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Heavy metal pollution in the western part of Peshawar metropolis, north Pakistan

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ABSTRACT

Peshawar is the capital of North-West-Frontier-Province (NWFP) and the largest trade centre in the northwestern part of Pakistan. Due to high rate of urbanisation and the sudden influxes of Afghan refugees in the past two decades, the city has become one of the most polluted ones in the South Central Asia. The increased load of transportation with no or limited expansion of roads, unplanned and uncontrolled industrialisation and poor sanitation have caused the atmosphere unprecedentedly overburdened with smokes and dusts of all kinds. This paper is a part of a detail study carried out to determine heavy metal concentrations in air dust, soil and sewerage of the Peshawar metropolis.

In the western part of Peshawar metropolis at 16 chowks (road crossings), air dust samples were collected at nose height and at ground positions in open buckets filled with distilled water for 48 hours. From the same locations, clay/road-mud samples were collected from solidified clay on ground surface. Similarly, soil samples were collected from non-metalled parts at 2 feet depths in subsurface from 10 locations. Correspondingly, sewerage samples were collected from sewerage water and sewerage mud. Vehicular traffic counting was carried out at each chowk for 12 peak hours. At nose height the heavy metal contents showed ppm ranges of: Cr = 0.06-3.2, Co = 0.3-2.4, Ni = 0.17-5.97, Cu = 0.88-8.8, Zn = 0.81-17, Fe = 3-57 and Pb 2-25. The heavy metals concentrations at ground positions were noticed to be higher than at the nose level. The soil samples do not show significant enrichment in heavy metals and are therefore classified as the normal soils. In sewerage water samples the heavy metals concentrations showed ppm ranges of Cr = 0.1-3.81, Co = 0-2, Ni = 0.1 -3, Cu = 0.13-3, Zn = 0.1 - 4.3, Fe = 13-99 and Pb = 1.81-10. Sewerage mud showed higher concentrations of these metals as compared to sewerage water. A systematic positive variations between the atomic masses of the metals and their concentrations was noticed in air, clay, sewerage water and sewerage mud, indicating that the higher the atomic mass, the higher was the rate of fall/deposition of that particular metal, if available. It was also noticed that compared with water, air is a finer sorting agent for heavy metals.

At each chowk, both individual metal and the total dust fall showed positive correlation with the total number of vehicles, indicating that the moving vehicular traffic is the major cause of keeping metals-loaded dust in the air. However, these vehicles may not be considered as the major source of emanating these metals from their exhausts. The study showed that the major sources of heavy metals in the western part of Peshawar metropolis are small metal shops, workshops, construction projects, rusted bridges, fences and vehicles on the roads as well as the damaged sewerage system.

INTRODUCTION

Environmental pollution is an undesirable change in physical, chemical and biological characteristics of air, land and water that may or will affect human life and other organisms. Extremely polluted air can cause illness and even death where as polluted water can kill marine life. Soil pollution can effect the normal growth of plants and crops and can contaminate surface and subsurface water. So, air and water pollution makes life vulnerable in the atmosphere and hydrosphere, respectively, while soil pollution reduces the amount of land for cultivation and habitation (Mackenzie, 1975; Srivastava, 1994).

Currently environmental pollution may be attributed largely to the abuse of natural resources mainly for industrial development. The global atmosphere and hydrosphere are continuously intoxicated by the incorporation of poisonous gases, noise, heat, industrial effluents and different types of garbage. Heavy and trace metals are one of the environmental toxins released by metal-based industries, metal-using projects and the vehicular traffic. These metals cause several carcinogenic impacts and other impairments both in animals and plants. Trace metals are those present in very low concentration in human body where as heavy metals are referred to those metals whose densities are at least 5 times greater than that of water (e.g. chromium, cobalt, cadmium, mercury). Some of the metals are essential for good health (e.g. copper and zinc) but their deficiency or over-dosage may cause defects or intoxication. Toxic metals are all those metals whose concentration in the environment is now considered to be harmful (IARC, 1976; Montgomery, 1992; Baranowska, 1993).

Pakistan is one of the developing countries where industries population and unplanned urbanisation are growing up at fast rate. This has resulted into high rate of deforestation and expansion of unmetalled roads, poor sewerage system, industries without treatment plants and wide-spread slums, especially in or around the major cities and industrial estates. Such a scenario is the cause of tremendous environmental pollution in air, water and soils of these areas. Both stationary and moving sources are responsible for the generation and dissemination of pollution. Stationary sources include small and large industrial plants, power generation plants, construction projects and brick kilns, etc. Mobile sources include cars, truck, rikshas, aircrafts and other run by internal combustion engines.

Peshawar is one of the major metropolises of the country and the provincial capital of NWFP. Like other big cities of Pakistan, here also environment is being polluted ruthlessly and carelessly. According to the 1981 census, Peshawar district had a population of 1,650,941 (Economic Survey, 1994-95). With a growth rate of 4.1 (Akram, 1992), the population of Peshawar must have been 3,186,908 by 1996. With extremely limited planning and program for urban development and the continuos inflow of Afghan refugees, Peshawar looks like a city of chaos and confusion covered under heavy smoke and dust during the peak business hours.

