Environmental Geochemistry of the Soils of Peshawar Basin, N.W.F.P., Pakistan

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Summery: Peshawar basin is situated at the southern foothills of the lesser Himalayas in the North West Frontier Province of Pakistan. It is mainly composed of the Quaternary fluvial and lacustrine sediments. The soil of the basin has been classified into Peshawar piedmont soil, Peshawar floodplain soil and Peshawar lacustrine soil. These soils of have been evaluated for major, minor, trace and heavy metals. The chemical analyses of these soils showed that the concentration of SiO_2, TiO_2, Fe_2O_3 and MnO are in the range of normal soil. However, Al_2O_3, MgO, CaO, Na_2O, K_2O and P_2O_5 and all the analyzed trace and heavy metals, except Co, were higher than the limits reported for normal soil. The soils of certain areas of the Peshawar piedmont and the Peshawar floodplain had trace and heavy metals in very high concentrations and should be further investigated for their effects on the ecosystem. The high concentrations of CaO, NaO and K_2O in these soils could be attributed to the water-logging and salinity in the area while high MgO, Cu, Ni and Cr could be correlated with the rocks of the Dargai ultramafic complex and the high P_2O_5 could be either contributed by alkaline rocks or fertilizers or both.

Introduction

Peshawar basin is an intermountain basin (> 5500 Km^2) in the southwestern part of the Himalayan Crystalline Nappe and Thrust Belt of the lesser Himalayas in the North West Frontier Province (NWFP) of Pakistan. Major cities of the basin are Peshawar (capital), Mardan, Charsadda, and Nowshera. The east-west flowing Kabul river and its tributaries irrigate the basin and join the Indus river at the eastern exit. Peshawar basin is surrounded by mountain ranges of Khyber in the northwest, Attock-Cherat in the south and Swat in the northeast. It has Quaternary fanglomerates along the margins of the basin while the central part of the basin is generally covered with fluvial micaceous sand, gravels and lacustrine deposits. The soils of the basin have been classified into Peshawar piedmont soil, Peshawar floodplain soil and Peshawar lacustrin soil [1].

Soil is an unconsolidated material that essentially supports plant growth and agricultural activities. The climate, parent material, topography, plants and organic activities play significant roles in the formation of soil [2]. After its formation, the soil is generally altered by chemical, physical and biological processes which support rooted plant life. Due to these chemical changes the chemistry of soil has greater importance with regards to agricultural and environmental point of wiew. There are certain major, minor, trace and heavy metals (i.e., Si, Al, Ca, Mg, Fe, Na, K, Mn, P, Ti, Cu, Pb, Zn, Ni, Cr, Co etc.) in the soil that are essential for the growth of plants kingdom. However, certain plant species concentrate excess amount of these metals in their tissues which pose greater risk for contamination of food chain [3, 4]. These elements are mainly released from parent material of soil, fertilizers, living organisms, sewage sludge, chemical industries, irrigation water, pesticides, coal combustion residues and from many other sources [5, 6]. These elements could be a significant source of soil nutrients, if present in permissible limit, while the high concentration of these elements at certain level are toxic to the agricultural land and produce soil pollution [7-9]. Soil is one of the most important sinks of the elements in the environments and may retain contaminants in clay particles and serve as filters for the pollutants [10]. This soil pollution disturbs the natural composition of the thin layer of fertile soil. Soil pollution may also contaminate surface and subsurface water system and hence render the land unhygienic for living purposes [11].

There is a greater concern nowadays that metal polluted soil might result in human exposure to environmental toxicants [12-14]. The present study is, therefore, conducted on the environmental assessment of soil of the Peshawar basin in regard to major, minor, trace and heavy metal pollution. This

paper deals with the chemical characters of soils of the Peshawar basin, which is used for the determination of various sources of contamination and identifies the character of soil for the growth of plants in the area.

Classification of Soil of Peshawar Basin

Various types of soils in the Peshawar basin classified as (1) Peshawar piedmont soil, (2) Peshawar lacustrine soil and (3) Peshawar flood plain soil and are briefly discussed below:

Peshawar Piedmont Soil

Peshawar piedmont soil is mainly present at the marginal parts of the basin and has been divided into low and high permeability stratas [1]. The soil of low permeability strata consists of silt, clay and rarely fine-sand, while the soil of high permeability is generally composed of sand and gravel from a depth of 30 m to 150 m. Thick clay strata of low permeability often separate the aquifers in the area. Dug wells in this area also indicate the low permeability and shallow groundwater of low capacity.

