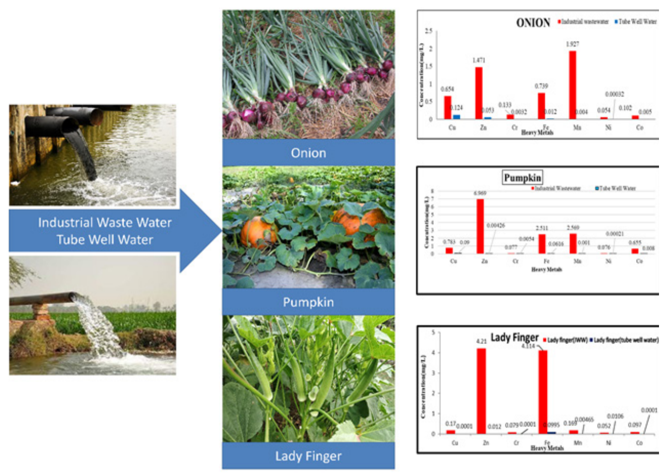

Figure 1: Comparison of concentrations in industrial wastewater and tube well water.

Correspondence to: Hafeez Ullah, Department of Chemical and Materials Engineering, National University of Sciences and Technology, Islamabad, Pakistan, Tel: +923330913395; E-mail: hafeez.pse3scme@student.nust.edu.pk

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There are many factors of soil contamination of which the most dominant factor is industrial wastewater irrigation. This results due to human activities like industrialization and municipal sewage [4]. The ingredients in industrial wastewater are biodegradable and non-biodegradable by nature. Metals present in the soil plays an important role in soil fertility, but if they exceed from their allowable limit, it causes major problems to the society. The most common heavy metals in industrial wastewater include cupper, arsenic, chromium, lead, iron. Arsenic is highly toxic and carcinogenic. Excess of lead in the soil inhibits the growth of plants because it decreases the photosynthetic ability of plants [5].

Copper is an important part of cell because of its involvement in many reactions. However, too much copper ions in cells can cause free radicals and oxidative stress. Copper metabolism in multicellular organisms involves cellular and systemic absorption, transmission, accumulation, and disposal [6]. Copper is unsafe and can cause many severe diseases and even death can occur, if taken in large amounts. Where zinc an essential component of human body. High concentration of zinc can lead to digestion problems, severe headache and decrease the functionality of immune system. The safe limit for adults is 1-100 mg/day. Nickel is needed to build red blood cells, but too much of it is hazardous. Ni accumulation in vegetables due to industrial wastewater irrigation leads to pregnancy problems, lung disorder and cancer [7]. The toxicity of arsenic to humans is dependent on age, gender, arsenic concentration and speciation, exposure time and dose, and nutritional state. Toxicological effects in humans include genetic variation, and chromatin structure regulation [8].

Currently, majority of people in Pakistan is facing the problem to access clean drinking water. Pakistan's agricultural output is mostly dependent on water-based irrigation systems, which are responsible for 90 percent of overall country agricultural productivity [9]. The unavailability of clean water for irrigation, the local farmers' uses industrial wastewater discharge for irrigation purposes. Such activities result in heavy metals accumulation in soil and vegetables. Hattar industrial estate is one of the leading industrial estates in Pakistan, providing quality products with competitive price. These industries release 2000 tons of untreated industrial wastewater in Jhar, Noro and Dojal spillways every day. It further passes through more than hundred villages of district Haripur and Attock as shown in Figure 1 [10]. In developed countries, the industrial wastewater is treated into different segments, making it beneficial for irrigation. In developing countries of subcontinent like Pakistan, Bangladesh, India, the industries discharge the wastewater untreated, which causes harmful effects on human life, environment as well as on aquatic life. The main objective of our research is to highlight the harmful effects of heavy metals accumulation and its transfer to vegetables from industrial wastewater irrigation at Hattar industrial estate, KPK, Pakistan. No appreciable work has been done to elaborate such issues. In this research paper, we will examine the amount of heavy metals present in industrial wastewater, its accumulation and biochemical changes in local soil quality. Hattar estate occupies a total area of 1,032 acres as shown in figure.

There are more than 400 industries mainly composed of textile, beverages, food, pharmaceuticals, chemicals, batteries etc., (Figures 2 and 3).

