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Soil Characterization: An Indicator of Soil Pollution and Base for Soil Restoration

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Abstract: Soil is considered as the major source of nutrients for plants and micro-organisms. It acts as a sink for the deposition of minerals and metal ions from weathering and anthropogenic activities. Some of these metal ions and minerals are beneficial for the plants and their dependents, while some of the metal ions and minerals are extremely toxic in higher concentrations. Therefore, the soil characterization as a source for the detection of metal ions in the soil of disturbed and un-disturbed areas of Peshawar was considered for the present study. Soil samples were collected randomly and digested for the extraction of metal ions. Higher concentration of metal ions was observed in soil samples of disturbed sites as compared to undisturbed. The results indicated that human activities are the main cause of soil pollution. It was recommended that environmental protection and urban development agencies should focus before these toxics adversely affect the local population.

Keywords: Soil characterization, metal ions, metals toxicity, Peshawar.

Introduction

Soil is one of the biggest sinks in industrial areas, where mining, metal refining, paint, coal, arms, batteries, fertilizers and petro-chemicals industries contribute most of the inorganic pollutants. Most toxic part of these chemicals are heavy metal ions (Khan et al., 2008; Zhang et al., 2010). Heavy metals are toxic and cause adverse effects on animals and plants (Evanko et al., 1997). Unlike organic contaminants, heavy metal ions do not take part in any chemical or microbial decomposition (Kirpichtchikova et al., 2006) and remain in soil for a long period of time (Adriano, 2001).

Heavy metal ions present in soil have bad effect on the decomposition of organic pollutants (Maslin and Maier, 2000). Heavy metal ions may cause health problems such as lung cancer, kidney diseases, corrosion of mucosal layer, nephrotoxicity, hepatotoxicity and cardiomyopathy (Rahim et al., 2016; McLaughlin et al., 2000; Ling, 2008). Heavy metals affect the ecosystem through different ways of food cycles (Rahim, Imdad et al. 2016; Ling, 2008).

In many developing countries with highest population density (Pakistan) and lack of financial assistance for the environment protection, these pollutants can affect local population harmfully. The adverse effects of heavy metals on plants in developed countries have been published by many researchers (Bhanarkar et al., 2005; Singh and Agrawal, 2007; Ismail et al., 2012; Ahmed, et al., 2015). Whereas, very little attention is given for the measurement of heavy metals in order to control soil pollution in developing countries.

Therefore, characterization of soil is necessary for the conservation and protection of natural habitat. Soil characterization provides facts about major source of pollution and health threats. Hence, soil characterization can be used as a base for policy making for the betterment of public health and environmental protection. For this purpose, the study was carried out to know the level of selected heavy metal ions in disturbed and un-disturbed areas of Peshawar region and to explore danger of heavy metals present in the soil of disturbed and also un-disturbed sites of the study area.

Materials and Methods

Study Area

Peshawar, the capital city of Khyber Pakhtunkhwa, Pakistan, is located in between 34.01° latitude north and 71.58° longitude east. Peshawar is the oldest city of Khyber Pakhtunkhwa with an area of 1,257 km^2. The average annual temperature is about 22.7 $^{\circ}$C with highest in June (on average at around 40 $^{\circ}$C) and lowest in January (4 $^{\circ}$C). The average annual rainfall has been recorded as 384 mm. Whereas, the lowest rainfall occurs in October about 11 mm and most of the precipitations have been observed in March.

Sampling and Analysis

Soil samples were collected from 0-6 cm depth from eighteen points; nine from undisturbed sites and nine from disturbed sites. Undisturbed site is without any anthropogenic activity around 500 m, whereas, in disturbed area, industries are located.

Quantitative determination of heavy metal ions was carried out using Perkin Elmer atomic absorption spectrophotometer AAS-700.

One gram of dried soil was taken in platinum crucible. The soil was moistened with the help of few droplets of deionized water. 10 ml of HF of 48 % and 1 ml of $HClO_4$ (70 %) were added. Then, the crucible was kept on sand-bath and heated up to dryness. 10 ml of concentrated HCl was added and heating was continued till dryness. 20 ml of 6 N HCl was added to dried residue and diluted with deionized water. The resulting mixture was transferred to 100 ml volumetric flask and further diluted up to the mark with deionized water (Parent, 2000).