This study is a part of a large project designed to find out the levels of heavy and trace metals in the air dust, soil and sewerage at various chowks (cross roads) along Jamrud Road, Peshawar Cantonment, Peshawar City, the Budni Canal to which all the sewerage of Peshawar city is released Budni Canal is the tributary of Kabul River. This paper deals only with heavy metals study in Peshawar Cantonment and its western part along the Jamrud Road, all referred to western part of Peshawar metropolis (Fig.1).

EXPERIMENTAL WORK

Treatment of samples

Dust samples in air were collected, both at hanging and ground positions, in clean pans (diameter = 12") half filled with distilled water. At hanging positions, the pans were hanged at a height of about 5 feet, at 16 chowks in Peshawar city (Fig. 1). For ground positions the pans were placed at roadside on foot paths at the same locations. Solid vehicular emanations and other dust particles were collected for 48 hours in both types of pans. These samples were than collected in polyethylene bottles, already washed with de-ionised water. They were filtered through Whatman No. 42 filter paper and the residues collected were dried in the oven at 110^o C over night, followed by weighing them to calculate the rate of dust fall during 48 hours. Each dried residue along with filter was put in porcelain crucible and heated in a Muffle Furnace at 950°C for about 4 hours. The ignited samples were then stored in glass bottles for the determination of heavy metals.

Clay at roadside (road-mud) was collected from spots where it would be deposited for a considerable amount of time. Such spots would be considered suitable foci for the deposition of dust, particularly heavy metals; once deposited are difficult to be blown away or removed. Clay samples were collected at all 16 locations from where the air samples were also collected. A known quantity (about 2 gm) of samples were ignited in the Muffle furnace at 1000°C. The ignited samples were then

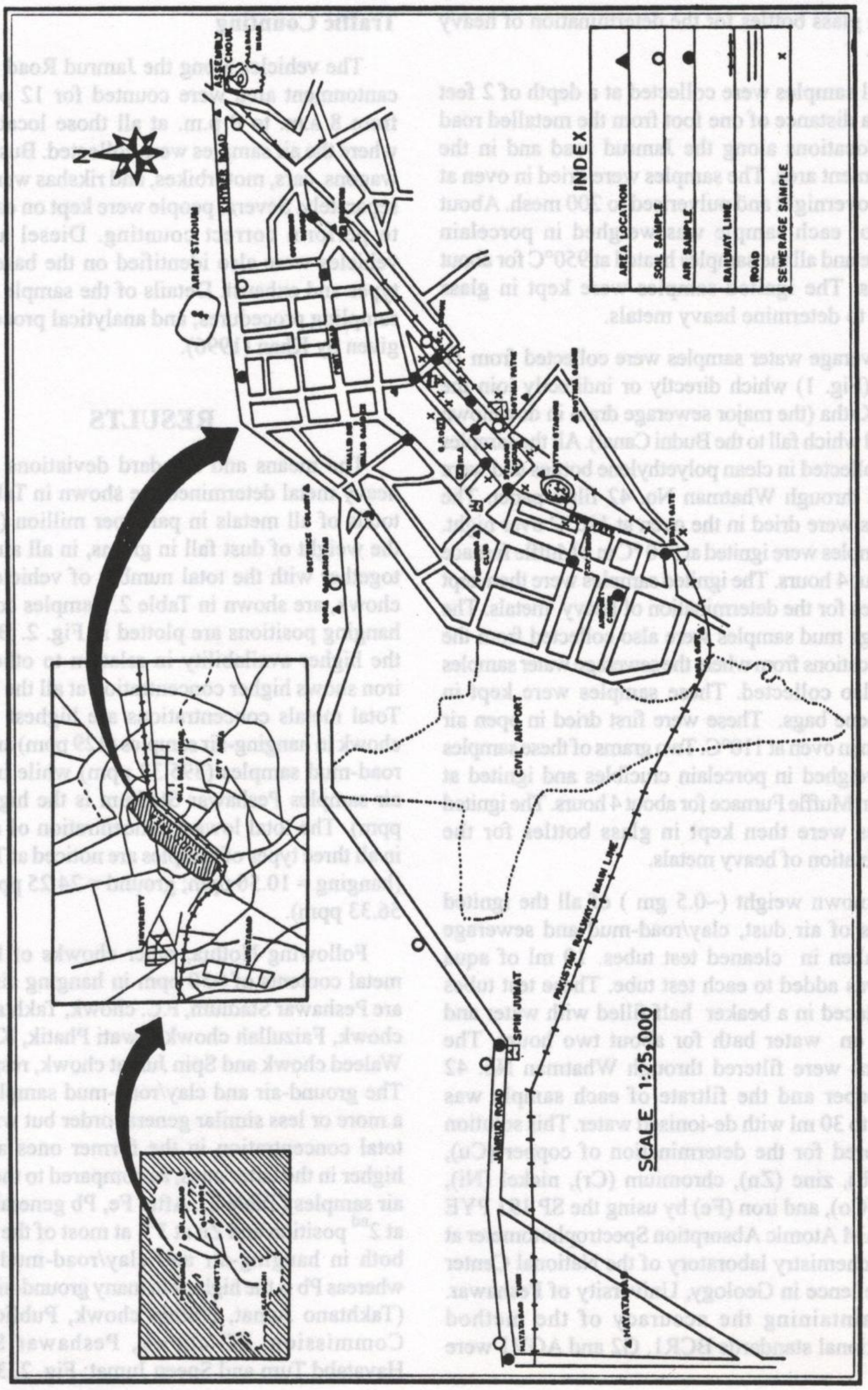

Fig. 1: Locations of samples collected for the study in Peshawar Cantonment and to the west along Jamrud Road.

kept in glass bottles for the determination of heavy metals.