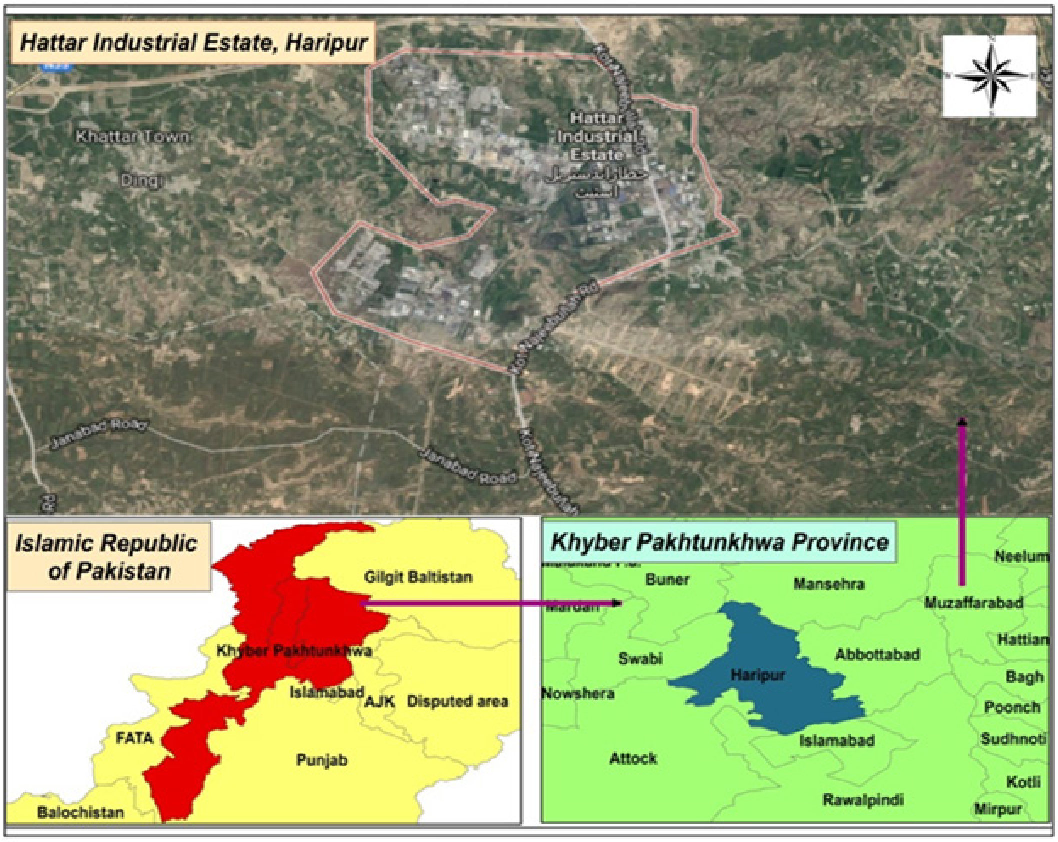

Figure 2: Location of industrial estate of Hattar in the map of Pakistan.