Peshawar Floodplain Soil

Peshawar floodplain soil is confined to the vicinities of the current and past courses of Kabul and Swat rivers, where these rivers have deposited these sediments. These sediments consist of sand with intercalations of clay spread out by river overflow during high floods.

Peshawar Lacustrine Soil

Peshawar lacustrine soil is classified on the basis of lacustrine deposits that mainly occur in the central part of the basin in Nowshera, Mardan and Swabi areas. Such deposits are probably the latest lake deposits of catastrophic floods along the Indus, deposited in the lake environment.

Results and Discussion

Different locations in the Peshawar basin (Fig. 1) were selected for the collection of representative soil samples from the various agricultural lands for the determination of major, minor, trace and heavy elements in the soil. The concentration of major element oxides (i.e., SiO_2, Al_2O_3, Fe_2O_3, MgO, CaO, Na_2O and K_2O) and minor element oxides (i.e., TiO_2, MnO, and P_2O_5) in the various types of soils of Peshawar basin are given in Tables 1-3 while the trace and heavy metals (i.e., Cu, Zn, Pb, Co, Ni and Cr) in these soil samples are given in Tables 4-6. The data have also been graphically presented in Figs. 2 and 3.

Major and Minor Element Oxides

It is clear from Tables 1-3 that the Peshawar piedmont soil has highly variable concentration of major and minor oxides both in the A and B horizons and also in the samples collected from different places. It has SiO_2 in the range of 40.78 to 58.56 wt %, TiO_2 in the range of 0.47 to 0.98 wt %, Al_2O_3 in the range of 12.60 to 28.05 %, Fe_2O_3 in the range of 2.11 to 7.11 wt %, MnO in the range of 0.03 to 0.11 wt %, MgO in the range of 0.42 to 3.48 wt %, CaO in the range of 2.12 to 13.09 wt %, Na_2O in the range of 0.22 to 2.33 wt %, K_2O in the range of 0.72 to 2.42 wt % and P_2O_5 in the range of 0.10 to 2.40 wt %. The loss on ignition (LOI) is in the range of 7.91 to 15.68 wt %.

The concentration of major and minor element oxides is also variable in Peshawar floodplain soil (Table-2). SiO_2 is ranges from 44.00 to 56.78 wt %, TiO_2 from 0.41 to 0.93 wt %, Al_2O_3 from 14.12 to 22.58 wt %, Fe_2O_3 from 4.07 to 7.04 wt %, MnO from 0.05 to 0.10 wt %, MgO from 1.18 to 3.58 wt %, CaO from 4.21 to 12.66 wt %, Na_2O from 1.30 to 2.16 wt %, K_2O from 1.64 to 2.60 wt % and P_2O_5 from 0.95 to 6.20 wt %. Loss on ignition is ranging from 7.75 to 11.86 wt %.

Variable concentrations of major and minor element oxides are also noticed in the Peshawar lacustrine soil (Table-3). This soil has SiO_2 between 45.32 to 55.12 wt %, TiO_2 between 0.03 to 0.97 wt %, Al_2O_3 between 10.89 to 23.09 wt %, Fe_2O_3 between 3.59 to 5.04 wt %, MnO between 0.08 to 0.10 wt %, MgO between 1.24 to 1.52 wt %, CaO between 7.92 to 10.56 wt %, Na_2O between 1.01 to 1.48 wt %, K_2O between 1.54 to 2.17 wt %, P_2O_5 between 0.25 to 4.65 wt % and the loss on ignition is between 12.66 to 14.78 wt %.

