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Heavy metals pollution in soils of Peshawar city, NWFP, Pakistan

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ABSTRACT: *Soil samples from 10 locations in Peshawar city have been analyzed for heavy metals including Cr, Co, Ni, Cu, Zn, Fe and Pb in order to evaluate the impact of heavy metals pollution reported earlier in the air, surface clay and sewerage system of Peshawar city by Hamidullah et al., (1997). It is concluded that heavy metals found in the dust fall of the city on the roadsides have so far not reached the soil horizon. The relative enriched Cr in the soils compared to the heavy metals data of the corresponding air samples, reported earlier, has been attributed to the source material including the rock of the Main Mantle Thrust and Kohistan Island Arc. Highier Fe in these soils has been attributed to the process of soil formation. It has been warned that though heavy metals do not directly percolate into the soil horizon within the city at an alarming rate, these metals make their way from surface through the sewerage system of the city and via Budni Canal to Kabul River which is the feeder of the underground water system in Peshawar Basin. The indirect potential threat of heavy metals pollution to the subsurface strata of the basin does exist and needs to be blocked.*

INTRODUCTION

Trace elements are found at levels of <0.1% in lithosphere and are other than the eight abundant rock-forming elements i.e., O, Si, Al, Fe, Ca, Na, K and Mg. Trace elements are present in plant or animal tissue in concentration <0.01% of the organism (Adriano, 1986). Trace metals are essential for human, animal and plant nutrition in trace amount but can become poisonous or toxic when their concentrations exceed the beneficial limit. Heavy metals are defined as metals which react readily with dithizone (C_6H_6N) and have densities at least five times greater than water, e.g. Cr, Co, Ni, Cu, Fe, Pb, Zn, Sb, (Bates & Jackson, 1987). In lithosphere, except Fe most of the heavy metals can be classified as trace elements. (Forester & Wittmann, 1979). Soils are derived from rocks and contain a considerable portion of the organic matter derived from plants and animals. Soils may contain heavy metals proportionate to their sources. The higher their concentration in the source rock, the higher they may be present in the derived soils. However, heavy metals may get enriched or depleted in particular soils with respect to the source rock according to the process involved in soil formation. From the soil once in the food chain, heavy metals may concentrate in humans and in other organisms and their excess may become ultimately toxic for the hosts. In order to classify the soils of a particular area as free of hazardous amounts of heavy metals a comparison with normal soils of the world may be regarded very useful.

Peshawar city, the metropolis capital of the NWFP is an overpopulated, over congested, and polluted city. Smokes, dusts and heavy metals fly in the air of Peshawar at highly alarming rates. We have already reported extensive heavy metals pollution in the air, sewerage and on ground surface of both Peshawar city and Peshawar cantonment

areas (Hamidullah et al., 1997; Hamidullah et al., 1998) and have pointed out possible sources of heavy metals among the local industry, metal businesses, workshops, rusted vehicles, bridges, metal fences and old demolishing buildings. We also carried a concern if these metals may have percolated from surface to subsurface polluting the soils and underground water of the city. In addition the soils of the Peshawar basin may have derived partly from the nearby geological source of the Main Mantle Thrust (MMT) and Kohistan Island Arc (KIA) generally rich in chromium, lead, zinc and several other metals (Hamidullah & Onstot, 1992). As a result the soils themselves may be serving as a source of heavy metals to the air and water systems of the Peshawar. In order to find answers to these questions, soil samples were collected from Peshawar city to analyze them for heavy metals, compare them with normal soils of the world and find out if these soils are the sources and/or recipient of the heavy metals noticed in the air of Peshawar city by Hamidullah et al. (1997).

ANALYTICAL TECHNIQUES

Ten soil core samples at a depth of about 2 feet each were collected along roadside in different parts of Peshawar city (Fig.1). The samples were dried in oven at 110°C over night and were thus pulverized to 200-mesh size. About 2 gram of each sample was weighed in porcelain crucible and all the samples were ignited at 950°C for about 4 hours. The ignited samples were kept in glass bottles for the determination of heavy metals.

