Plant communities and soil heavy metals relationships in the vicinity of the industrial areas of Korangi and Landhi in Karachi, Pakistan.

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Abstract--A relationship between soil heavy metals and plant communities of the industrial areas of Korangi and Landhi in Karachi was studied. Soil samples were collected from twenty eight stands around the industrial locations of Korangi and Landhi for analysis of ferric, copper, zinc, chromium and lead. On the basis of leading dominant species, fifteen plant communities were recognized in which some of the communities were dominated by single species. All the communities were correlated with the soil heavy metals of the industrial areas. The range of ferric, copper, zinc, chromium and lead in plant communities were between 0.763-12.079 μg^{-g}, 0.023-2.988 μg^{-g}, 0.033-4.220 μg^{-g}, 0.000-4.139 μg^{-g} and 0.000-0.053 μg^{-g} respectively. In all of the plant communities, means values of soil heavy metals were in ferric (7.062 μg^{-g}), copper (1.062 μg^{-g}), zinc (1.031 μg^{-g}), chromium (0.664 μg^{-g}) and lead (0.016 μg^{-g}).

Key words: Industrial areas, industrial soil, plant communities, plants-soil relationship and soil heavy metals.

1 Introduction

Industrial pollution due to heavy metals in Karachi is a critical issue. The industries emit extensive range of heavy metals such as ferric, copper, zinc, chromium and lead into the air, water and soil. The heavy metal levels decreased with an increase in the distance from the factory [1]. In some raw industrial effluents from electroplating and chromium industries, Cr VI predominates [2]. There are different types of heavy metals such as zinc, cadmium, cobalt and nickel, which are used in the industries for many purposes [3]. Lagerwerff and Specht [4] have reflected that heavy metals of cadmium, nickel, lead and zinc accumulated in soils caused damage to the vegetation and microflora. Emissions of cadmium and copper from a metal refinery caused widespread contamination of soil and vegetation in Mersey side, North-West England [5].

The excessive uptake of lead and cadmium from soil reduced the yield of plants because of reduction in the metabolic and nutritional processes [6]. Wahab and Hashem [7] have illuminated heavy metal pollution in the atmosphere and in soil due to industrial wastes, application of fertilizers, corrosion of sheeting, and burning of coal and wood at Jubail in Saudi Arabia.

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Martinez and Motto [8] had explicated elevated grades of lead, zinc and copper in soils as a result of industrial activities, atmospheric deposition and the land application of sewage sludges and industrial by products. The heavy metals of Fe, Cu, Zn & Cr were mostly higher in *Leucaena leucocephala* plants which were grown in soil of industrial zones of Korangi and Landhi than control site of Karachi University Campus [9]. Soil of the industrial places has also been used to detect the accumulation, deposition of metal pollution [10], [11]. Notable concentration of lead, zinc and copper in soil along the sewage effluents channels of Malir river (Karachi) were found by [12] which influenced on the composition of plant communities at the locality there was showing *Paspalidium geminatum* as a most dominant species.

Due to ruinous and harmful character of industries which are contaminating the soil close to industries of Korangi and Landhi in Karachi. It is needed to assess the effects of heavy metals polluted soil of industrial territories and their correlation with plant communities.

2 Materials and Methods

The study was based on the analysis of heavy metals in soil samples of twenty eight stands, which were collected from the proximity of different factories from Korangi and Landhi industrial areas of Karachi. Samplings of vegetation of these stands were conducted by Point Centered Quarter Method by employing twenty five sampling points in each stands. Observations were based on four plants measurement at each point. The circumference of every individual species was recorded. Phytosociological attributes like cover, relative cover, density, relative density, frequency, relative frequency and importance

value index of each species were calculated and analyzed [13]. Two soil samples from each stand were obtained from 0-30 cm depth. Soil samples were stored in labeled polythene bags and brought to the laboratory. Later the samples were air dried, lightly crushed and passed through 2 mm sieve and kept in the laboratory for analysis. For heavy metal analysis in soil, all the soil samples were wet digested and metals (ferric, copper, zinc, chromium and lead) were analyzed by atomic absorption spectrophotometer (Perkin Elmer Model No. 3100).

3 Results

In most of the plant communities, the soil had high quantity of ferric subsequently copper and zinc whereas, chromium and lead were less (Table 1). The characteristics of different plant communities recorded at Korangi and Landhi industrial areas are given below:

3.1 *Abutilon-Prosopis* community

This community was located at Khan Towel factory in the Korangi industrial area. The soil of *Abutilon-Prosopis* community contained moderate degree of ferric (8.500 μg^{-g}), copper (1.015 μg^{-g}) and zinc (0.565 μg^{-g}) while, chromium (0.005 μg^{-g}) and lead (0.007 μg^{-g}) were low.