Soil samples were collected at a depth of 2 feet and at a distance of one foot from the metalled road at 10 locations along the Jamrud road and in the cantonment area. The samples were dried in oven at 110°C overnight and pulverised to 200 mesh. About 2 gm of each sample was weighed in porcelain crucible and all the samples heated at 950°C for about 4 hours. The ignited samples were kept in glass bottles to determine heavy metals.

Sewerage water samples were collected from 18 drains (Fig. 1) which directly or indirectly join the Shahi Katha (the major sewerage drain in downtown city and which fall to the Budni Canal). All the samples were collected in clean polyethylene bottles and were filtered through Whatman No. 42 filter paper. The residues were dried in the oven at 110°C over night. The samples were ignited at 950 °C in a Muffle furnace for about 4 hours. The ignited samples were then kept in bottles for the determination of heavy metals. The sewerage mud samples were also collected from the same locations from where the sewerage water samples were also collected. These samples were kept in polyethene bags. These were first dried in open air and then in oven at 110°C. Two grams of these samples were weighed in porcelain crucibles and ignited at 950°C in Muffle Furnace for about 4 hours. The ignited samples were then kept in glass bottles for the determination of heavy metals.

A known weight (~0.5 gm) of all the ignited samples of air dust, clay/road-mud and sewerage 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 de-ionised water. This solution was stored for the determination of copper (Cu), lead (Pb), zinc (Zn), chromium (Cr), nickel (Ni), cobalt (Co), and iron (Fe) by using the SP 191 PYE UNICAM Atomic Absorption Spectrophotometer at the geochemistry laboratory of the National Center of Excellence in Geology, University of Peshawar. For maintaining the accuracy of the method international standards BCR1, G2 and AGV1 were used.

Traffic Counting

The vehicles along the Jamrud Road and in the cantonment area were counted for 12 peak hours from 8 a.m. to 8 p.m. at all those locations from where the air samples were collected. Buses, trucks, wagons, cars, motorbikes, and rikshas were counted separately. Several people were kept on each chowk to perform correct counting. Diesel and petrol vehicles were also identified on the bases of their types and exhaust. Details of the sample localities, sampling procedures, and analytical procedures are given by Khan (1996).

RESULTS

The means and standard deviations of all the heavy metal determined are shown in Table 1. The totals of all metals in parts per million (ppm) and the weight of dust fall in grams, in all air samples, together with the total number of vehicles at each chowk, are shown in Table 2. Samples collected at hanging positions are plotted in Fig. 2. Because of the higher availability in relation to other metals, iron shows higher concentration at all the locations. Total metals concentrations are highest at Nothia chowk in hanging-air samples (129 ppm) and in clay/road-mud samples (395.32 ppm) while in ground-air samples Peshawar Stadium is the highest (236 ppm). The total lowest concentration of all metals in all three types of samples are noticed at TV chowk (hanging = 10.56 ppm; ground = 24.25 ppm; clay = 56.33 ppm).

Following Nothia, other chowks of high total metal contents of >50 ppm in hanging air samples are Peshawar Stadium, F.C. chowk, Takhtano Jumat chowk, Faizullah chowk, Swati Phatik, Khalid Bin Waleed chowk and Spin Jumat chowk, respectively. The ground-air and clay/road-mud samples follow a more or less similar general order but with higher total concentration in the former ones and much higher in the latter ones, as compared to the hanging air samples (Table 2). After Fe, Pb generally stands at 2nd position and Zn at 3rd at most of the locations both in hanging-air and clay/road-mud samples whereas Pb is the highest in many ground-air samples (Takhtano Jumat, Nothia chowk, Public Service Commission, FC chowk, Peshawar Stadium, Hayatabd Turn and Speen Jumat; Fig. 2, 3 and 4).

Table 1: Totals, means and standard deviations for the heavy metals data from the western part of Peshawar metropolis. Numbers in parentheses refer to the number of samples/locations.