Results and Discussion

Soil Characterization

Soil samples were analyzed for heavy metal ions, and comparison was carried out between disturbed and un-disturbed sites. Major differences between the two sites were observed. Presence of heavy metal ions in high ratio at disturbed areas describes the role of human activities in contamination of soil. The summarized results of the disturbed and un-disturbed sites have been shown in Table 1 and 2 respectively. Cadmium was not detected in both disturbed and undisturbed sites. However, higher concentrations of cobalt and nickel were observed in disturbed sites while un-disturbed sites are indicated in below detection limits.

Copper (Cu)

The results of the concentrations of copper in disturbed and undisturbed sites have been shown in Fig. 1. The concentration of copper was found in the range of 1.412 to 1.890 mg/kg. Higher concentration of copper was recorded for site no. 9 in disturbed area and lower was recorded for site no. 8 of undisturbed area. The permissible level of copper for agricultural soil and food crops suggested by WHO (World Health Organization) are 60 and 73.3 mg/kg respectively (Rahim, et al., 2016). The results indicate that copper is present within the permissible range. Such copper performs a very important role in photosynthesis, carbohydrate and protein metabolism (Robson and Graham, 1981; Başar, 2009). Whereas, higher concentrations of copper may cause stunting and reduce branching (Başar, 2009).

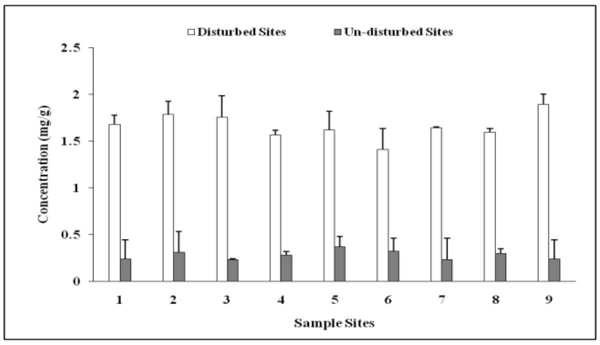

Fig. 1 Concentrations of copper in soil samples collected from disturbed and undisturbed sites

Zinc (Zn)

The concentrations of zinc in soil samples have been shown in Fig. 2. The results indicate that the concentration of zinc ranged from 1.17 to 29.6 mg/kg and 2.04 to 66.63 mg/kg, respectively for undisturbed and disturbed sites. Whereas, higher concentrations of 29.6 mg/kg and 66.63 mg/kg were observed in the soil of sites no. 2 and 1 respectively, for undisturbed and disturbed sites. The disturbed sites indicate 2.25 times higher concentrations than undisturbed sites. The literature shows that higher level of zinc reduces the amount of iron and interference with magnesium (Başar, 2009; Bear, 1964). Luckily, the results indicate that concentration of zinc has been found within the recommended level, which ranges from 10 to 300 mg/kg (Başar, 2009; Bear, 1964). As such, major sources of zinc through which it enters the soil are zinc sulphides, zinc oxides and zinc silicates. Zinc can be reduced by increasing phosphorus and pH level of soil (pH > 6.5).

Lead (Pb)

The results indicate that the concentration of lead ranged from 0.19 to 0.42 mg/kg in the soil samples collected from undisturbed sites (Fig. 3). The concentration range of 1.06 to 1.96 mg/kg was observed for disturbed sites. Higher concentration of 0.42 mg/kg was observed for sample no. 4 of the un-disturbed site, while 1.96 mg/kg was observed for

Table 1 Levels of heavy metal ions in soil samples of disturbed sites.

Sites	Zn (mg/kg)	Co (mg/kg)	Cd (mg/kg)	Pb (mg/kg)	Cu (mg/kg)	Ni (mg/kg)	Fe (mg/kg)
1	66.63±3.02	0.36±0.00	BDL*	1.30±0.01	1.67±0.08	8.68±1.00	31.36±4.07
2	4.31±0.51	0.26±0.01	BDL	1.96±0.00	1.78±0.14	0.73±0.50	31.57±3.65
3	4.13±1.00	0.23±0.03	BDL	1.76±0.03	1.75±0.23	0.70±0.09	31.53±2.54
4	3.10±0.21	0.19±0.00	BDL	1.40±0.00	1.56±0.05	0.73±0.44	30.93±8.36
5	3.03±1.34	0.21±0.00	BDL	1.55±0.00	1.62±0.09	0.70±0.28	30.93±5.08
6	2.04±1.15	0.27±0.00	BDL	1.34±0.02	1.41±0.22	0.67±0.11	32.85±4.33
7	3.15±0.49	0.25±0.01	BDL	1.07±0.01	1.64±0.01	0.78±0.03	31.48±2.60
8	4.74±0.09	0.24±0.00	BDL	1.22±0.00	1.59±0.04	2.59±0.39	31.21±1.83
9	3.89±0.02	0.29±0.00	BDL	1.06±0.00	1.89±0.11	0.79±0.04	32.20±2.85

*Below Detection Level

Table 2. Levels of heavy metal ions in soil samples of un-disturbed sites.

