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Distribution of heavy metals in different land-uses in Sadiqabad, Pakistan

Sana Akhtar[1*], Savitha Anum Shahraz[1], Hafiza Sadia Ramzan[2], Sajid Rashid Ahmad[2], Sidra Asghar[1]

[1] *Department of Environmental Sciences, Kinnaird College for Women, Lahore, Pakistan*

[2] *College of Earth and Environmental Sciences, University of the Punjab, Quaid-e-Azam Campus, Lahore, Pakistan*

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Abstract

Soils are the major sinks for heavy metals released through broad range of industrial, farming and manufacturing sources. The main objective of the study was to determine the heavy metals based soil quality with respect to different land uses. Soil from different land uses of Sadiqabad city were assessed to determine the concentrations of selected heavy metals (Cr, Co, Ni, Mg, Cd, Cu, Pb& Zn) along with other parameters (P, K, N, pH, EC & MC). The Pearson Correlation test revealed a strongly significant correlation at the (0.01) level in Fluoride. Nickel (0.5 to 1.1µg/g) was within the EPA standard value (82 to 37µg/g). Lead and Fluoride were violating the acceptable ranges of the given standards in all collected soil samples. The contaminants can be transferred to humans through consumption of food grown on contaminated agricultural land or through inhalation of contaminated dust thus, leading to the elevated burden of heavy metals in residents and commuters of the area.

***Corresponding Author:** Sana Akhtar ✉ sanakhtar23@gmail.com

Introduction

Heavy metals are naturally occurring elements which are present in varying concentrations in all ecosystems. They are found in elemental form and in a variety of other chemical compounds. Heavy metals are released into the city atmosphere from the anthropogenic sources like vehicles, power plants, industries, residential heating and other emissions. Heavy metals are non-biodegradable and have long term impacts on food security and require strategies for instant remediation. Heavy metals are mostly toxic at very low concentrations and cause permanent changes in the body mostly in the central nervous system which leads to the psychotic problems (Wauana and Okieimen, 2011).

Soil plays many important roles in our society including the food source, thus it is extremely important to conserve the soil and maintain its sustainability (Siepak and Sobczynski, 2009). Heavy metal concentrations in soil are related to the biological, geological and chemical cycles.

They can also be pre deposited by anthropogenic activities like transportation, industrialization, disposing of solid waste and agricultural activities. The heavy metals are present in the soil in various forms which manipulate their reactivity, mobility and bio availability (Banat *et al.,* 2005). When heavy metals absorb in the soil they stay within the soil for a longer period of time. The soils in urban areas contains high amount of heavy metals (Poon and Liu, 2001).

As per soil uses for different landscape World Health Organization (WHO) and United States Environmental Protection Agency developed guidelines ranges for determining the concentration of heavy metals (Aelion *et al.,* 2008).

The industrial processes and human activities releases' large quantity of heavy metals and causes serve threats to plants, animals and humans beings (Solgi *et al.,*2012).

The toxicological effects of heavy metals can be acute, chronic, sub chronic, neurotoxin, carcinogenic, mutagenic and teratogenicity (Trukdogan *et al.,* 2002).

Heavy metals are very important for living organisms, but at certain levels, it shows toxic effects, when they exceeds the permissible limit (Abanuz, 2011). The exceeding concentrations of heavy metals cause significant impacts on human health, but children are mostly affected.

The accumulation of heavy metals in the body can damage the central nervous system by causing poisonous effects and other diseases (Cronkvic *et al.,* 2006). Heavy metals mainly enter to human body via ingestion, inhalation, and skin contact or may be from food chain (Salah *et al.,* 2013).

In urban areas horticulture cropping system the organic parameters were mostly exposed to higher rate of pollutants. The contamination of horticulture products can exceed the contamination rate of consumption due to dietary exposure from heavy metals by causing health effects (Rizo *et al.,* 2013).