The average concentrations of the major and minor element oxides of the three types of soils of the Peshawar Basin have been compared among each other and also with that of the normal soil of Bohn [15] in Figure 2. It is evident from this figure that the average contents of SiO_2, TiO_2 and MnO are similar

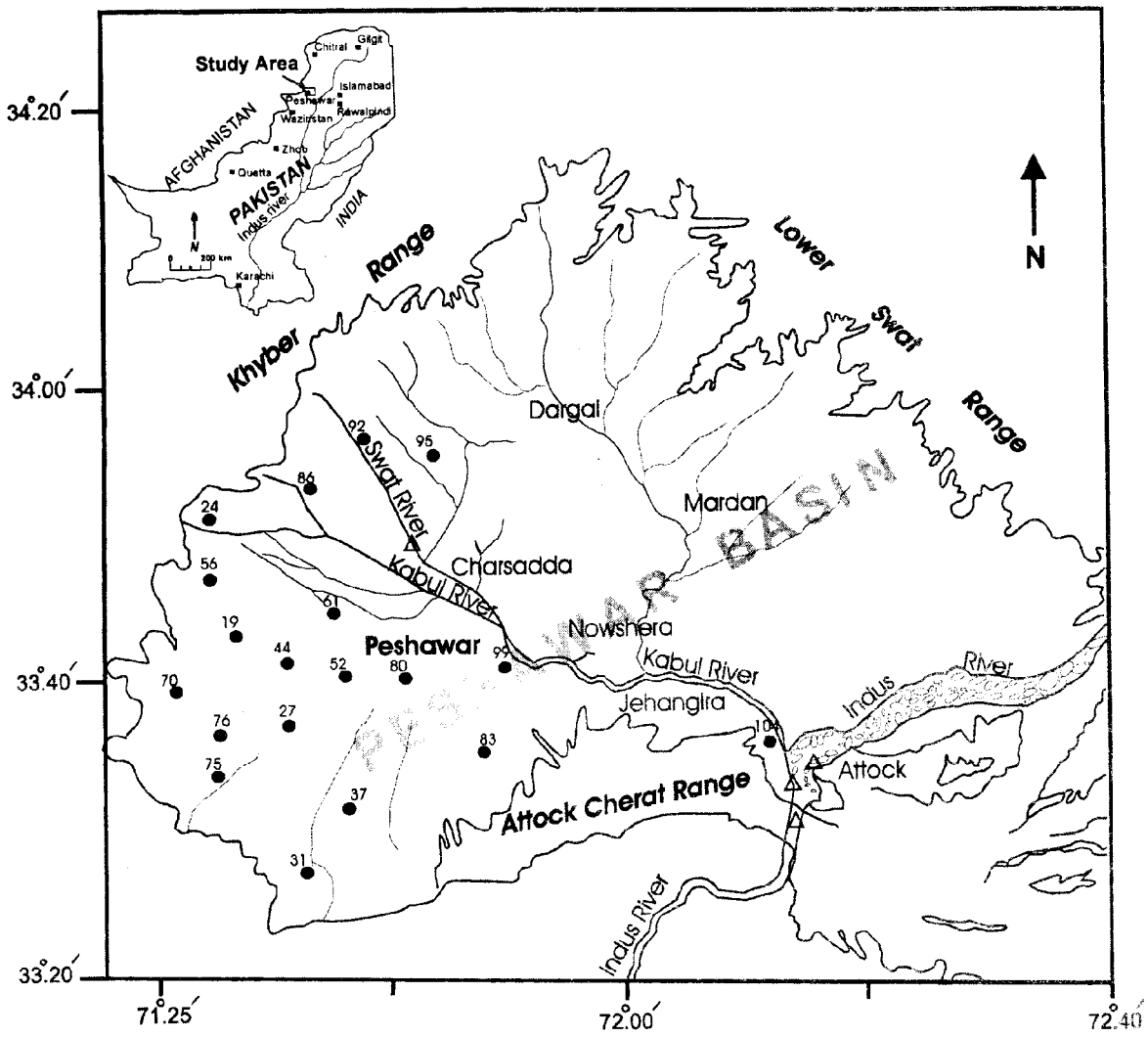

Fig 1. Map of the Peshawar basin showing the locations of soil samples.

in all the three types of soils of the Peshawar basin and are within the permissible limit for the normal soil. The Peshawar floodplain soil has relatively high Fe_2O_3, MgO, Na_2O, K_2O and P_2O_5 while Al_2O_3 and CaO are relatively high in the Peshawar piedmont and Peshawar lacustrine soils respectively (Fig. 2). However, all three types of soils of Peshawar basin have Al_2O_3, MgO, CaO, Na_2O, K_2O and P_2O_5 exceeding the values for normal soil of Bohn [15].