Metals	Cr	Co	Ni	Cu	Zn	Fe	Pb
Total hang-air (16)	011.11	011.80	034.25	067.39	130.05	438.75	237.66
Mean	000.69	000.74	002.14	004.21	008.13	027.42	014.85
SD	000.88	000.78	001.75	003.05	005.26	019.19	012.38
Total ground-air (16)	035.80	027.27	087.77	130.14	230.81	691.93	701.51
Mean	002.24	001.70	005.49	008.13	014.43	043.25	043.84
SD	002.04	001.89	003.64	004.65	007.76	025.08	029.93
Total road mud (16)	088.90	086.44	174.68	232.99	419.10	1612.50	1274.00
Mean	005.56	005.40	010.92	014.56	026.19	100.78	079.63
SD	004.15	004.07	006.37	008.12	014.33	053.13	034.58
Total soil (10)	125.00	040.00	231.00	284.00	217.00	2090.00	180.00
Mean	012.50	004.00	023.10	028.40	021.70	209.00	018.00
SD	002.84	001.33	002.18	003.92	002.67	015.63	003.02
Total sewerage water (18)	021.77	011.14	015.14	023.22	026.97	713.00	082.44
Mean	001.21	000.62	000.84	001.29	001.50	039.61	004.58
SD	001.25	000.65	000.91	000.89	000.96	020.01	002.42
Total sewerage-mud (11)	033.98	015.62	035.77	051.42	088.56	813.00	143.86
Mean	003.09	001.42	003.25	004.67	008.05	073.91	013.08
SD	003.13	001.53	003.06	003.87	007.26	040.06	010.52

Soil samples collected from 10 locations indicate much higher Fe content than the rest of the metals (Fig. 5a). All the metals however, fall within the ranges prescribed for these in normal soils of the world (ranges shown on Fig. 5). Therefore these soils cannot be considered as a source for delivering metals into air.

Like the soils the sewerage water collected from 18 locations and sewerage mud samples collected from 11 locations indicate higher Fe content as compared to other metals. Pb generally stands 2nd and Zn the 3rd. The highest Pb content upto 10 ppm are noticed in drains around FC Petrol pump (D2, D6; Fig. 6 and 7), with Shahi Katha being the 2nd and Dil Jan Plaza the 3rd. Other metals are also correspondingly high in drains at these locations.

To study the comparative behaviour of these metals, the averages of each metal in samples from all locations in a particular media (i.e. hanging-air, ground air, clay/road-mud, soil, sewerage water,

Table 2: Showing totals of metals, dust fall and vehicles at various chowks in western Peshawar.

Locations	Total of all metals in hanging-air samples (ppm)	Total of all metals in ground-air Samples (ppm)	Total of all metals in clay/road mud samples (ppm)	Weight of dust fall in grams in hanging-air samples	Number of vehicles at various chowks 8 am-8 pm	Weight of dust fall in grams in ground-air samples
Takhtano Jumat	86.26	165.11	274.78	2.889	30232	4.753
Deans Hotel	43.37	67.81	154.77	2.013	12247	4.113
Nothia Chowk	128.52	206.69	395.32	3.231	33540	5.917
Gora Qabristan	36.23	59.82	193.56	2.337	41903	4.613
Pub. Serv. Com.	14.03	30.07	60.19	1.673	8845	2.836
Kh.Bin W. Chowk	54.57	96.78	217.59	2.772	23914	4.557
FC Chowk	118.83	209.28	401.7	2.803	36496	5.317
Faizullah Chowk	80.48	155.27	349.25	2.764	8590	5.497
Pesh.Stad. Chowk	125.37	235.64	393.76	3.294	40017	6.387
TV Chowk	10.56	24.25	56.33	1.887	8910	2.327
Hayatabad Turn	36.28	95.47	237.92	1.933	16549	2.876
Speen Jumat	50.89	117.43	264.37	2.107	13498	3.759
Air Port Chowk	21.11	39.88	86.29	1.807	6911	3.807
Swati Phatik	80.35	147.74	316.02	2.908	14265	5.116
Pesh. Museum	10.70	182.88	322.35	2.801	26926	5.221
Khyber Road	33.46	71.11	164.41	1.926	12349	3.317

sewerage mud) are plotted in Fig. 8. The graphs show that Fe is the highest among metals in all media. Also except Pb, all the metals are generally high in soils as compared to other media. These graphs also show that on surface the average metal content are the highest in clay/road-mud, intermediate in ground-air and lowest in hanging air samples. Similarly the average metal content of sewerage-mud are higher than of sewerage-water. All these graphs also show a systematic increase in the mean concentrations of metals (Pb> Zn> Cu> Ni> Co> Cr) in accordance to their atomic mass numbers, i.e. the higher the atomic mass number, the higher the concentration of that element, except for Fe, indicating unusual spikes due to its high availability. This behaviour has been noticed in individual samples in all media (see Khan, 1996; Saifullah, 1996; Hamidullah et al., 1997).

The dust collected both at hanging and ground positions at each chowk in 48 hours indicate general positive correlation with the number of vehicles (Fig.9).