Lead is known as a dangerous pollutant and can be accumulated in urban soil structures. There are two major source of lead *viz.* leaded gasoline and lead based paints. The lead contamination in urban soil regions considered as a greater human health risk and environmental concern but gaps are found in knowledge about the spatial distributions of lead in urban area (Schwaz *et al.,*2012).The main aim of the paper is to determine the soil quality of different land usesin terms of heavy metals in the study area.

Materials and methods

Study area

The study area was Sadiqabad, district of Rahim Yar Khan, city of Punjab province, Pakistan (Fig. 1).

The study area is Sadiqabad is the administrative part of Rahim Yar Khan and near the border of Punjab province of Pakistan. The total population is about 189931.

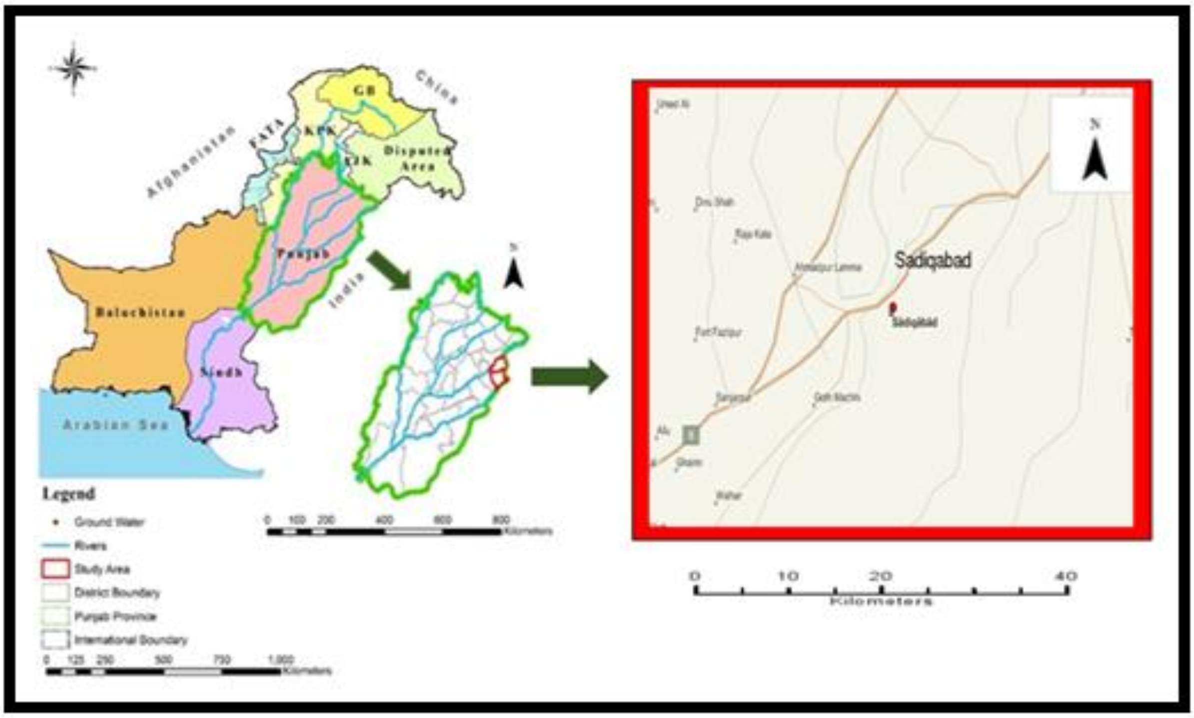

Fig. 1. Map of study area.

The Latitude of Sadiqabad is about 28, 3000 (2818'0.00N) and its longitude is about 70, 1333 (707'59.880 E). It is one of the most progressive cities of Pakistan and rich in the fields of agricultural and industrial development. From the industrial point of view it is the most progressing city of Pakistan, and there are about 56 cotton industries, 100 oil mils, and 15 marble factories working there.

Sampling procedures

By conducting a filed survey the soil samples were collected from different areas land uses of Sadiqabad with the help of GPS coordinates. The soil sample was collected from four different areas like residential, commercial, industrial and agricultural areas of the selected study area i.e., Sadiqabad, by using the grab type of sampling method. A total of 80 soil samples were collected from all 4 sampling sites, 20 from Residential location, 20 from Industrial location, 20 from Agricultural location and 20 from Commercial location. 5 sampling sites were selected from each sampling location; 3 samples were collected from varying depths in polyethylene bags by using gloves and then sealed by labeling the area, date and time and sampling code after collection.