Sites	Zn (mg/kg)	Cd (mg/kg)	Co (mg/kg)	Pb (mg/kg)	Cu (mg/kg)	Ni (mg/kg)	Fe (mg/kg)
1	1.40±2.00	BDL*	BDL	0.24±0.00	0.24±0.09	BDL	162.60±4.54
2	29.60±2.41	BDL	BDL	0.21±0.01	0.31±0.23	BDL	201.20±5.38
3	1.26±0.22	BDL	BDL	0.37±0.00	0.23±0.01	BDL	198.11±3.87
4	1.21±1.01	BDL	BDL	0.42±0.02	0.28±0.04	BDL	211.80±7.40
5	1.30±0.30	BDL	BDL	0.36±0.01	0.37±0.09	BDL	208.14±10.91
6	1.72±0.41	BDL	BDL	0.19±0.00	0.32±0.14	BDL	219.80±13.63
7	1.17±1.03	BDL	BDL	0.35±0.03	0.23±0.23	BDL	216.11±12.75
8	1.26±0.74	BDL	BDL	0.19±0.00	0.30±0.06	BDL	221.12±9.05
9	1.40±0.55	BDL	BDL	0.24±0.02	0.24±0.18	BDL	162.60±11.96

*Below Detection Level

sample no. 2 of the disturbed site. The literature indicates that lead particles come from detaching lead paint, vehicles and lead batteries. Lead can be found in the form of lead sulfides, carbonates, sulfates and lead oxides (Bear, 1964). The recommended level of lead in surface soil is below 50 mg/kg (Başar, 2009; Bear, 1964). The results showed that the observed concentrations are below the recommended level which indicates that local communities are safe. However, long term policies are required to maintain low lead (Pb) concentrations.

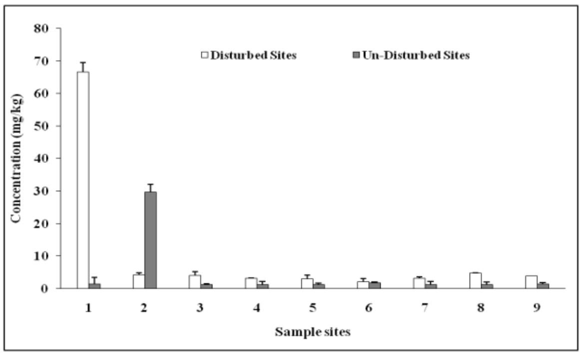

Fig. 2 Concentrations of zinc in soil samples collected from disturbed and undisturbed sites.

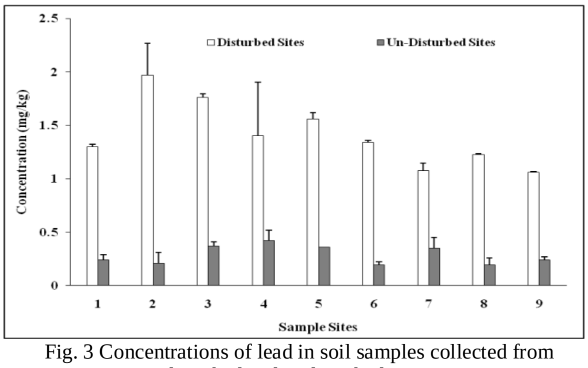

Fig. 3 Concentrations of lead in soil samples collected from disturbed and undisturbed sites.

Iron (Fe)

Strangely, the undisturbed sites indicated higher concentrations of iron in all samples (Fig.4). The results indicate higher iron concentrations of 221.12 mg/kg for site no. 8 of undisturbed area. Whereas, the disturbed sites showed lower concentrations of iron with maximum concentration of 32.85 mg/kg for site no. 6. Mostly, soil contains 1 to 5 % of total iron in the form of iron silicates, minerals, oxides and hydroxide. The reddish and yellowish colors of soil indicate the presence of iron oxides and iron hydroxides. The concentration of iron in soil may be decreased with the increase in pH and minimum amount could be observed from pH 7.40 to 8.50 (Başar, 2009; Bear, 1964). The pH of the disturbed sites is slightly higher than un-disturbed sites which have affected the iron concentration and made it low.