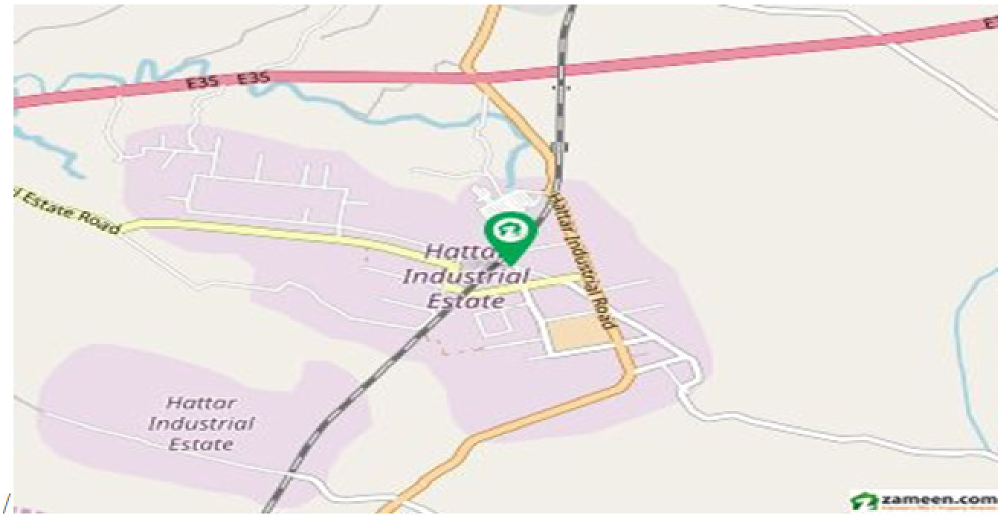

Figure 3: Location of industrial estate Hattar, Haripur.

METHODOLOGY

Data collection

In this study, different samples of industrial wastewater, soil and vegetables were collected from the farmlands of industrial estate Hattar, KPK, and Pakistan. The samples were collected from site in october-november of 2018. The discharge of wastewater used for irrigation vegetables and other crops. Soil samples were collected from agricultural land irrigated with industrial wastewater. Vegetables sample include onion, okra and bottle gourd.

Sample preparation, handling and analysis: The collected Samples were prepared in project lab, department of chemical engineering, university of engineering and technology, peshawar for spectrophotometric analysis.

Vegetables sample preparation: Samples of vegetables were washed properly with the help of distilled water to remove the pollutants that were present due to air. The roots, stem, and leaves were separated with the help of a knife. The edible part of each vegetable sample was placed in an oven at a temperature of 700°C and at the time duration of 24 hours as shown. The purpose of drying was to remove all the moisture content. After 24 hours, the dried samples were crushed and grinded with the help of pestle and mortar and then sieved.

Digestion of vegetable samples: In digestion, the samples were treated with a solvent for the extraction of valuable components. For analysis of each sample i.e., dried and powdered, 0.5 g of each sample was weighed accurately. After which digestion of each sample was carried out using 1 ml of hydrochloric acid HCL and 4 ml of nitric acid HNO_3 using digestion tubes. Each sample was allowed to cool and then filtered of with the help of Whatman filter paper 42. Water was added to filtrate up to mark of 25 ml. The sample of each vegetable was ready for absorption Spectrophotometry analysis.

Soil samples preparation: Digestion of soil samples were carried out according to the method adapted by Mustafa Tuzen in a paper named determination of heavy metals in soil, mushroom and plant samples by "Atomic Absorption Spectrometry" (AAS). 2 g of each sample was taken and then 10 ml of concentrated nitric acid was added. The liquid was then boiled for 35 mins. After cooling 5 ml of $HCLO_4$ was added followed by gentle boiling till the appearance of white dense fumes, then after cooling 20 ml of distilled water was added and boiled until the release of fumes stopped. The solution was cooled again and filtered followed by the addition of distilled water up to 25 ml volume. The tube well sample was prepared on the same way.

Water sample preparation: Different water samples were taken from the canal of wastewater coming out of different industries of the industrial estate of Hattar. Water samples were taken at different distances (30 m-400 m) and analyzed in the CRL lab of University of Peshawar for heavy metals concentration. The tube well water samples were also taken and tested in the same way.

Determination of heavy metals in prepared samples

All tests were performed in CRL laboratory, university of peshawar. The prepared samples of industrial wastewater, soil and vegetables was observed with the help of Atomic Absorption Spectrophotometer (AAS) to determine the concentration of heavy metals.

Transfer factor: The transfer factor is a measure of the transport of heavy metals from the soil to vegetable crops. Plant metal concentrations (C-Plant) and soil metal concentrations (Soil) were compared to calculate the soil-plant Transfer Factor (MTF) (C-Soil). The following equation was used to compute the TF [11].

$$TF = \frac{Metal\ Concentration\ in\ Vegitables}{Metal\ Concentration\ in\ Soil}$$

RESULTS AND DISCUSSION

The heavy metal concentrations in industrial wastewater and tube well water shows different pattern. Figure 4 shows the comparison of heavy metals concentration in industrial wastewater to tube well or controlled water. In industrial and tube well water sample, the highest level was found of Zn (6.415 mg/lt) in all sample, followed by Fe (3.375 mg/lt) in industrial waste water. The results also revealed that the highest concentration found in tube well water was of Fe (0.19 mg/lt) and Zn (0.17 mg/lt), respectively. The order of heavy metals concentration in industrial wastewater follows as Zn>Fe>Cr>Cu>Mn>Co>Ni (Figure 4).