A known weight (~0.5 gm) of all the ignited samples were taken in cleaned test tubes. 10 ml of aqua regia was added to each test tube. These test tubes were placed in a beaker half filled with water and heated on water bath for about two hours. The solutions were filtered through Whatman No. 42 filter paper and the filtrate of each sample was diluted to 30 ml with deionized water. Using an SP 191 PYE UNICAM Atomic Absorption Spectrophotometer at the geochemistry laboratory of the National Center of Excellence in Geology, University of Peshawar the heavy metals of interest including chromium (Cr), cobalt (Co), nickel (Ni), (Cu), zinc (Zn), iron (Fe) and lead (Pb) were determined in these solution. For maintaining the accuracy of the method international standards BCR1, G2 and AGV1 were used. The heavy metals concentration obtained in the soils are shown in Table 1..

TABLE 1. HEAVY METALS CONTENTS OF THE SOILS FROM VARIOUS LOCATIONS OF PESHAWAR CITY

Sample Locations	Cr	Co	Ni	Cu	Zn	Fe	Pb
Shami Road	10	04	12	13	28	8000	03
Bacha Khan Chowk	12	02	16	18	25	9000	07
Firdous Chowk	12	05	18	15	30	10000	08
General Bus Stand	13	03	12	16	26	10056	10
Thana Gul Bahar Chowk	19	02	14	14	24	1027	08
Assembly Chowk	17	04	17	17	28	9080	09
Ganj Chowk	10	03	18	16	22	9014	08
Thana Yakka Toot Chowk	10	05	16	14	20	9060	04
Dabgari Chowk	15	07	17	18	26	9076	07
Civil Quarters Chowk	10	02	15	21	27	1015	06
Minimum Limit	05	00	20	20	10	5000	05
Maximum Limit	1000	1000	30	40	300	50000	25

RESULTS

The values of the analyzed Cr, Co, Ni, Cu, Zn, Fe and Pb in soils from different locations in Peshawar city are compared with the recommended international values of all such metals in various soils of the world given by different scientists (Fig. 2a-g). It is noteworthy to state that all the metals in all the samples from Peshawar city fall with in the ranges of normal soils of the world shown for each metal on the plots. Some values plot even below the minimum limit (e.g Ni at all locations, Cu at Shami Road and several other locations etc.).

The heavy metals data of the soils were also compared with concentrations of these metals in the air samples at nose level and ground position and in surface clays over the same locations obtained by Hamidullah et al. (1997; Fig.3a-g). Cr is higher than the corresponding nose and ground level concentrations at all localities (Fig. 3a). At