DISCUSSION

As mentioned earlier, this study represent only a small part of a large study devised for the whole Peshawar Metropolis (Saifullah, 1996; Hamidullah et al, 1997). It has revealed significant information about the systematic settlement and distribution of heavy metals in air. It is evident from Fig. 8 that heavy metals having high atomic masses, deposit sooner and in greater proportion than those having lower atomic masses. The study also shows that heavy metals are higher close to the ground than at nose level and in clays/road-mud than in air. Further, it indicates that the source of heavy metals is closer to the ground (i.e. surface or subsurface). Compositionally, soil samples collected at depths of 2 feet at various chowks in the study area reflect heavy metal ranges recommended by different scientists for various normal soils of the world. This evidence indicate that the source of heavy metals in the air of western Peshawar is not the subsurface soil, rather it is right on the surface. The relatively high concentration of metals in soils as compared to

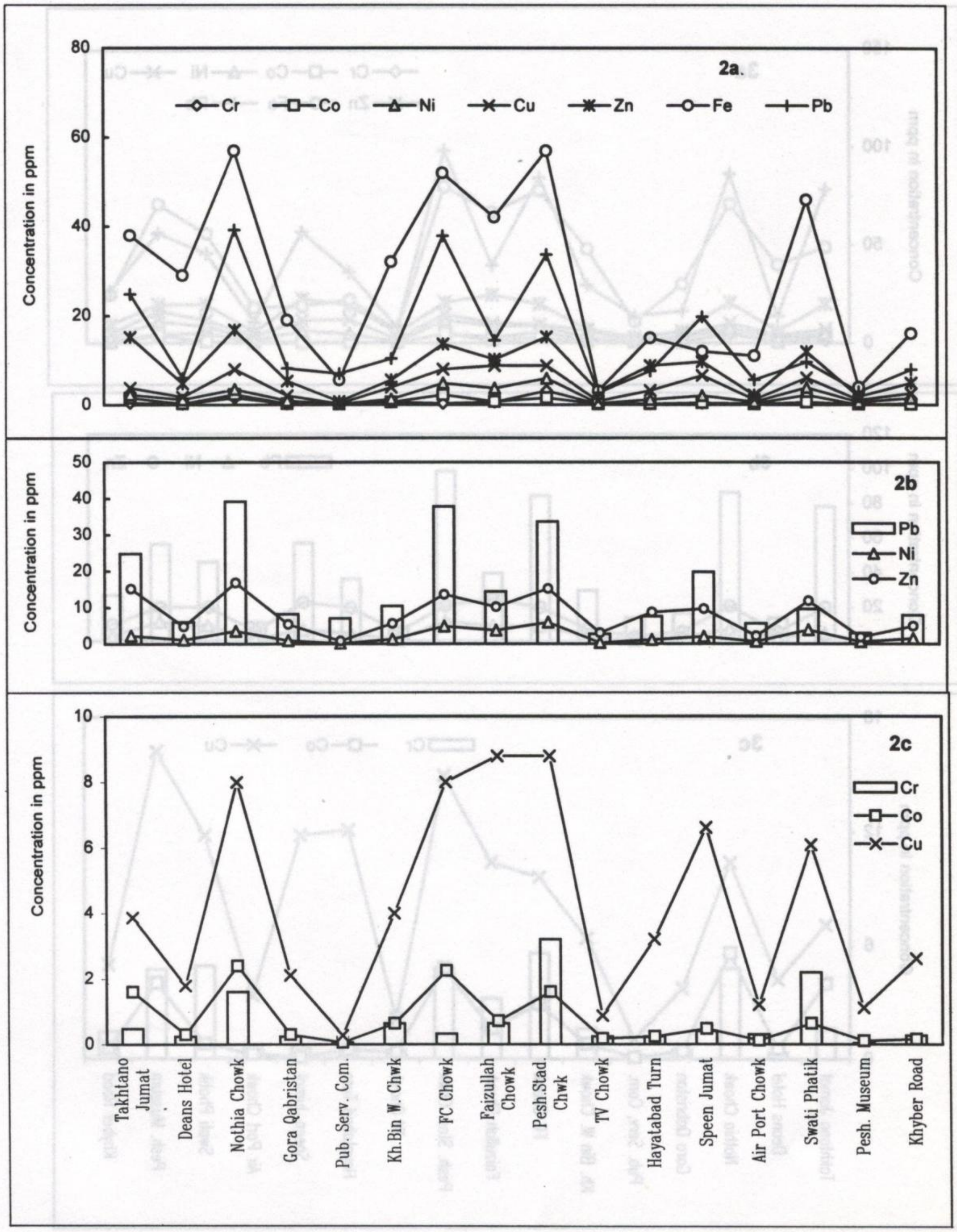

Fig. 2: Graphs of hanging-air samples from 16 locations of Peshawar cantonment and west.