The high MgO content (> 1.50 wt %) of the soils of the Peshawar basin (Tables 1-3) and can be attributed to sources rich in magnesium bearing minerals such as dolomite and other mafic and ultramafic rocks. Such kinds of rocks are common in the surroundings of Peshawar basin and also along the course of Indus, Kabul and Swat rivers which are responsible for the deposition of magnesium rich Quaternary strata in the basin. The very high concentration of CaO (> 2.50 wt %) in the basin (Tables 1-3) can be due to the deposition of calichi ($CaCO_3$) which has been reported in many areas of the basin and could have been caused by water-logging and salinity. It is precipitated at higher levels due to rise and fall of water table. The samples having high concentration of Na_2O (> 1.50 wt %) can

Table-1: Major element oxides (in wt %) in the Peshawar piedmont soil.

	Kafir Dheri		W. Colony		Jamrud Road		Hyatabad P3		Ser Band		Shabqadar	
	19A	19B	24A	24B	70A	70B	75A	75B	76A	76B	86A	86B
SiO_2	47.56	50.45	54.23	56.45	50.38	56.34	46.67	47.34	48.57	47.85	51.34	50.00
TiO	0.72	0.98	0.90	0.67	0.62	0.59	0.47	0.79	0.98	0.89	0.74	0.98
Al_2O_3	28.05	25.97	19.56	18.79	21.39	22.89	16.78	16.45	16.60	18.46	18.67	23.23
Fe_2O_3	4.47	4.86	3.72	2.13	4.22	2.11	3.07	3.25	4.52	4.45	6.65	7.11
MnO	0.11	0.10	0.10	0.04	0.07	0.03	0.10	0.08	0.09	0.09	0.08	0.09
MgO	1.33	1.15	1.09	1.16	1.59	0.42	0.95	0.96	1.41	1.65	3.38	3.48
CaO	2.12	4.68	5.24	4.78	6.33	3.23	13.09	12.43	8.87	8.20	5.21	2.99
Na_2O	1.62	1.30	2.19	0.72	0.93	0.22	1.38	0.77	1.03	1.09	1.72	1.72
K_2O	2.42	2.30	1.88	1.23	2.36	0.72	1.46	1.55	1.97	1.96	1.79	1.82
P_2O_5	0.10	0.10	0.13	1.75	0.30	0.15	0.80	0.45	2.40	1.75	1.40	0.18
LOI	8.71	7.91	9.21	9.34	11.71	12.73	13.79	15.68	15.56	14.73	9.53	8.02
Total	97.21	99.80	98.25	97.06	99.90	99.43	98.56	99.75	102.00	101.12	100.51	99.62

	Derwazgai		Talla Band		Speen Khak		Khairabad		
	31A	31B	37A	37B	83A	83B	104A	104B	Average
SiO_2	47.02	47.45	56.23	52.99	50.34	40.78	56.34	58.56	50.84
TiO	0.86	0.73	0.71	0.85	0.72	0.76	0.69	0.54	0.76
Al_2O_3	22.29	17.55	12.60	14.03	13.12	21.89	16.34	16.02	19.03
Fe_2O_3	3.79	4.20	2.60	4.03	3.63	3.45	3.45	3.65	3.97
MnO	0.09	0.09	0.09	0.08	0.08	0.08	0.09	0.09	0.08
MgO	1.32	1.62	1.18	1.21	1.32	1.35	2.26	2.22	1.55
CaO	8.07	9.73	8.06	9.42	11.66	12.74	5.49	5.24	7.38
Na_2O	1.38	1.45	1.39	1.09	1.35	1.36	2.33	2.02	1.35
K_2O	2.06	1.94	1.38	1.72	1.78	1.55	2.08	2.02	1.80
P_2O_5	1.80	2.10	1.10	0.40	0.75	1.25	0.90	0.75	0.92
LOI	12.68	14.62	14.49	14.22	14.63	14.28	10.12	9.34	12.07
Total	101.36	101.48	99.83	100.04	99.38	99.49	100.08	100.45	99.76

Table-2: Major element oxides (in wt %) in the Peshawar floodplain soil.