The samples were brought to the lab and stored in the lab for further analysis.

Laboratory and quality control processes

Each of the 80 samples was analyzed for the presence of selected heavy metals such as Cr (Chromium), Cd (Cadmium), Ni (Nickel), Mg (Manganese),Co (Cobalt),Cu (Copper) and Pb (Lead). Due to anthropogenic activities like mining, burning of fossil fuels, discharging of industrial effluents these heavy metals were selected for analysis as their concentration increases in the urban and sub urban soils of Sadiqabad city. At lower levels the presence of these heavy metals may lead cause toxicity in soils, plants , human beings, wildlife and as well as in water.

Parameters

The physico- chemical parameters (pH, TDS, TSS, Moisture Content, and Fluoride) while the selected heavy metals were Copper, Cobalt, Zinc, Manganese, Cadmium, Chromium, Nickel and lead. The inorganic components included Sodium, Potassium, Nitrogen and Phosphorous (Table 1).

Statistical analysis

The results obtained by the analysis of the soil sample were recorded and then interpreted statistically using IBM SPSS version 20 through the calculation of mean, maximum,minimum,standard deviation and establishing the correlation of different factors to determine the relation of the metal concentration with respect to different land use.

Results

In this study the soil samples collected from different land uses were analyzed for their quality and characteristics. A total of 80 soil samples from 4 lands use i.e Agricultural, Industrial, Commercial and Residential, were analyzed for physico-chemical, inorganic parameters were and heavy metals concentration in the soil samples.

Table 1. Physical and chemical parameters analyzed for all collected samples.

Parameters	Standard Method Number	Instrument	Model Number
Moisture Content (MC)	---	Drying Oven	Memmert Oven UNE 200
Electrical Conductivity(EC)	HACH 8160	Conductivity meter	Eutech instrument Pc 510
Potential Hydrogen (pH)	HACH 8156	pH meter	Eutech instrument Pc 510
Metallic parameters			
Parameters	Standard Procedure	Model Number	Method Number
Iron, Copper, Chromium, Cobalt, Zinc, Nickel, Cadmium, Manganese	Atomic Absorption Spectrophotometer	Buck Model 210 VGP	HACH 8008, 8143, 8023, 7200, 8009, 1001, 8017, EPA 82149 respectively
Lead (Pb)	Ion Selective Electrode	Thermo Electron, Orion Dual Star	EPA 8317
Inorganic parameters			
Parameters	Standard procedure	Model Number	Method Number
Sodium, Potassium	Flame Emission Photometer	Sherwood 410	HACH 8131, HACH 8049
Total Nitrogen (N)	Kjedhal Method	--	EPA 10208
Phosphorus (P)	UV Visible Photometer	Stand- alone UV-6000	EPA 8048

Statistical analysis (Maximum, Minimum, Mean and Standard Deviation) of physico-chemical parameters including pH, electrical conductivity, fluoride, and lead of 20 soil samples collected from Industrial location is given in Table 2.

The average pH ranged from (8.11-9.59) in industrial soil samples with mean± SD (8.8350±.44112) which was strongly alkaline. The electrical conductivity ranged from (3.8µs/cm -1551µs/cm) with mean± SD (277.922±366.9397). Comparison with EPA standard (0.57µs/cm) revealed that EC range was exceeding the permissible limits in industrial soil samples.

The moisture content ranged from (0.40%to 0.830%) with mean± SD (0.22100±0.224708) in all the collected soil samples.

Table 2. Descriptive statistics of industrial location soil samples.