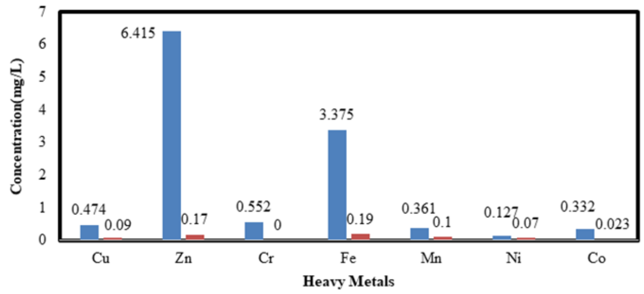

Figure 4: Comparison of concentration of heavy metals in industrial wastewater and tube well water. **Note:** (■) Industrial wastewater sample, (■) Tube well water sample.

Figure 5 illustrates the comparison of concentration of heavy metals in soil irrigated with industrial wastewater and tube well water. In case of soil samples, Fe concentration was the highest followed by Zn>Ni>Mn>Cu>Cr>Co. The increase in concentration of heavy metals in soil is mainly due to the irrigation of soil with untreated industrial wastewater coming out from different industries of the Industrial Estate of Hattar (Figure 5).

As the distance increases from the source heavy metal concentration shows a decreasing trend as shown in Figure 6. The initial point was considered at 30 m and second point at 400 m. The concentration of Zn decreases from 6.415 mg/lt to 5.31 and Fe from 3.375 to 2.97 mg/lt, respectively. This decrease in concentration can led us to the result that if we cannot treat water then we should try to use it for irrigation as far away from the source as possible (Table 1 and Figure 6).

Table 1 shows the concentration of heavy metals in vegetables (Lady Finger, Onion, and Pumpkin) irrigated with industrial wastewater and tube well water. The result showed that the concentration of Zn in pumpkin was 6.969 mg/lt which was recorded the highest in our study followed by Zn in lady finger (4.114 mg/lt). In general, the concentration of heavy metals (mg/kg) in lady finger decreased in the order of Zn>Fe>Cu>Mn>Co>Cr>Ni. In comparison to lady finger and onion, pumpkin had the highest concentrations of Zn, Cu, and Cr. The vegetable irrigated through the tube well water shows a satisfactory results in which onion had the highest concentrations of Cu, Zn and Mn (Figures 7-9).

Figures 7-9 shows the comparison of heavy metals in lady finger, pumpkin and onion irrigated with industrial wastewater and tube well water respectively. The vegetables samples result revealed that, pumpkin has the highest accumulation of Zn, Fe and Mn followed by Cu>Co>Ni>Cr. Onion have Mn, Zn and Fe in highest concentration along with Cu>Cr>Co>Ni. The accumulation of Zn and Fe was observed to be the highest in case of lady finger followed by Cu>Mn>Co>Cr>Ni. Transfer factor was determined for each vegetable. Figure 10 shows the data for the transfer factor of each vegetable. The results showed that Cu, Zn, Mn, and Co has the highest transfer factor for pumpkin. Cr has the highest intake for onion, Fe for lady finger. The intake of Ni was the least one for each vegetable. So, we can suggest that all the vegetables should not be cultivated in the area where there is a higher concentration of those metals for which they showed the highest transfer factor; like in our case; Cu, Mn, Zn, Co for Pumpkin, Cr for onion and Fe for lady finger (Figure 10).

Table 1: Concentration of heavy metals in vegetables irrigated through industrial wastewater and tube well water.