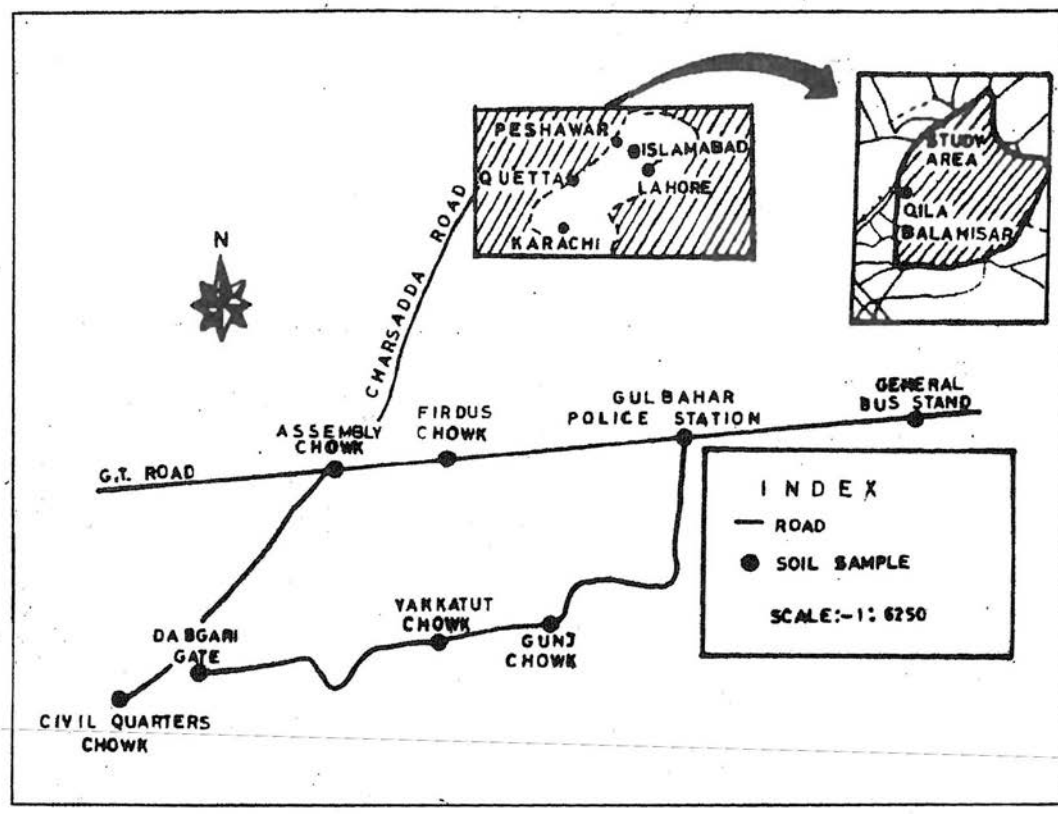
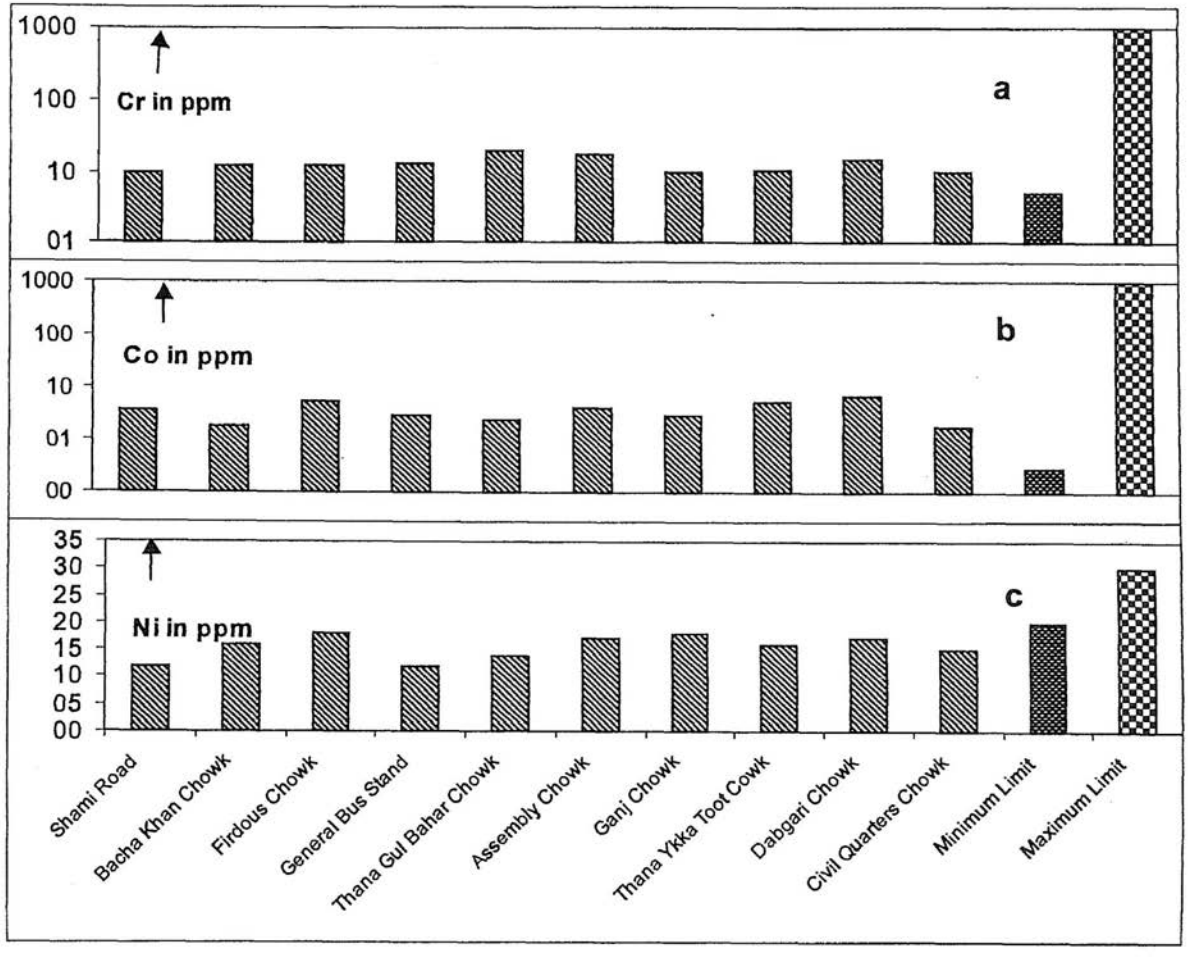