	Mathra		Khazana		MandzaiSirk		Taranzai		Aman Kot		
	56A	56B	61A	61B	92A	92B	95A	95B	99A	99B	Average
SiO_2	55.67	54.86	55.23	56.78	47.70	50.12	47.23	44.00	44.12	45.12	50.08
TiO	0.63	0.86	0.41	0.83	0.81	0.93	0.80	0.52	0.43	0.62	0.68
Al_2O_3	18.45	19.12	18.12	18.12	22.58	19.45	16.23	20.18	14.34	14.12	18.07
Fe_2O_3	4.29	4.56	4.07	4.18	7.04	6.86	5.42	5.58	4.90	5.33	5.22
MnO	0.10	0.08	0.09	0.08	0.06	0.05	0.08	0.09	0.09	0.08	0.08
MgO	1.19	1.18	1.36	1.28	3.52	3.40	3.58	3.21	3.52	3.25	2.55
CaO	4.39	4.21	6.57	5.89	4.79	4.21	11.40	10.10	12.66	11.26	7.55
Na_2O	1.87	1.26	2.00	1.95	2.16	2.06	1.60	1.42	1.30	1.42	1.70
K_2O	2.60	2.23	2.18	2.21	1.78	1.73	2.03	2.14	1.64	1.76	2.03
P_2O_5	0.95	3.65	1.90	2.15	3.15	4.15	2.60	1.95	6.20	6.12	3.28
LOI	8.06	9.40	10.37	9.00	7.75	6.60	10.95	11.86	11.60	10.54	9.61
Total	98.20	101.41	102.30	102.47	101.34	99.56	101.93	101.05	100.80	99.62	100.87

Table-3: Major element oxides (in wt %) in the Peshawar lacustrine soil.

	Bazid Khel		Landi Arbab		Pando		Urmar Payan		
	27A	27B	44A	44B	52A	52B	80A	80B	Average
SiO_2	46.34	45.53	52.57	54.79	55.12	52.89	45.32	49.02	50.20
TiO	0.67	0.97	0.40	0.85	0.03	0.86	0.52	0.79	0.64
Al_2O_3	23.09	20.12	13.56	10.89	12.74	13.57	15.13	15.34	15.56
Fe_2O_3	4.38	4.91	4.27	5.04	4.68	4.61	3.77	3.59	4.41
MnO	0.09	0.10	0.09	0.10	0.09	0.09	0.08	0.08	0.09
MgO	1.47	1.35	1.45	1.39	1.37	1.36	1.24	1.52	1.39
CaO	9.02	8.58	8.95	8.88	7.92	8.49	9.44	10.56	8.98
Na_2O	1.21	1.06	1.23	1.13	1.01	1.08	1.64	1.48	1.23
K_2O	1.89	2.00	2.11	1.97	2.17	1.99	1.76	1.54	1.93
P_2O_5	4.15	0.25	2.30	1.90	1.95	4.65	2.30	2.20	2.46
LOI	12.68	14.62	14.49	14.22	14.63	14.28	12.66	14.78	14.05
Total	104.99	99.49	101.42	101.16	101.71	103.87	93.86	100.90	100.93

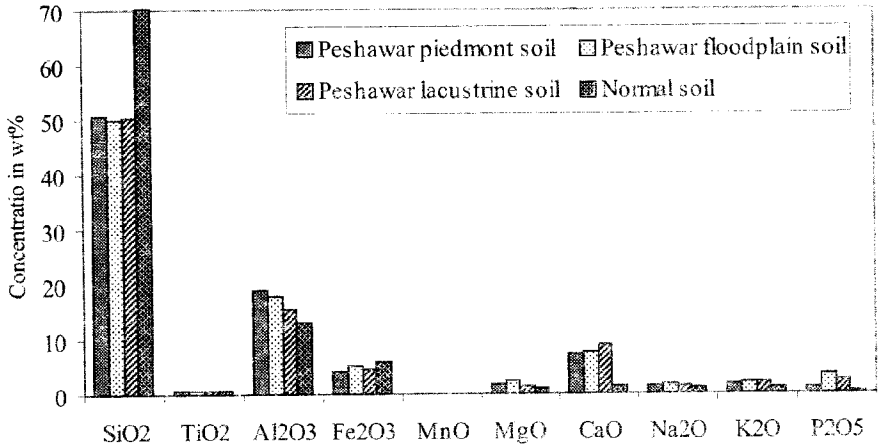

Fig 2: Comparison of major and minor element oxides among the soils of Peshawar basin and with those of the normal soil.

also be attributed to the water-logging and salinity in many parts of the basin. The high concentration of P_2O_5 in the majority of the soil samples (Tables 1-3) of the basin can be attributed to the individual or combined effect of erosion of alkaline rocks in the surroundings of Peshawar basin and or the excessive use of fertilizers.