	N	Minimum	Maximum	Mean	Std. Deviation
pH	20	8.11	9.59	8.8350	±0.44112
Electrical Conductivity	20	3.8	1551.0	277.922	±366.9397
Moisture Content	20	0.000	0.830	0.22100	±0.224708
Fluoride	20	26.90	10489.00	1461.3645	±2828.89577
Lead	20	224.5	438.9	289.360	±55.9257

The Fluoride range varied from (10489ppm-26.90ppm) of the industrial land use with the mean± SD (1461.3645±2828.89577). The EPA has not given any standard value for both these physico-chemical parameters.

Lead ranged from (224.5ppm-438.9ppm) with the mean± SD (289.360±55.9257). The lead values were also exceeding the permissible limits given by EPA (120µg/g).

Statistical analysis (Maximum, Minimum, Mean and Standard Deviation) of physico -chemical parameters which includes pH, electrical conductivity, fluoride, and lead of 20 soil samples collected from Commercial location is represented in Table 3.

The pH ranged from (7.25-8.64) with mean± SD (7.8805± 0.48368). pH value of soil samples collected from commercial location was strongly alkaline. The electrical conductivity ranged from (569.0μs/cm-768.0μs/cm) with mean ± SD (2948.300 ± 2326.5180). The EC was exceeding the EPA limits of (0.57μs/cm). The moisture content was calculated to be varying between (.030%-1.010%) with mean± SD (0.31100± 0.282711) in all the collected soil samples. The fluoride range varied from (29.69ppm-206.40ppm) with mean± SD of (79.4735 ± 71.93307). There are no such standards provided by EPA for both moisture content and fluoride in soil.

The lead ranged from (96.2ppm-492.4ppm) with mean±SD (292.193±83.5127), were also exceeding the limits of EPA standards mentioned above Pb (120μg/g).

Table 3. Descriptive statistics commercial location soil samples.

	N	Minimum	Maximum	Mean	Std. Deviation
pH	20	7.25	8.64	7.8805	.48368
Electrical Conductivity	20	569.0	7680.0	2948.300	2326.5180
Moisture Content	20	0.030	1.010	0.31100	0.282711
Fluoride	20	29.69	206.40	79.4735	71.93307
Lead	20	96.2	492.4	292.193	83.5127

Statistical analysis (Maximum, Minimum, Mean and Standard Deviation) of physico -chemical parameters which includes pH, Electrical Conductivity, Fluoride and Lead of 20 Residential soil samples is represented in Table: 4.

The pH range varied from (7.08-9.26) with mean± SD (8.2710± 0.71639), implying that pH range of soil samples collected from residential location was alkaline.

The EC ranged from (2.6μs/cm-78.2μs/cm) with mean ±SD (38.921±18.5853), this range was also exceeding the permissible limits given by EPA (0.57μs/cm).

The range of moisture content varied from (0.140%-1.480%) with mean±SD (0.883650±0.355339).

Fluoride ranged from (9.50ppm-870.40ppm) with mean± SD (317.7050±195.69651) in all the collected soil samples.

The EPA has not given any standard value for both these physico-chemical parameters. On the other hand the lead ranged from (32.6ppm-16420.0ppm) with mean± SD (1705.456± 3650.4062) so the lead value were also exceeding the permissible limits and the EPA standard for lead (120μg/g) in the soil samples of this land use.

Table 4. Descriptive statistics of residential location soil samples.

	N	Minimum	Maximum	Mean	Std. Deviation
pH	20	7.08	9.26	8.2710	.71639
Electrical Conductivity	20	2.6	78.2	38.921	18.5853
Moisture Content	20	0.140	1.480	0.883650	0.355339
Fluoride	20	9.50	870.40	317.7050	195.69651
Lead	20	32.6	16420.0	1705.456	3650.4062

Statistical analysis (Maximum, Minimum, Mean and Standard Deviation) of physico -chemical parameters which includes pH, Electrical Conductivity, Fluoride and Lead of 20 soil samples collected from Agricultural location is represented in Table 5.

The pH varied from (7.63-8.61) in agricultural soil samples with mean± SD (8.0125±.26901). pH range in all soil samples collected from agricultural location was higher than the standard value given by USA (6.6-7.3). pH of soil samples collected from agricultural location was strongly alkaline. The EC ranged from (3.1μs/cm -131.5μs/cm) with mean± SD (56.950±31.306). According to the EPA standards (0.47 μs/cm) the EC values of agricultural soil samples were exceeding the permissible limits.