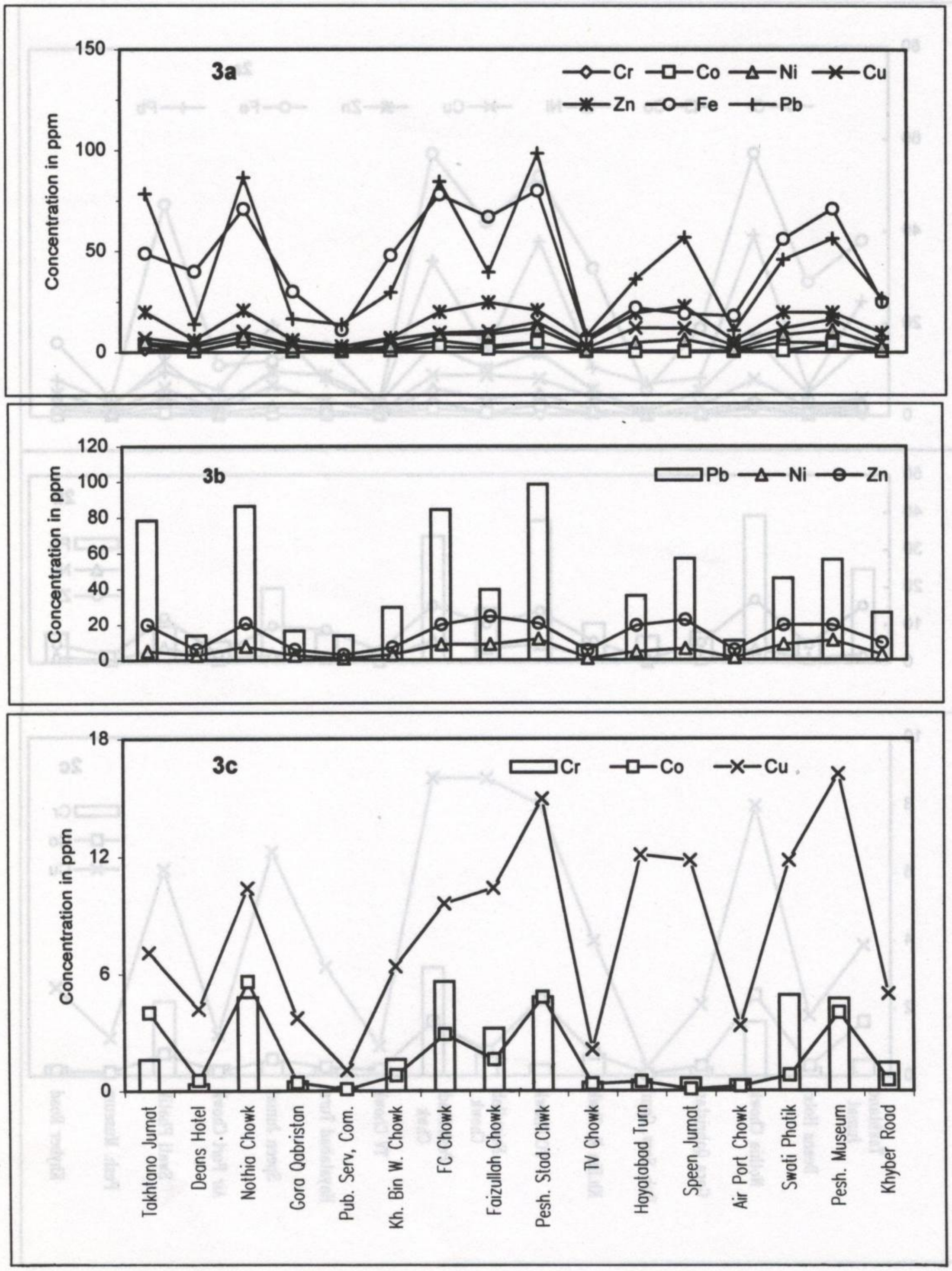

Fig. 3: Graphs of ground-air samples from 16 locations of Peshawar cantonment and west.