3.2 *Abutilon* community

Abutilon community was in the proximity of Chushtia Bed Sheets, Fatima Garment and Fancy Ply Board factories at the Korangi industrial area and One Tech Ply Board factory at Landhi industrial sites. In this community, the level of ferric (8.887 μg^{-g}), copper (1.039 μg^{-g}), zinc (1.494 μg^{-g}) and lead (0.021 μg^{-g}) were appropriate whereas, chromium (0.235 μg^{-g}) was less.

3.3 *Abutilon-Cressa* community

Abutilon-Cressa community was situated at Paramount Garment factory in the Korangi industrial region. Considerable level of ferric (9.130 μg^{-g}) and copper (1.503 μg^{-g}) were found in this community. The concentration of zinc (0.211 μg^{-g}) was moderate and lead (0.003 μg^{-g}) was low, while chromium was not present in soil of this community.

3.4 *Abutilon-Tribulus* community

Abutilon-Tribulus community was occurred near the Triple A Dying factory in the Korangi industrial estate. Elevated level of ferric (9.206 μg^{-g}) and lead (0.043 μg^{-g}) were determined. Whereas, appropriate concentrations of copper (0.963 μg^{-g}) and zinc (1.129 μg^{-g}) were noted while, chromium was absent in the community.

3.5 *Cressa* community

Cressa community was located at One Tech Rubber factory at the Korangi industrial region of Karachi. Low content of ferric (4.729 μg^{-g}) and zinc (0.051 μg^{-g}) were examined in this community whereas, copper (1.534 μg^{-g}) and chromium (3.450 μg^{-g}) were high with moderate concentration of lead (0.020 μg^{-g}).

3.6 *Cressa-Abutilon* community

Cressa-Abutilon community was around the Polyfex Plastic factory in Korangi industrial zone. Maximum amount of copper (2.988 μg^{-g}) and zinc (4.220 μg^{-g}) were noted in this present community. Ferric (9.012 μg^{-g}) was also great with low chromium (0.001 μg^{-g}) while, lead (0.021 μg^{-g}) was moderate.

3.7 *Cressa-Senna* community

Cressa-Senna community was in the vicinity of Tanveer Garment factory in the Korangi industrial locality. In this community, the value of ferric (8.364 μg^{-g}) and copper (0.824 μg^{-g}) were moderate. The concentration of zinc (0.082 μg^{-g}) and chromium (0.005 μg^{-g}) was low, while, lead was not found in the community.

3.8 *Digera-Senna* community

Digera-Senna community was in the surrounding of Mustafa Garment and Tanveer Garment factories in Korangi industrial area. The ferric (3.161 μg^{-g}) and copper (0.534 μg^{-g}) were low in amount with moderate level of zinc (0.260 μg^{-g}). Chromium (2.115 μg^{-g}) and lead (0.035 μg^{-g}) were high in soil of this community.

3.9 *Suaeda* community

Suaeda community was in the proximity of National Oil refinery in Korangi industrial area. Moderate quantity of ferric (6.737 μg^{-g}) with little amount of copper (0.032 μg^{-g}) was recorded in the community. It contained moderate concentration of zinc (0.960 μg^{-g}) while, chromium and lead were not reported.

3.10 *Salsola* community

Salsola Community was found around National Oil refinery in Korangi industrial site. Moderate level of ferric (5.116 μg^{-g}) and zinc (0.498 μg^{-g}) while low concentration of lead (0.004 μg^{-g}) and copper (0.041 μg^{-g}) were investigated. Chromium was absent in soil of this community.

3.11 *Corchorus-Abutilon* community

Corchorus-Abutilon community was present around Haidery Flour mill in Korangi industrial site and International Leather industry in Landhi industrial area. The concentration of ferric (9.863 μg^{-g}), copper (1.310 μg^{-g}) and zinc (2.227 μg^{-g}) were high while, lowest chromium (0.002 μg^{-g}) and moderate concentration of lead (0.009 μg^{-g}) were found in soil of the community.