	Heavy metals(mg/L)	Cu	Zn	Cr	Fe	Mn	Ni	Co
Industrial wastewater	Lady finger	0.17	4.21	0.079	4.114	0.169	0.052	0.097
	Pumpkin	0.783	6.969	0.077	2.511	2.569	0.076	0.655
	Onion	0.654	1.471	0.133	0.739	1.927	0.054	0.102
Tube well water	Lady finger	0.00011	0.012	0.0001	0.0995	0.00465	0.0106	0.0001
	Pumpkin	0.09	0.00426	0.0054	0.0616	0.001	0.00021	0.008
	Onion	0.124	0.053	0.0032	0.012	0.004	0.00032	0.005

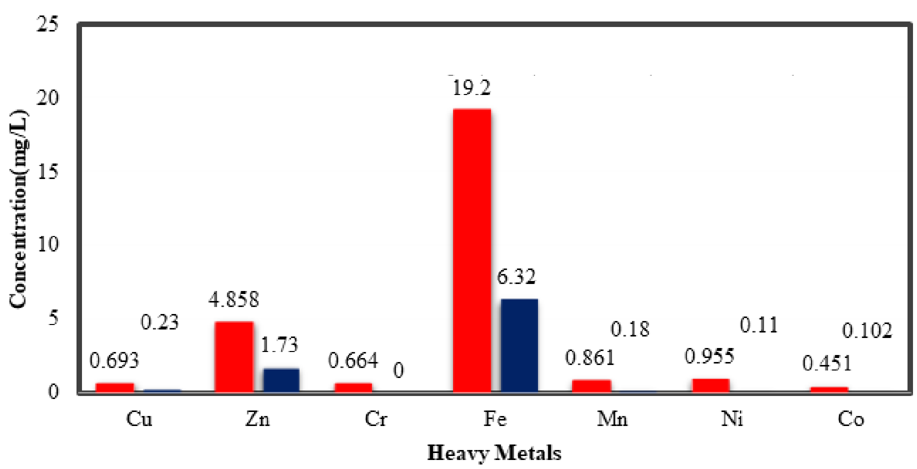

Figure 5: Comparison of concentration of heavy metals in soil irrigated with industrial wastewater and tube well water. **Note:** (■) Soil sample (IWW), (■) tube well water.

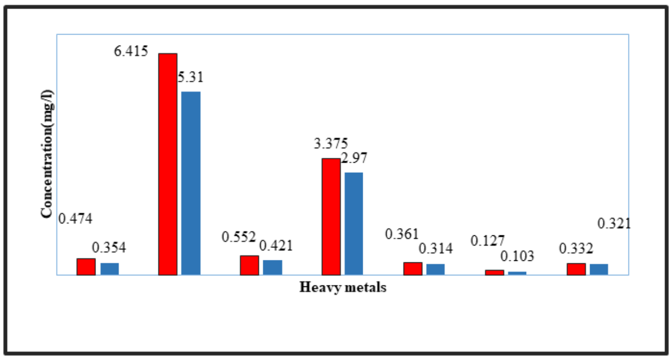

Figure 6: Concentration of heavy metals in vegetables irrigated through industrial wastewater and tube well water. **Note :** (■) Concentration of heavy metals at 30 m, (■) Concentration of heavy metals at 400 m.

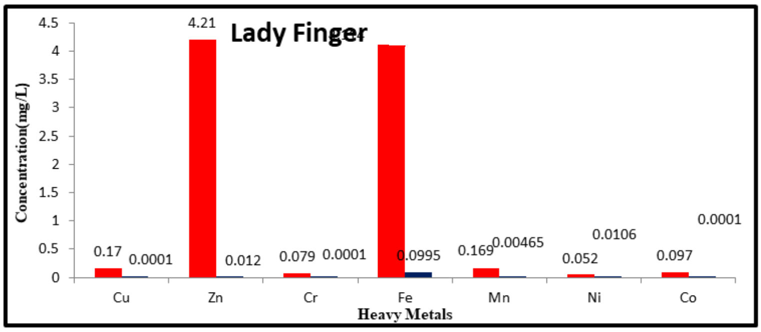

Figure 7: Comparison of concentration of heavy metals in lady finger irrigated with industrial wastewater and tube well water. **Note :** (■) Lady finger (IWW), (■) Lady finger (tube well water).