Fig. 1. Locations of the collected samples on the city sketch map.


1000
100
10
01
Cr in ppm
a
1000
100
10
01
00
Co in ppm
b
35
30
25
20
15
10
05
00
Ni in ppm
c
Shami Road
Bacha Khan Chowk
Firdous Chowk
General Bus Stand
Thana Gul Bahar Chowk
Assembly Chowk
Ganj Chowk
Thana Ykka Toot Cowk
Dabgari Chowk
Civil Quarters Chowk
Minimum Limit
Maximum Limit

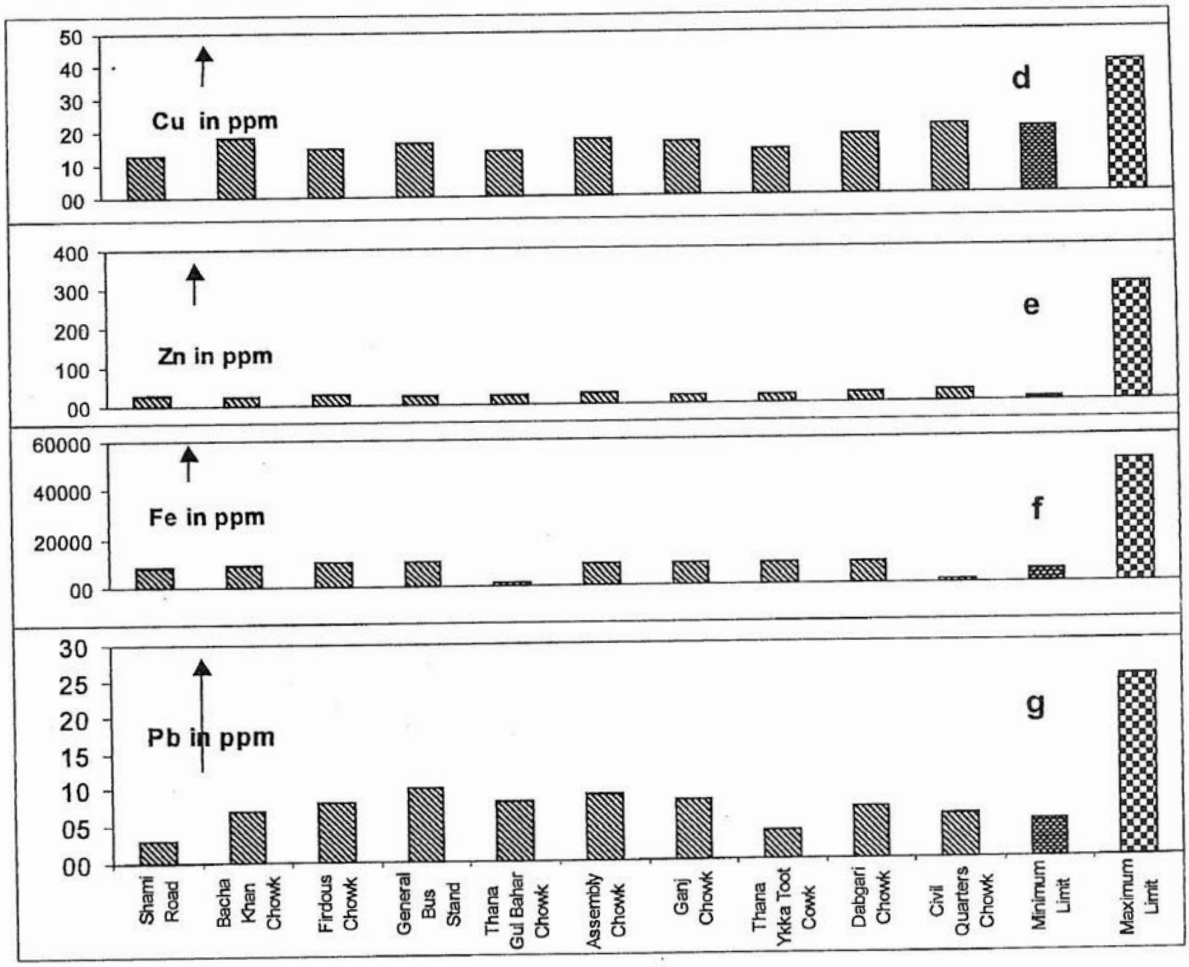
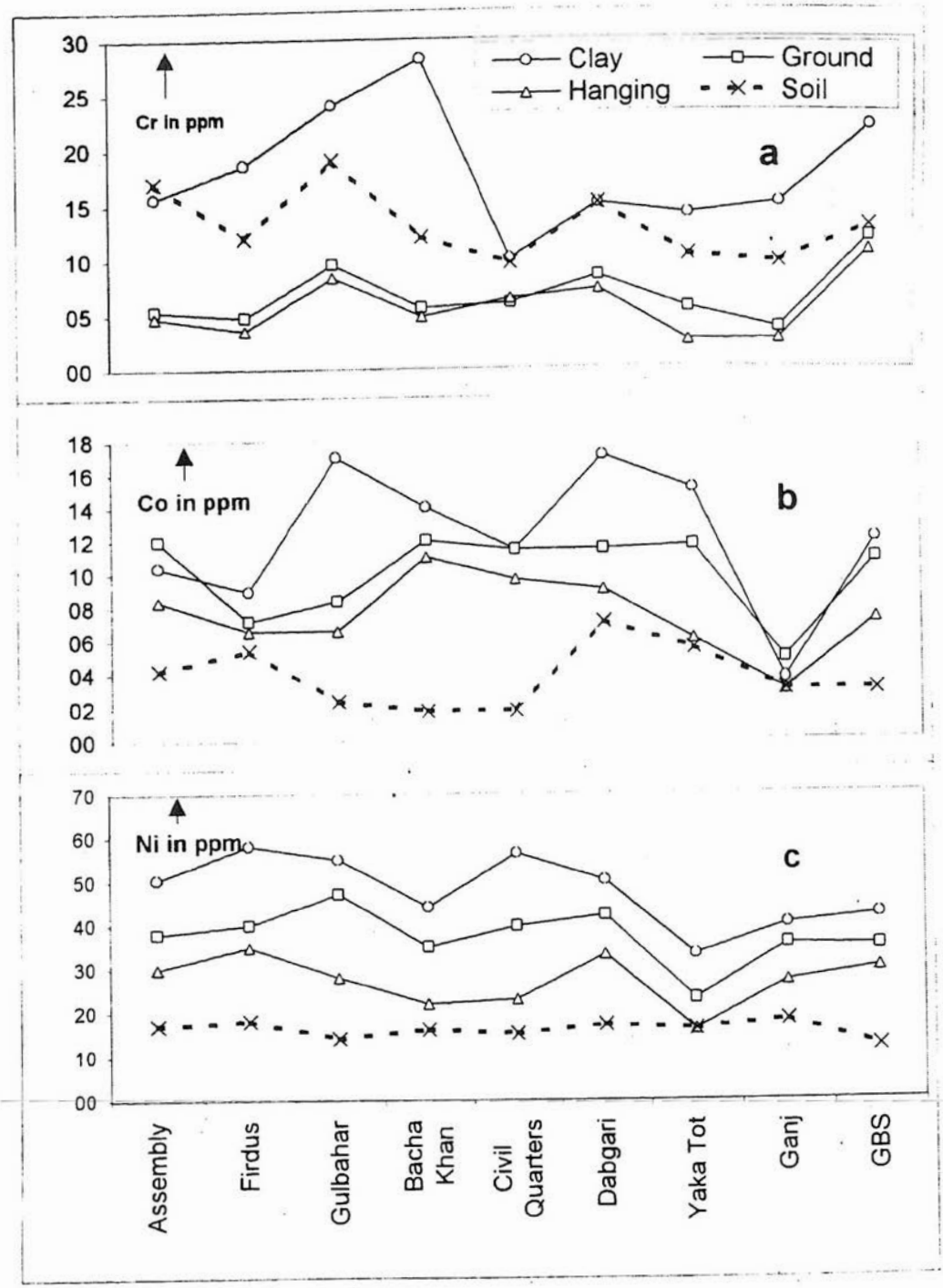