Table 5. Descriptive statistics of agricultural location soil samples.

	N	Minimum	Maximum	Mean	Std. Deviation
pH	20	7.63	8.61	8.0125	.26901
Electrical Conductivity	20	3.1	131.5	56.950	31.3061
Moisture Content	20	0.100	1.470	0.60000	0.446801
Fluoride	20	249.30	790.20	461.5250	140.92768
Lead	20	181.3	384.0	274.559	57.3422

The moisture content varied from (0.100%-1.470%) with mean± SD (0.60000±0.446801) and on the other hand the fluoride ranged from (249.30ppm-790.20ppm) with mean± SD (461.5250±140.92768). The EPA has not given any standard value for both these physico-chemical parameters. Lead ranged from (181.3ppm-384.0ppm) with mean± SD (274.559±57.3422) in all the collected 20 soil samples from agricultural land use and, it was also exceeding the EPA permissible limits (45μg/g).

Table 6. Correlation between pH, electrical conductivity, nickel, lead and fluoride in soil samples.

	pH	EC	Fluoride	Nickel	Lead
pH	1				
EC	-.037	1			
	.742				
Fluoride	.402**	-.101	1		
	.000	.374			
Nickel	.000	.161	.031	1	
	.999	.320	.848		
Lead	.119	-.087	-.032	-.090	1
	.292	.441	.776	.582	

**. Correlation is significant at the 0.01 level (2-tailed).

Discussion

The results are consistent with the study in Gilgit, Pakistan showing that the soil pH cumulative average range was about (8.66 – 8.97) in three different land uses including agricultural, barren and commercial (Sanam *et al.,* 2016). Another study in Sialkot established that wastewater of all the textile industries was acidic in nature and very low pH range may also cause the soil acidity. The observed pH value in that study was (7.67±0.47). The solubility of heavy metals concentration increases at lower pH range while decreases at higher pH range. While the Electrical conductivity was (0.18-0.10mS/cm) (Brobe *et al.,* 2010).The earlier studies show that increasing level of EC can affect the soil minerals and texture, plants nutrient availability and crop yields (Lee *et al.,*2006).

None of the heavy metals were detected in all the collected soil samples from four different locations including Industrial, Commercial, and Residential and Agricultural sites of Sadiqabad except nickel whose concentration ranged from (0.5 to 1.1µg/g). The permissible range given by EPA for Industrial, Commercial and Residential land uses was (82µg/g) and for Agricultural land use is (37µg/g). The Nickel is a by-product of oil and ghee industries as proved by a study in Sialkot, Pakistan. It also revealed the nickel concentration with mean±SD (85.46±16.87µg/g) was exceeding the permissible limit of (100µg/g) (Brobe *et al.,* 2010).

In order to determine the correlation of selected chemical parameters in the collected soil samples of four different land uses Pearson's correlation analysis was applied. The results in Table 6 indicate that** Correlation is significant at the 0.01 level (2-tailed) which means that there is a strongly positive correlation between fluoride (.402) and pH (1).

All collected soil samples from Agricultural, Industrial, Commercial and Residential area were also analyzed for fertility parameters which included Nitrogen, Potassium and Phosphorus. The detected concentrations of these fertility parameters (N, K and P) are represented in Fig. 2.