Trace and Heavy Metals

Trace and heavy metals data in the Tables 4-6 showed that the soils of the Peshawar basin have variable concentration in both the horizons (A and B) and also in the soils of different localities. The soil of Peshawar piedmont has Cu in the range of 50 to 695 mg/ kg, Zn in the range of 45 to 575 mg/ kg, Pb in the range of < 0.5 to 360 mg/ kg, Ni in the range of < 0.5 to 360 mg/ kg, Cr in the range of < 0.5 to 485 mg/ kg and Co is below the detection limit (Table-4). In the Peshawar floodplain soil of various localities, Cu ranges from 55 to 540 mg/kg, Zn from 65 to 200 mg/ kg, Pb from < 0.5 to 485 mg/ kg, Ni from < 0.5 to 300 mg/ kg, Cr from < 0.5 to 620mg/ kg and Co is below the detection limit (Table-5). The Peshawar lacustrine soil has Cu from 35 to 120 mg/ kg, Zn from 80 to 160 mg/ kg, Pb from < 0.5 to 190 mg/ kg, Ni from < 0.5 to 200 mg/ kg, Cr from < 0.5 to 155 mg/ kg and Co is below detection limit (Table-6).

The average concentration of trace and heavy metals of three types of soils of the basin have been compared with each other and also with those of the normal soil of Bohn [15] in Fig. 3 The Peshawar flood plain soil has a relatively high concentration of Cu (327 mg/ kg), Pb (187 mg/ kg), Ni (143 mg/ kg) and Cr (273 mg/ kg), while Zn is relatively high (295 mg/ kg) in the Peshawar piedmont soil. It is also evident from the Figure 3 that all the trace and heavy metals, except Co, exceed those of the normal soil. Therefore, the effects of these metals on ecosystem of this region of the province need to be further investigated. The high concentration of Cu, Cr, and Ni can be attributed to the rocks of the Dargai ultramafic complex exposed along the north and north-western parts of Peshawar basin.

Copper is an essential element for normal plant nutrition [16]. Its concentration of 5 to 20 mg/ kg in plant tissue is adequate for normal growth while less than 4mg/ kg is considered deficient and more than 20 mg/ kg is considered toxic [16, 17]. Absorption rate of Cu by plant roots is relatively low and a linear relationship exists between the absorption rate and the Cu concentration in the soil [18]. Though the Cu concentration of soils of the Peshawar basin is higher than that of the normal soil (~20 mg/ kg) but the occurrence of very high concentration (> 400 mg/ kg) of Cu in the soils of Shabqadar and Khairabad areas of Peshawar piedmont (Table-4) and the Mandzai Sirk, Taranzai and Amankot areas of Peshawar floodplain (Table-5) can be considered hazardous as far as the Cu-toxicity is concerned.

Zinc is very important element as far as the plant nutrition is concerned because it is involved in the number of metallo-enzymes which are essential for the stability of cytoplasmic ribosomes [16, 19]. Its