3.12 *Amaranthus-Prosopis* community

Amaranthus-Prosopis community was in the verge of Amin Maaz Ghee factory and Fahim Carpets factory in Korangi industrial location and Zeba Textile industry around Landhi industrial area. Manifestly higher extent of ferric (12.079 μg^{-g}) was recorded in this community. Copper (2.161 μg^{-g}), zinc (3.109 μg^{-g}) and lead (0.028 μg^{-g}) were obviously found while, chromium (0.001 μg^{-g}) was low.

3.13 *Gynandropsis-Digera* community

Gynandropsis-Digera community was in the location of Beam factory at Korangi industrial region. Low concentration of ferric (4.275 μg^{-g}) was found with

moderate value of copper (1.030 μg-g). The concentration of zinc (0.095 μg-g) and chromium (0.003 μg-g) were low while, lead was not reported in the community.

3.14 *Prosopis- Abutilon* community

Prosopis-Abutilon community was close to the Khan Towel factory situated at Korangi industrial site. Low level of ferric (0.763 μg-g), copper (0.023 μg-g) and zinc (0.033 μg-g) were reported in this community whereas, chromium (4.139 μg-g) and lead (0.053 μg-g) were literally high in the community.

3.15 *Cenchrus-Senna* community

Cenchrus-Senna community was situated at Mustafa Garment factory in Korangi industrial area. Moderate concentration of ferric (6.107 μg-g), copper (0.929 μg-g) and zinc (0.528 μg-g) were studied in the community, while, chromium and lead were not recorded.

The dominant species ascertained at the Korangi and Landhi industrial regions were also correlated with soil heavy metals. *Suaeda fruticosa* has highest I.V.I. (226.14) and occurred as dominant species in one stand in which moderate amount of ferric (6.737 μg-g), zinc (0.960 μg-g) and low level of copper (0.032 μg-g) were determined (Table 2). Chromium and lead were not found in the soil. *Salsola baryosma* (I.V.I. = 188.32) was also attained dominant in one stand where ferric (5.116 μg-g) and zinc (0.498 μg-g) were moderate and copper (0.041 μg-g) and lead (0.004 μg-g) were low while, chromium was not present in the stand. Both *S. fruticosa* and *S. baryosma* displayed less copper in their stands. *Corchorus trilocularis* (I.V.I. = 174.71) was dominated in two stands, where the amount of ferric (9.318 μg-g), copper (1.391 μg-g) and zinc (2.265 μg-g) were adequate while, chromium (0.002 μg-g) and lead (0.007 μg-g) were low. *Corchorus trilocularis* and *Corchorus depressus* (I.V.I. = 94.59) were also associated with high degree of ferric and zinc whereas, chromium was reduced in amount. *Amaranthus viridis* (I.V.I. = 105.06) was dominant in three stands and had greatly noticeable rate of ferric, copper and zinc in soil as related to all the other species. *Prosopis juliflora* (I.V.I. = 87.69) had lowest concentration of ferric, copper and zinc while, excess content of chromium and lead were elucidated. *Cenchrus biflorus* (I.V.I. = 76.57) which had markedly lower importance value index exhibited moderate magnitude of ferric, copper and zinc.

4 Discussion

Ferric concentration was fairly prominent in soil of most plant communities and leading dominant species as related to other metals. Ferric concentration was substantially higher in soil where *Amaranthus-Prosopis* community was growing at the Korangi industrial zone. Whereas, in case of first leading dominant species of stands, where *Amaranthus viridis* growing as a first leading dominant species the soil had high amount of ferric (12.079 μg-g), copper (2.161 μg-g) and zinc (3.109 μg-g) when compared to soils of the other first dominant species. Atiq-ur-Rehman, *et al.*, [9] have reflected that Fe concentration was apparent in *Leucaena leucocephala* plant as related to Cu and Zn after growing in soils of various factories of Korangi and Landhi industrial areas.

The association of *Cressa cretica* and *Abutilon indicum* communities had significant collaboration than other communities since, in the soils of *Cressa-Abutilon* community, strikingly higher amount of copper (2.988 μg-g) and zinc (4.220 μg-g) were observed which occurred at industrial site of the Korangi. The *Cenchrus ciliaris* formed an association with *Dactyloctenium aegypticum* with manifestly sufficient copper concentration (640 ppm) in soil on the heap area, located, along the sewage effluents channels of Lyari river which were contaminated from the effluents of the industrial areas along with other sources [14]. They also noted that the concentration of zinc (74 ppm) was apparently notable in soil of pure population of *P. geminatum* at the heap area. Some metals such as Cu, Co, Fe, Mo, Mn, Ni and Zn are essential mineral nutrients [15] at low degree while elevated concentrations are noxious.