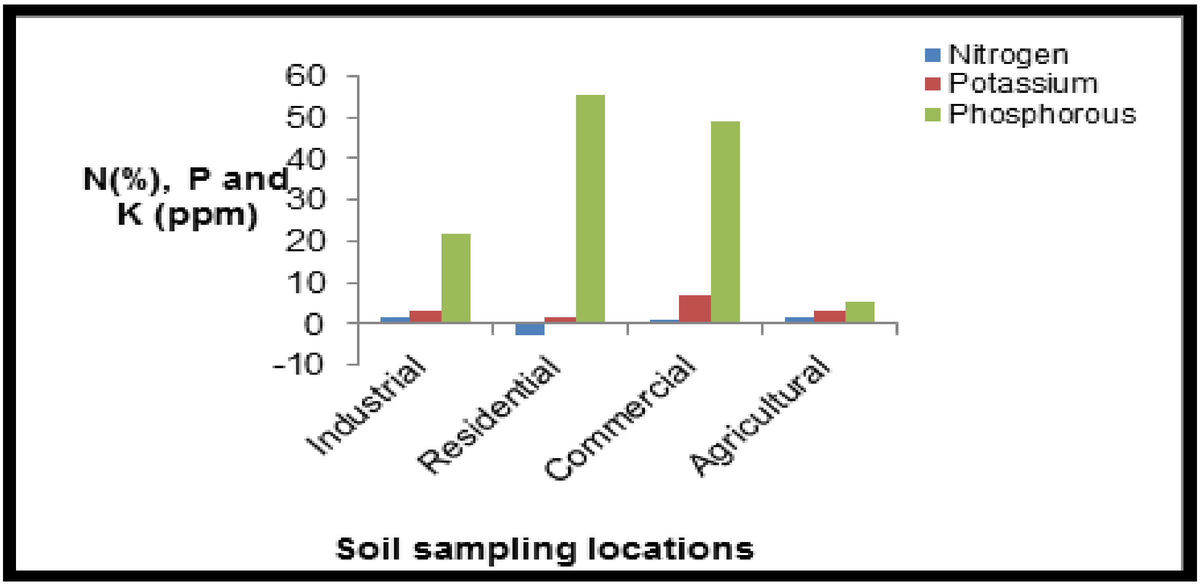

Fig. 2. Concentration of fertility Parameters in soil samples.

The study in Hong Kong demonstrated the lead concentration with mean±SD (88.1±62.0mg/kg) which was exceeding the recommended Netherlands soil contamination guidelines in urban soils because of anthropogenic activities within the urban areas. Lead is mostly emitted from manufacturing industries and from storage batteries, so it is known as the major contaminant in the soils of industrialized urban areas (Alam *et al.,* 2015).

A study conducted in Lahore also detected that the lead concentration (427.396±821.44µg/g), was exceeding the limit given by international standard (200µg/g). The lead exposure damages the neurological, kidney and endocrine system and also causes the reproductive dysfunction (Khan *et al.,* 2013). From the earlier studies it was noted that heavy metals mainly accumulated in the green vegetables from the soil. The concentration of heavy metals such as Pb ranged from (30.8-97.2mg/kg^{-1}) with mean±SD (64.0±15.02mg/kg^{-1}) and Ni ranged from (10.3-35.5mg/kg^{-1}) with mean±SD (22.9 ± 7.29mg/kg^{-1}) therefore, the results showed that these heavy metals concentration in vegetables were exceeding the permissible limits given by WHO and consumption of these vegetables may cause health risks to humans (Farooqi *et al.,* 2009).

Another study was conducted to determine the fluoride contamination in the surface and deep soil samples of Punjab, Pakistan detected that the concentration of fluoride was higher in deep soil samples with mean±SD (1.90±1.130mg/kg).Similarly industrial activities can also contaminate soil through fluoride rich dust, fumes and ash. Fluoride mean concentration in soils has little effect on vegetation and fluoride in soils is not readily accumulated by plants (Ranjan and Rajan, 2015).

Conclusion

This study was conducted in Sadiqabad city and four land uses were selected *viz.* Residential, Industrial, Agricultural and Commercial. It was concluded that from selected heavy metals Nickel was (0.5 to 1.1 µg/g) within the EPA standard value. The mean values of all the physical parameters including pH and Electrical Conductivity were exceeding the limits. Lead and Fluoride were also violating the acceptable ranges of the given standards in all collected soil samples. The Pearson's Correlations showed a strong positive significant correlation's among fluoride and pH. The chemical parameters like lead and fluoride can be transferred in humans through consumption of food grown on contaminated agricultural land and can cause health effects.

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