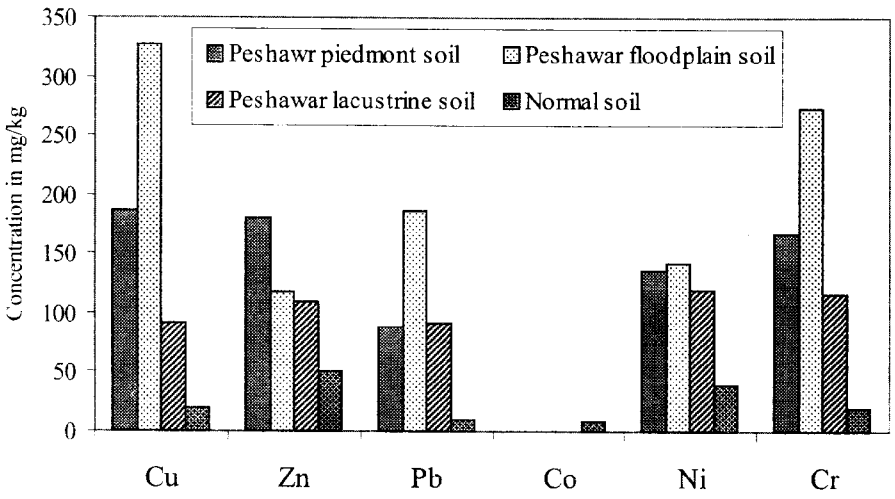

Fig. 3: Comparison of trace and heavy metals among the soils of Peshawar basin and with those of the normal soil.

Table-4: Trace and heavy metals (in mg/ kg) in the Peshawar piedmont soil.

	Kafir Dheri		W. Colony		Jamrud Road		Hyatabad P3		Ser Band		Shabqadar	
	19A	19B	24A	24B	70A	70B	75A	75B	76A	76B	86A	86B
Cu	135	105	75	85	65	70	120	70	110	55	575	695
Zn	260	105	80	80	105	45	165	45	120	130	256	255
Pb	60	105	45	20	30	35	55	35	<0.5	<0.5	360	195
Co	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ni	<0.5	<0.5	15	25	130	105	220	105	<0.5	155	140	175
Cr	90	135	80	25	110	20	<0.5	20	110	<0.5	315	570

	Darwazgai		Talla Band		Speen Khak		Khairabad		
	31A	31B	37A	37B	83A	83B	104A	104B	Average
Cu	90	50	100	110	65	55	595	510	187
Zn	260	80	75	105	390	315	145	575	180
Pb	105	<0.5	105	90	45	<0.5	25	95	88
Co	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ni	<0.5	195	<0.5	100	145	360	90	75	136
Cr	<0.5	155	70	60	100	<0.5	320	485	167

Table-5: Trace and heavy metals (in mg/ kg) in the Peshawar floodplain soil.

	Methera		Khazana		Mandzai Sirk		Taranzai		Aman Kot		
	56A	56B	61A	61B	92A	92B	95A	95B	99A	99B	Average
Cu	80	130	75	55	500	465	500	435	485	540	327
Zn	115	100	155	65	200	120	90	100	110	120	118
Pb	185	45	5	90	395	485	280	255	70	55	187
Co	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ni	70	<0.5	125	300	130	125	110	120	170	135	143
Cr	65	20	<0.5	<0.5	315	415	260	195	620	290	273

Table-6: Trace and heavy metals (in mg/ kg) in the Peshawar lacustrine soil.

	Bazid Khel		Landi Arbab		Phando		Urmar Payan		
	27A	27B	44A	44B	52A	52B	80A	80B	Average
Cu	95	120	100	35	130	100	55	95	91
Zn	110	140	160	105	100	100	80	80	109
Pb	<0.5	<0.5	190	45	90	<0.5	40	<0.5	91
Co	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ni	135	200	35	35	<0.5	130	195	105	119
Cr	100	<0.5	155	155	70	100	<0.5	<0.5	116

deficiency affects the nutritional quality of plant but its high concentration causes toxic effects in the plants [16-17]. It is evident from the Tables 4-6 that the Zn contents in majority of the soil samples of Peshawar basin exceed that of the normal soil (~50 mg/ kg). However, relatively high concentration (> 200 mg/ kg) of Zn is present in the soil of Kafir Dheri, Shabqadar, Derwazgai, Speen Khak and Khairabad areas of the Peshawar piedmont and the Mandzai Sirk area of the Peshawar floodplain (Table-5). Therefore, the Zn concentration in the soils of these areas can be considered hazardous for plants kingdom.

Lead uptake in the plant and distribution among the roots, stems and leaves is highly variable and it is mostly concentrated in the roots [16, 20]. However, the phytotoxicity of lead is low as compare to the other trace elements [16, 21]. It is clear in Tables 4-6 that the Pb concentration in most of the soil samples of all three types of soil is many-fold higher than that of the normal soil (~10 mg/ kg). However, soils of Shabqadar and Mathra areas of the Peshawar piedmont (Table 4), the Mandzai Sirk, and Taranzai areas of Peshawar floodplain (Table-5) and the Landi Arbab area of Peshawar lecastrine (Table-6) have very high concentrations (>150 mg/ kg) of Pb which could be hazardous to the ecosystem of the area.