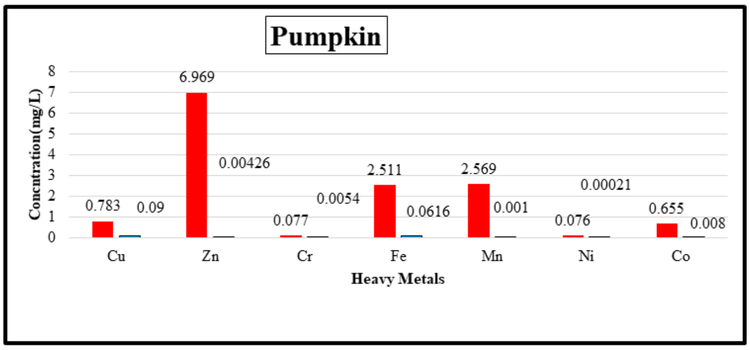

Figure 8: Shows the comparison of concentration of heavy metals in the pumpkin irrigated with industrial wastewater and tube well water. **Note:** (■) Industrial wastewater, (■) Tube well water.

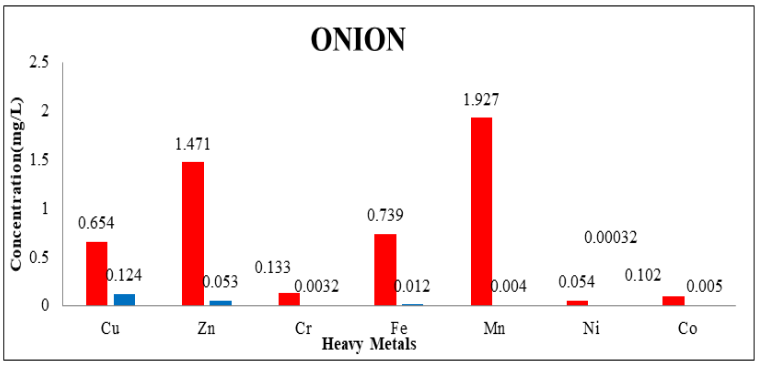

Figure 9: Comparison of concentration of heavy metals in the onion irrigated with industrial wastewater and tube well water. **Note:** (■) Industrial wastewater, (■)Tube well water.

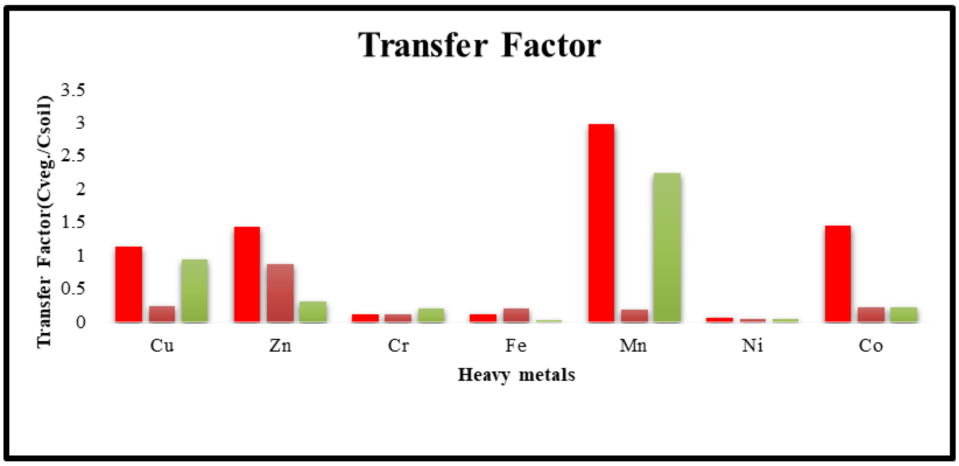

Figure 10: Comparison of transfer factor for all the three vegetables. **Note:** (■) Transfer factor for pumpkin, (■) TF for lady finger, (■) TF for onion.

CONCLUSION

This is the first study on the effect of wastewater irrigation on local soil quality and vegetables in the industrial estate of Hattar, Haripur Pakistan. The results obtained showed that industrial wastewater irrigation lead to changes in soil quality, increase in heavy metals concentration in vegetables (Co, Fe, and Zn). As from the results and discussion, the transfer factor for pumpkin is highest so we recommend not cultivating pumpkin on those lands, plus using the Industrial wastewater for irrigation at distance greater than 400 m because the concentration of heavy metals decreases with increase in distance from the source. Now it is the responsibility of the government as well as private organizations to start awareness programs in the local farmers.

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