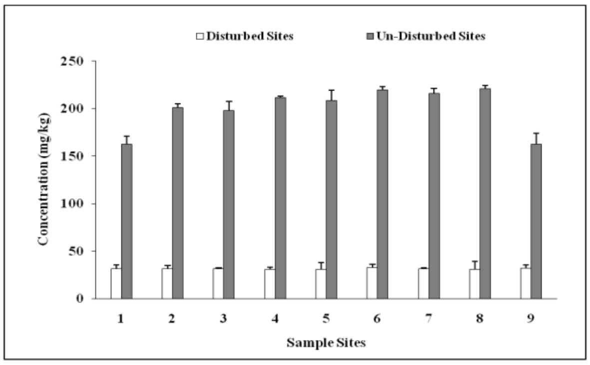

Fig. 4 Concentrations of iron in soil samples collected from disturbed and undisturbed sites.

Nickel (Ni)

The concentration of nickel in the soil samples of disturbed sites ranges from 0.670 to 8.685 mg/kg (Fig. 5). Whereas, nickel concentrations were not detected in the soil samples of undisturbed sites. The literature indicated that the concentration of nickel higher than 1.0 mg/kg may affect living organisms adversely. The literature survey shows that nickel is abundant in ultrabasic rocks which readily releases on weathering (Başar, 2009; Bear, 1964).

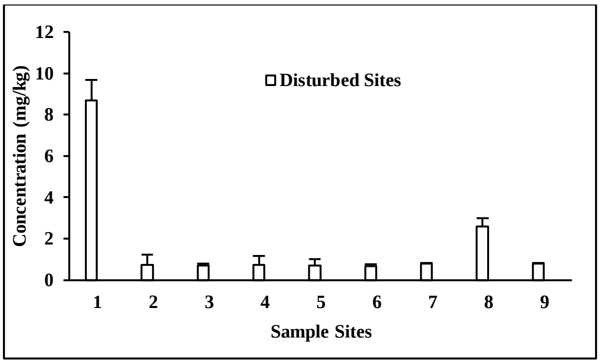

Fig. 5 Concentrations of nickel in soil samples collected from disturbed and undisturbed sites.

Cobalt (Co)

The results obtained for cobalt are depicted in Fig. 6. The results indicate that the concentration of cobalt ranges from 0.19 to 0.36 mg/kg in the soil samples of disturbed sites. However, cobalt concentration was not detected in the soil samples of undisturbed sites. The literature survey indicates that the concentration of cobalt lower than 0.1 mg/kg will be considered cobalt deficiency. The recommended level of cobalt ranges from 0.1 to 70 mg/kg (Başar, 2009; Bear, 1964). It is clear from the results that cobalt deficiency is found in the soil of undisturbed area. The concentration of cobalt in the soil samples of disturbed sites was observed within the recommended limits.

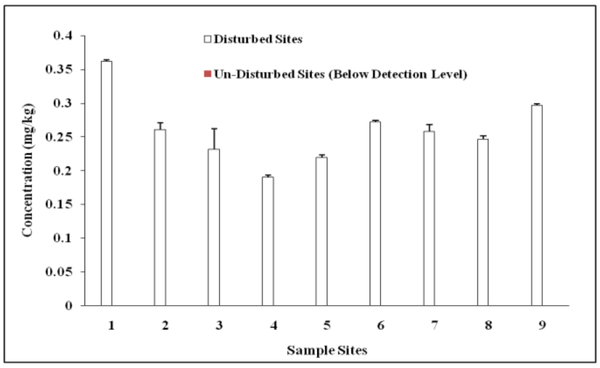

Fig. 6 Concentrations of cobalt in soil samples collected from disturbed and undisturbed sites.

Cadmium (Cd)

The maximum permissible limit of cadmium is 0.5 mg/kg (Rahim, et al., 2016). Whereas, cadmium was neither detected in soil samples of undisturbed nor disturbed sites of the study area.