Prosopis-Abutilon community had obvious importance due to distinct concentrations of chromium (4.139 μg-g) and lead (0.053 μg-g) in their soils. Municipal waste based composts and sewer water, often mixed with industrial discharges, are used for fertilizing and irrigating arable lands [16]. These wastes frequently restrain heavy metals, including chromium, in appreciable amount. The *P. geminatum* and *Atriplex insignis* association produced *Paspalidium-Atriplex* community represented much evident Pb contents in soil, which exhibited the tolerance of these plant species in soil along the Malir river which were polluted by the effluents of the industrial areas along with other sources [12].

In this study, *Prosopis juliflora, Abutilon indicum, Amaranthus viridis* and *Cressa Cretica* were tolerant species. The effects of metals on vegetation were varied and could involve in the extinction of some species [1]. The soil of *P. juliflora* had considerably higher concentrations of toxic metals like chromium and lead whereas, the soil of *A. indicum* showed conspicuous level of ferric. *C. cretica* plant displayed factual amount of copper while *A. viridis* had marked concentrations of ferric, copper and zinc in soil as a first dominant species. The associations of above-mentioned plants produced, *Prosopis-Abutilon, Cressa-Abutilon* and *Amaranthus-Prosopis* communities which had important soils characters like *Prosopis-Abutilon* community had distinct range of chromium and lead. The *Cressa-Abutilon* community demonstrated prominent level of copper and zinc in soil. In case of *Amaranthus-Prosopis* community, ferric concentration was predominant in soil. *C. Cretica, A. viridis* and *P. juliflora* were third, sixth and eighth dominant species respectively according to total important value index where *A. indicum* was a most dominant species [17]. In spite of noticeable metal accumulation of ferric, lead, copper, chromium and zinc in the leaves, *Abutilon indium* was found in the industrial zones of Karachi [18]. In addition, generally soils of plant communities of Korangi industrial area had significant amount of heavy metals mainly chromium and lead than Landhi zone.

REFERENCES

[1] Aksoy, U. Sahin, and F. Duman, "Robinia pseudo-acacia L. as a possible biomonitor of heavy metal pollution in Kayseri," Turk. J. Bot., vol. 24, pp. 279-284, 2000.

[2] D.I. Khasim, N.V. Nanda, and R.C. Hussain, "Environmental contamination of chromium in agricultural and animal products near chromate industry," Bull. Environ. Contam. Toxicol., vol. 43, pp. 742-746, 1989.

[3] B.L. Valee and D.D. Ulmer, "Biochemical effect of mercury, cadmium and lead" Annu. Rev. Biochem., vol. 41, pp. 91-128, 1990.

[4] J.W. Lagerwerff and A.W. Specht, "Contamination of roadside soil and vegetation with cadmium, nickel, lead and zinc," Environ. Sci. Technol., vol. 4, pp. 583-586, 1970.

[5] A. Hunter, M.S. Johnson, and D.J. Thompson, Ecotoxicology of copper and cadmium in a contaminated grassland ecosystem. I. Soil and vegetation contamination. J. Appl. Ecol., vol. 24, pp. 573-586, 1987.

[6] S. Burzynski and K. Mereck, "Effect of Pb and Cd on enzymes of nitrate assimilation in cucumber seedling," Acta Physiologiae Plant., vol. 12 pp. 105-110, 1990.

[7] Wahab A. and R. Hashem, "Soil analyses and mycoflora of the Jubail industrial city in Saudi Arabia," J. Univ. Kuwait (Sci.), vol. 22, pp. 231-237, 1995.

[8] C.E. Martinez and H.L. Motto, "Solubility of lead, zinc, and copper added to mineral soils," Environ. Pollut., vol. 107, pp. 153-158, 2000.

[9] S. Atiq-ur-Rehman, M.Z. Iqbal, and M. Mumtaz, "Metal transfer ratio of Leucaena leucocephala: an experimental study using the soils of industrial areas of Korangi and Landhi, Karachi," J. Basic Appl. Sci., vol. 3, no. 1, pp. 11-18, 2007.

[10] S. Kuo, P.E. Heilman, and A.S. Baker, "Distribution and forms of copper, zinc, cadmium, iron, and manganese in soils near a copper smelter," Soil Sci., vol. 135, pp. 101-109, 1983.

[11] C.D. Maxwell, "Floristic changes in soil algae and cyanobacteria in reclaimed metal contaminated land at Sudbury, Canada," Water Air Soil Pollut., 60, 381-394, 1991.