Fig.2a-g. Bar diagrams of the heavy metals concentrations in various soils of Peshawar city. The minimum and maximum limits of these metals in soil are after Adriano (1986), Aubert & Pinta (1977), Forstner & Wittaman (1979), NAS (1974), Nriagu (1978) and Saifullah (1976).


Clay
Ground
Hanging
Soil
Cr in ppm
a
30
25
20
15
10
05
00
Co in ppm
b
18
16
14
12
10
08
06
04
02
00
Ni in ppm
c
70
60
50
40
30
20
10
00
Assembly
Firdus
Gulbahar
Bacha Khan
Civil Quarters
Dabgari
Yaka Tot
Ganj
GBS

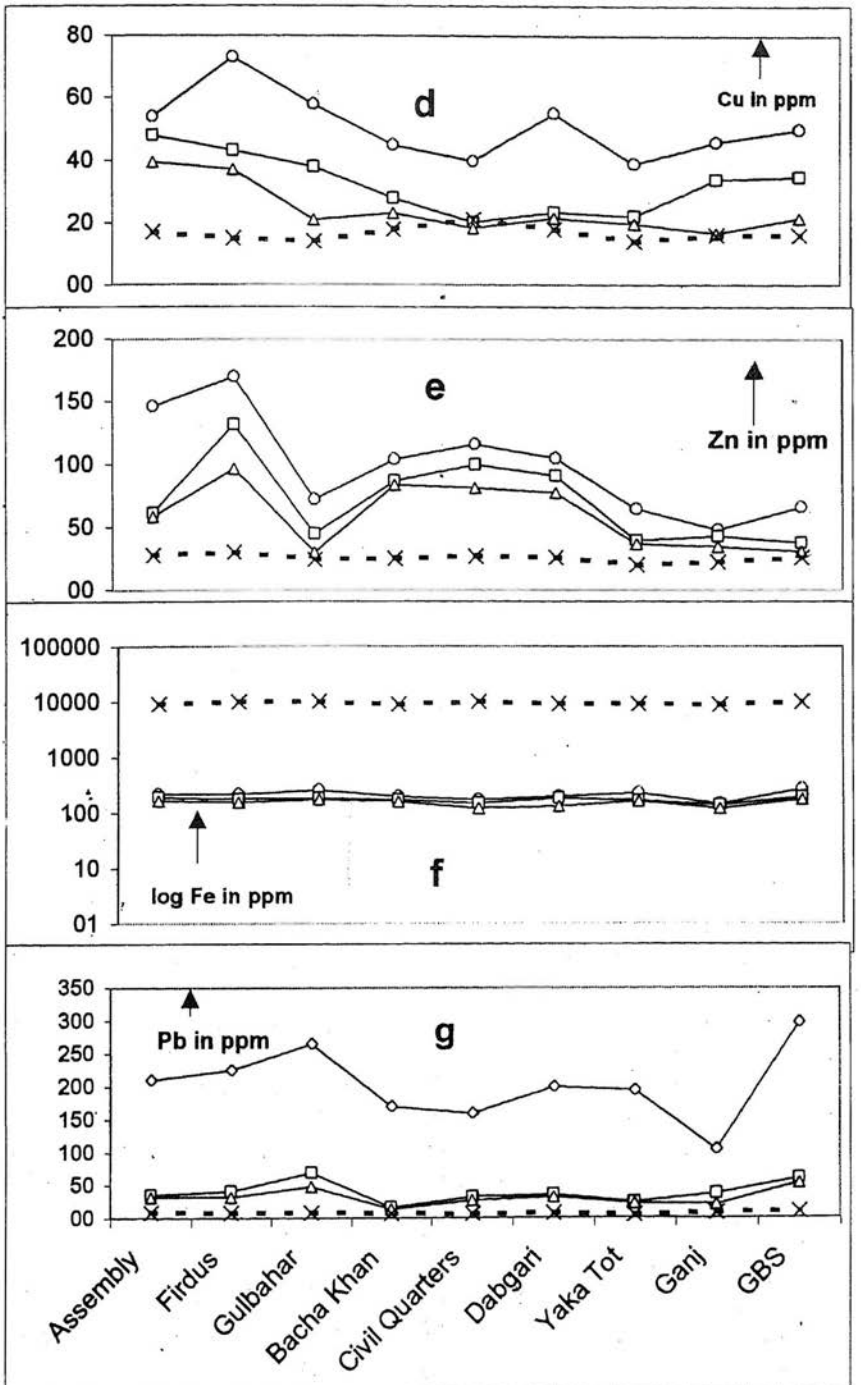


Fig. 3a-g.Comparison of the heavy metals patterns of the soils from various locations of Peshawar city with the patterns of these metals in the air and clays from the same locations.

assembly Chowk it is slightly higher than the corresponding clay sample whereas at Civil Quarters and Dabgari it is more or less similar to Cr in clays at these localities. At the rest of the places Cr contents are lower than those of the corresponding clays. It is interesting to note that the general pattern of Cr in soils at various localities is similar to that of the clays as well as to those of the nose level and ground level Cr concentrations at these localities. On the other hand, Co in soils under investigation is lower at all localities than the corresponding clays and the nose level and ground level air samples. In addition, the general pattern of Co in soils also differ markedly from the other three patterns (Fig.3b). Ni, Cu, Zn and Pb show flat patterns with lower concentrations at all localities than the corresponding clays and air at nose and ground levels (Figs. 3c,d,e,g). In contrast Fe is multifold higher than the corresponding clays and air at nose and ground levels at all locations indicating its steady increase during the process of soil formation ((Fig. 3f; also see Brownlow, 1979).

DISCUSSION AND CONCLUSIONS