Nickel is a normal constituent of plant tissues and if present in permissible amount, its beneficial effects on plant growth are reported. However, its high concentration in the plants produces toxicity symptoms but the severity of toxicity varies with the plants species [16, 22]. Ni concentration of the soil of the Peshawar basin in Tables 4-6 indicates that most of the soil samples have high concentration of Ni as compare to that of the normal soil (~ 40 mg/ kg). However, very high concentration of Ni (> 200 mg/ kg) in the soils of Hayatabad Phase 3 and Speen Khak area in Peshawar piedmont (Table-4), Khazan area in the Peshawar floodplain (Table-5) and Bazid Khel area in the Peshawar lacustrine (Table-6) have alarming Ni concentration as far as the availability of Ni in soil for absorption by plants kingdom is concerned.

Chromium has stimulatory effects on plant growth [23]. The Cr toxicity in plants from the soil is not known, except possibly in soils derived from ultramafic rocks [16]. It is clear from Tables 4-6 that the concentration of Cr in majority of the soil samples of the Peshawar basin exceeds that of the normal soil (~ 20 mg/kg). Very high concentrations of Cr are found in the soil of Shabqadar (315-570 mg/ kg) and Khairabad (320-485 mg/ kg) in the Peshawar piedmont (Table-4) and Aman Kot (290-620 mg/ kg) in the Peshawar floodplain (Table-5) which could be considered hazardous for the ecosystem of the area.

Experimental

Sampling

Two representative core samples of soil from each agricultural land at various locations, as shown in Fig. 1, were taken up to a depth of 20cm and from 20 to 40 cm at each spot and are named as samples of horizon A and B respectively. The samples were stored in the polyethylene bags and were transferred to the Geochemistry laboratory of the National centre of Excellence in Geology, University of Peshawar for further chemical analyses.

Analytical Procedure

The soil samples were, collected during field, were dried in air and then pulverized to 100 mesh size in the ball-mill. About 50g powder of each soil sample was selected after quartering and coning technique. The samples were then dried overnight in the oven at 110 °C for further analyses.

Major Element Oxides

Two types of stock solutions (A and B) were prepared for the major element oxides. Stock solution A was prepared by mixing 0.05g of soil powder with NaOH in the nickel crucible and was fused on burner at high temperature for five minutes. The crucible was cooled to get the fusion cake. The fusion cake was then dissolved with 10 N HCl and a final solution of 1000 ml was made with de-ionized water. This solution was used for the determination of SiO_2 by the method of ammonium molybdate and Al_2O_3 by the method of 8-hydoxyquinoline by using the Pye-Unicam UV/ visible spectrophotomer [24]. Stock solution B was prepared by decomposing 0.5 g of powder soil sample in hydrofluoric-perchloric acids mixture and final dissolution to 250ml with de-ionized water [24]. This solution was used for the determination of Fe_2O_3, MgO, CaO, Na_2O and K_2O by using the Perkin Elmer atomic absorption spectro-photometer. The loss on ignition, mainly due to

decomposition carbonates and organic phases, was determined by heating about 2.00 g of powder soil sample in the porcelain crucible at 950 °C in the muffle furnace for four hours and the weight difference was calculated as loss on ignition.

Trace and Heavy Metals

About 1.00g of the soil powder sample was taken in the teffelon beaker. About 5 ml of hydro-fluoric acid was added to it and then heated for half an hour and then about 15ml of equa regia was added and heated on low heat until final paste was obtained. The contents of the beaker were dissolved by the 2N HCl and then filtered through the whatman (No. 42) filter paper and the final solution was made to 25ml. This solution was used for the determination of Cu, Zn, Pb, Co, Ni and Cr by using the Perkin Elmer atomic absorption spectrophotometer under standardizing conditions.

Conclusions

Various major and minor oxides (i.e., Al_2O_3, MgO, CaO, Na_2O, K_2O and P_2O_5) and the trace and heavy metals (i.e., Cu, Zn, Pb, Ni and Cr) in the soils of Peshawar basin exceed those of normal soil. The heavy and trace elements in the soils of certain areas are present in toxic level and can have environmental effects on the ecosystem of these areas of the basin.

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