[12] Qamar-Uz-Zaman and Iqbal, M.Z. Vegetation pattern along the sewage effluents channels of Malir river (Karachi). Turk. J. Bot., vol. 18, pp. 425-430, 1994.

[13] J.T. Curtis and R.P. MacIntosh, "An upland forest continuum in the Prairie-forest border region of Wisconsin," Ecology, vol. 32, pp. 465-496, 1951.

[14] M.Z. Iqbal, D. Gill, and M. Shafiq, "Plant Communities along the sewage effluents channels of Lyari river in Pakistan," Taiwania, vol. 43, pp. 1-11, 1998.

[15] M. Shafiq, and M.Z. Iqbal, "Tolerance of Peltophorum pterocarpum D. C. Baker Ex K. Heyne Seedlings to lead and cadmium treatment," J. New Seeds, vol. 7, pp. 83-94, 2005.

[16] D.E. Baker and L. Chesnin, "Chemical monitoring of soils for environmental quality and animal and human health," Adv. Agron,, vol. 27, pp. 305-374.

[17] S. Atiq-ur-Rehman, "Effects of Soil of Industrial Areas on Plants," Ph.D. thesis, 161 p., Dept. of Bot., Univ. Karachi, Karachi-75270, Pakistan, 2006.

[18] S. Atiq-ur-Rehman and M.Z. Iqbal, "Level of heavy metals in the foliage of naturally growing plants collected from Korangi and Landhi industrial areas of Karachi city, Pakistan," Pak. J. Bot., vol. 40, no. 2, pp. 785-789, 2008.

Table 1. Correlation of soil heavy metals (Fe, Cu, Zn, Cr and Pb in μg-g) with plant communities found around the industrial areas of Korangi and Landhi.

Sr. No.	Communities	Fe	Cu	Zn	Cr	Pb
1	*Abutilon-Prosopis*	8.500	1.015	0.565	0.005	0.007
2	*Abutilon*	8.887	1.039	1.494	0.235	0.021
3	*Abutilon-Cressa*	9.130	1.503	0.211	0.000	0.003
4	*Abutilon-Tribulus*	9.206	0.963	1.129	0.000	0.043
5	*Cressa*	4.729	1.534	0.051	3.450	0.020
6	*Cressa-Abutilon*	9.012	2.988	4.220	0.001	0.021
7	*Cressa-Senna*	8.364	0.824	0.082	0.005	0.000
8	*Digera-Senna*	3.161	0.534	0.260	2.115	0.035
9	*Suaeda*	6.737	0.032	0.960	0.000	0.000
10	*Salsola*	5.116	0.041	0.498	0.000	0.004
11	*Corchorus-Abutilon*	9.863	1.310	2.227	0.002	0.009
12	*Amaranthus-Prosopis*	12.079	2.161	3.109	0.001	0.028
13	*Gynandropsis-Digera*	4.275	1.030	0.095	0.003	0.000
14	*Prosopis-Abutilon*	0.763	0.023	0.033	4.139	0.053
15	*Cenchrus-Senna*	6.107	0.929	0.528	0.000	0.000

Table 2. Correlation of first dominant species with soil heavy metals (Fe, Cu, Zn, Cr and Pb in μg^{-g}) found around the industrial areas of Korangi and Landhi.

Dominant species	•NS	ΔMIVI	Fe	Cu	Zn	Cr	Pb
Suaeda fruticosa	1	226.14	6.737	0.032	0.960	0.000	0.000
Salsola baryosma	1	188.32	5.116	0.041	0.498	0.000	0.004
Corchorus trilocularis	2	174.71	9.318	1.391	2.265	0.002	0.007
Abutilon indicum	10	134.22	8.929	1.122	1.108	0.141	0.018
Cressa cretica	4	145.33	6.709	1.720	1.101	1.726	0.015
Amaranthus viridis	3	105.06	12.079	2.161	3.109	0.001	0.028
Digera alternifolia	2	99.35	3.161	0.534	0.260	2.115	0.035
Corchorus depressus	1	94.59	10.954	1.148	2.152	0.004	0.012
Gynandropsis gynandra	2	91.90	4.275	1.030	0.095	0.003	0.000
Prosopis juliflora	1	87.69	0.763	0.023	0.033	4.139	0.053
Cenchrus biflorus	1	76.57	6.107	0.929	0.528	0.000	0.000

• NS = No. of stands in which sp. is showing 1st. position,
ΔMIVI= Mean Importance value index