The data obtained for the soils of Peshawar city indicates that their heavy metals contents are within the normal ranges defined for soils from other parts of the world. On comparison with the air and clay patterns, Cr is the only metals that shows values higher than those of the nose and ground level air samples but generally lower than the clay samples. This feature may be attributed to the occurrence of high Cr in the sources of the soils including the chromitites deposits of the MMT (Tahirkheli, 1979) and of the KIA rocks through which River Swat and River Indus are flowing and have remained the careers of sediments for the quaternary deposits of the Peshawar Basin (see Cornwell & Hamidullah, 1992). Some chromium may have percolated from the clay and air sources on the surface, described by Hamidullah et al. (1997; Figs 3a-g), but as other metals, except Fe, are all well below the corresponding air and clay samples at all localities, the former possibility appears more likely, i.e., a Cr source in rocks of MMT and KIA.

Dust fall and the surface clays of Peshawar city have been reported to be highly enriched in heavy metals due to sources mentioned above and the normal concentration of these metals in the soils indicate that the latter have not got yet contaminated from surface sources existing on the roads of the city. This is probably because most of the heavy metals on the surface get washed out with wind and surface runoff to the sewerage system of the city and ultimately to Budni Canal and Kabul river (Shahalam branch; see Hamidullah et al., 1997). Therefore the heavy metals though pose a potential threat to the soils and the underground waters of Peshawar city in the long run, currently they have not contaminated the subsurface strata. However, Kabul River acts as a feeder to the ground water system of Peshawar basin and any contamination of this river may be considered as a potential threat to the aquifer in the surrounding areas and thus to the food chain of the living organisms including human beings and animals in the region (see Tariq, 2001). Further detailed work on the surface and underground water and soils of the basin has been carried out and will be published soon (Tariq, 2001).

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