Conclusion

Soil samples were collected from disturbed and un-disturbed sites of the Peshawar region, Khyber Pakhtunkhwa. The samples were analyzed by Atomic Absorption Spectrophotometer (AAS-700). The pH of the soil sample was recorded from 5.0 to 6.1. It was observed that concentration of metal ions increased with urbanization and improper sewage system in disturbed area. Less vegetation in the area of disturbed sites decreases phyto-remediation, which is an important factor of high accumulation of heavy metal ions.

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References

Adriano, D.C. (2001). Arsenic. In Trace elements in terrestrial environments. Springer, New York, NY, USA. 219-261.

Ahmed, W., Ahmad, M., Rauf, A., Shah, F., Khan, S., Kamal, S., Shah, S., Khan, A. (2015). Evaluation of some trace metal levels from the leaves of salix Nigra in Hayatabad industrial estate, Peshawar, Khyber Pakhtunkhwa, Pakistan. *Am. J. Biomed. Life Sci.*, **3**, 21-24.

Başar, H. (2009). Methods for estimating phyto available metals in soils. *Communi. in Soil Sci. Plant Analy.*, **40**(7-8), 1087-1105.

Bear, F.E. (1964). Chemistry of the soil. *Soil Sci.*, **98**(1), 70-74.

Bhanarkar, A.D., Srivastava, A., Joseph, A.E., Kumar, R. (2005). Air pollution and heat exposure study in the workplace in a glass manufacturing unit in India. *Environ. Monito. Asses*., **109**(1-3), 73-80.

Evanko, C.R., Dzombak, D.A. (1997). Remediation of metals-contaminated soils and groundwater. Pittsburg, USA: Ground-Water Remediation Technologies Analysis Center.

Ismail, M., Muhammad, D., Khan, F.U., Munsif, F., Ahmad, T., Ali, S., Khalid, M., Haq, N.U., Ahmad, M. (2012). Effect of brick kilns emissions on heavy metal (Cd and Cr) content of contiguous soil and plants. *Sarhad J. Agric*., **28**(3), 403-409.

Khan, S., Cao, Q., Zheng, Y.M., Huang, Y.Z., Zhu, Y.G. (2008). Health risks of heavy metals in contaminated soils and food crops irrigated with wastewater in Beijing, *China. Environ. Pollu*., **152**(3), 686-692.

Kirpichtchikova, T.A., Manceau, A., Spadini, L., Panfili, F., Marcus, M.A., Jacquet, T. (2006). Speciation and solubility of heavy metals in contaminated soil using X-Ray microfluorescence, exafs spectroscopy, chemical extraction and thermodynamic modeling. *Geochimica et Cosmochimica Acta*, 70(9), 2163-2190.

Ling, W., Shen, Q., Gao, Y., Gu, X., Yang, Z. (2008). Use of bentonite to control the release of copper from contaminated soils. *Soil Research,* **45**(8), 618-623.

Maslin, P., Maier, R.M. (2000). Rhamnolipid-enhanced mineralization of Phenanthrene in organic-metal contaminated Soils. *Bioremed. J*., **4**(4), 295-308.

McLaughlin, M.J., Zarcinas, B.A., Stevens, D.P., Cook, N. (2000). Soil testing for heavy metals. *Communi. Soil Sci. Plant Analy.*, **31**(11-14), 1661-1700.

Parent, R.A. (2000). Genium's handbook of safety, health, and environmental data for common hazardous substances. *Inter. J. Toxico*., **19**(3), 219-221.

Rahim, M., Imdad, U., Adnan, Khan., Mas, R.H.M.H. (2016). Health risk from heavy metals via consumption of food crops in the vicinity of district Shangla. *J. Chem. Soci. Pakistan*, **38**(1), 177-187.

Rahim, M., Imdad, U., Hassan, W., Ahmad, N. (2016). Heavy metal profile of Shilajit samples obtained from Gilgit and Chellas, Pakistan (Short Communication). *J. Phys. Sci.*, **27**(2), 139-144.

Robson, A.D., Graham, R.D. (1981). Copper in the soil and plants. Academic Press, New York, 213-234.

Singh, R.P., Agrawal, M. (2007). Effects of sewage sludge amendment on heavy metal accumulation and consequent responses of beta vulgaris plants. *Chemosphere*, **67**(11), 2229-2240.

Zhang, M.K., Liu, Z.Y., Wang, H. (2010). Use of single extraction method to predict bioavailability of heavy metals in polluted soils to rice. *Communi. Soil Sci. Plant Analy.*, **41**(7), 820-831.