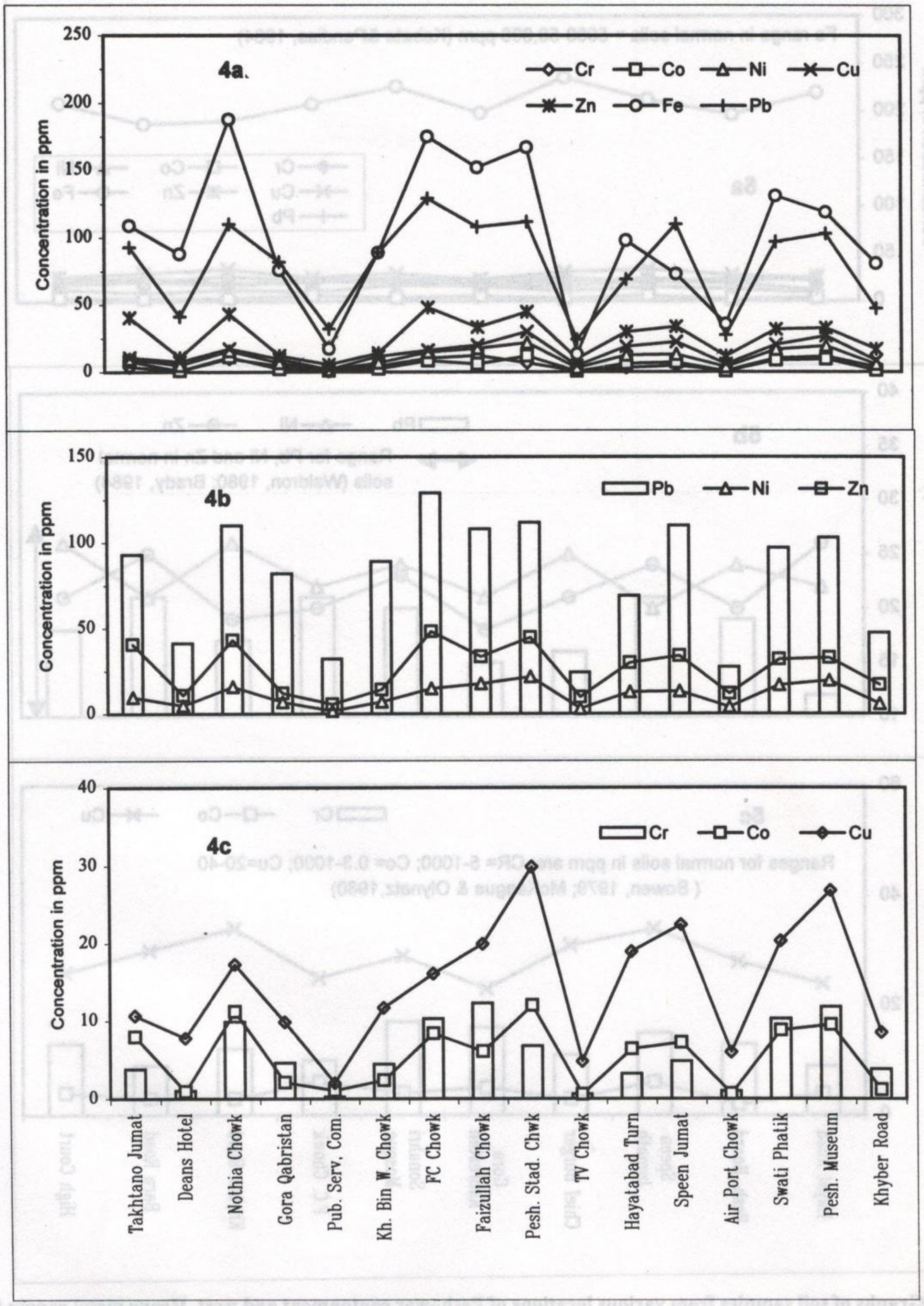

Fig. 4: Graphs of road-mud samples from 16 locations of Peshawar cantonment and west.

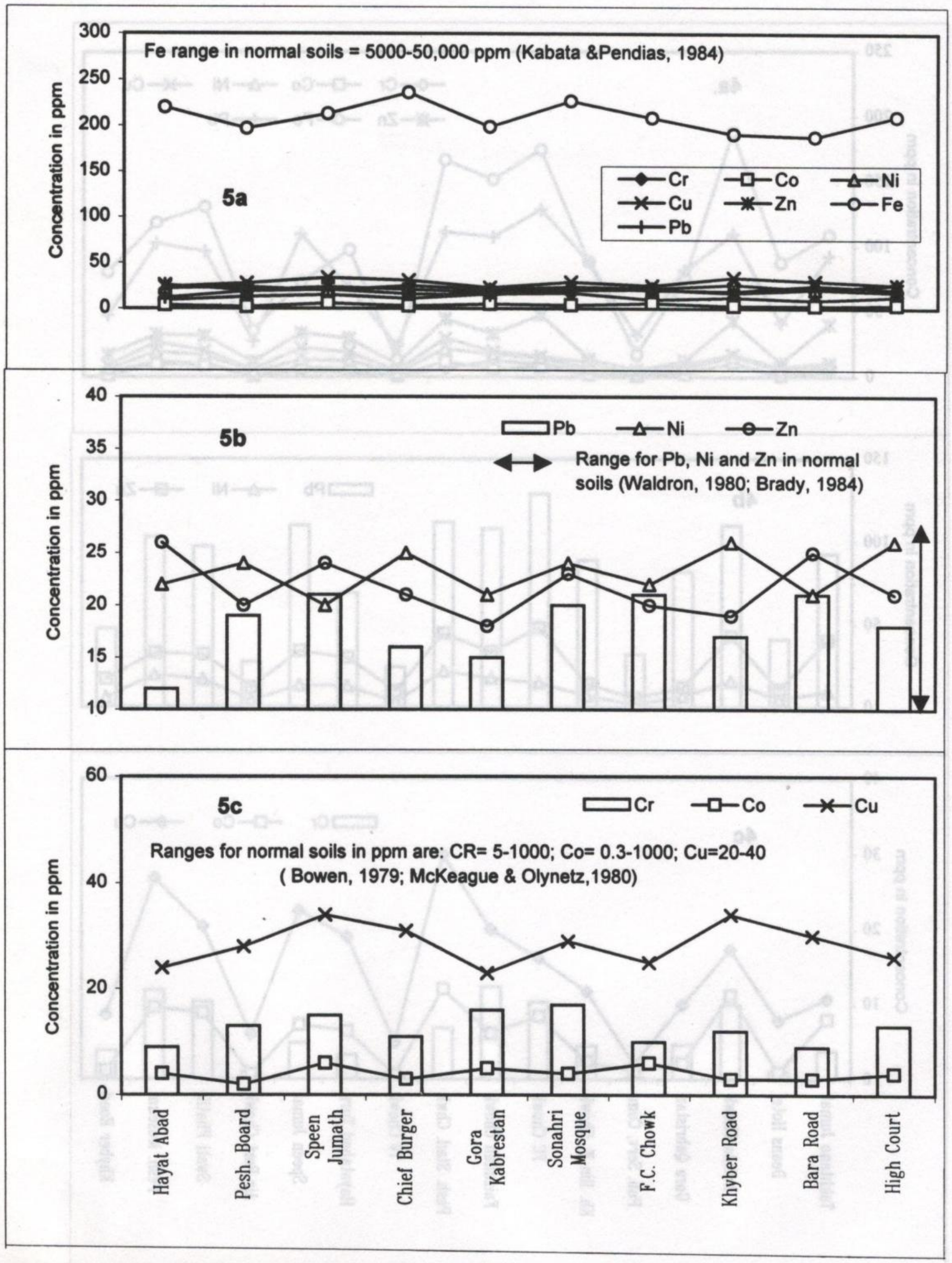

Fig. 5: Graphs of soil samples from various locations of Peshawar cantonment and west. Heavy metal ranges for normal soils are also shown.

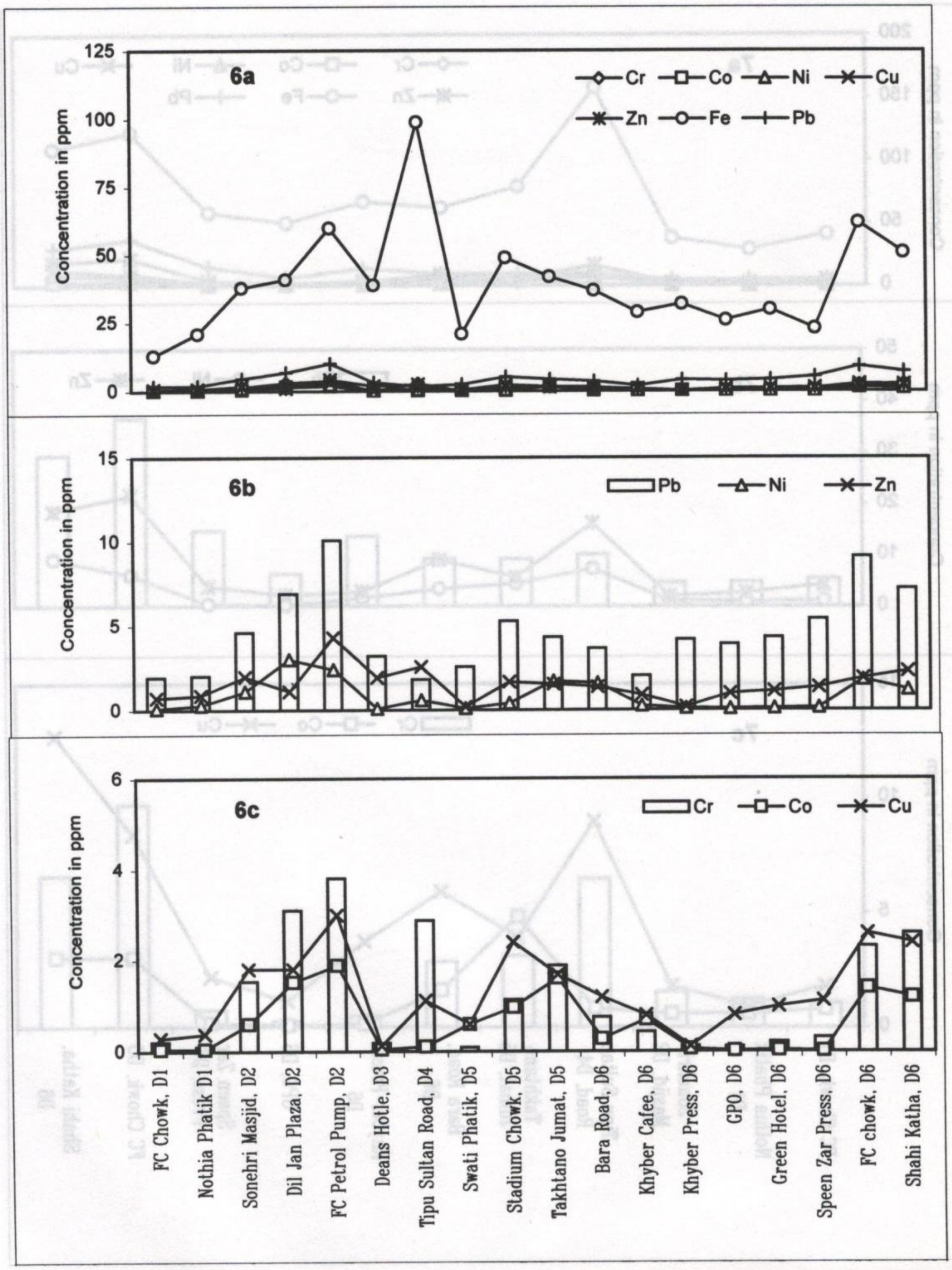

Fig. 6: Graphs of sewerage water samples from various locations of Pewhawar cantonment and west.

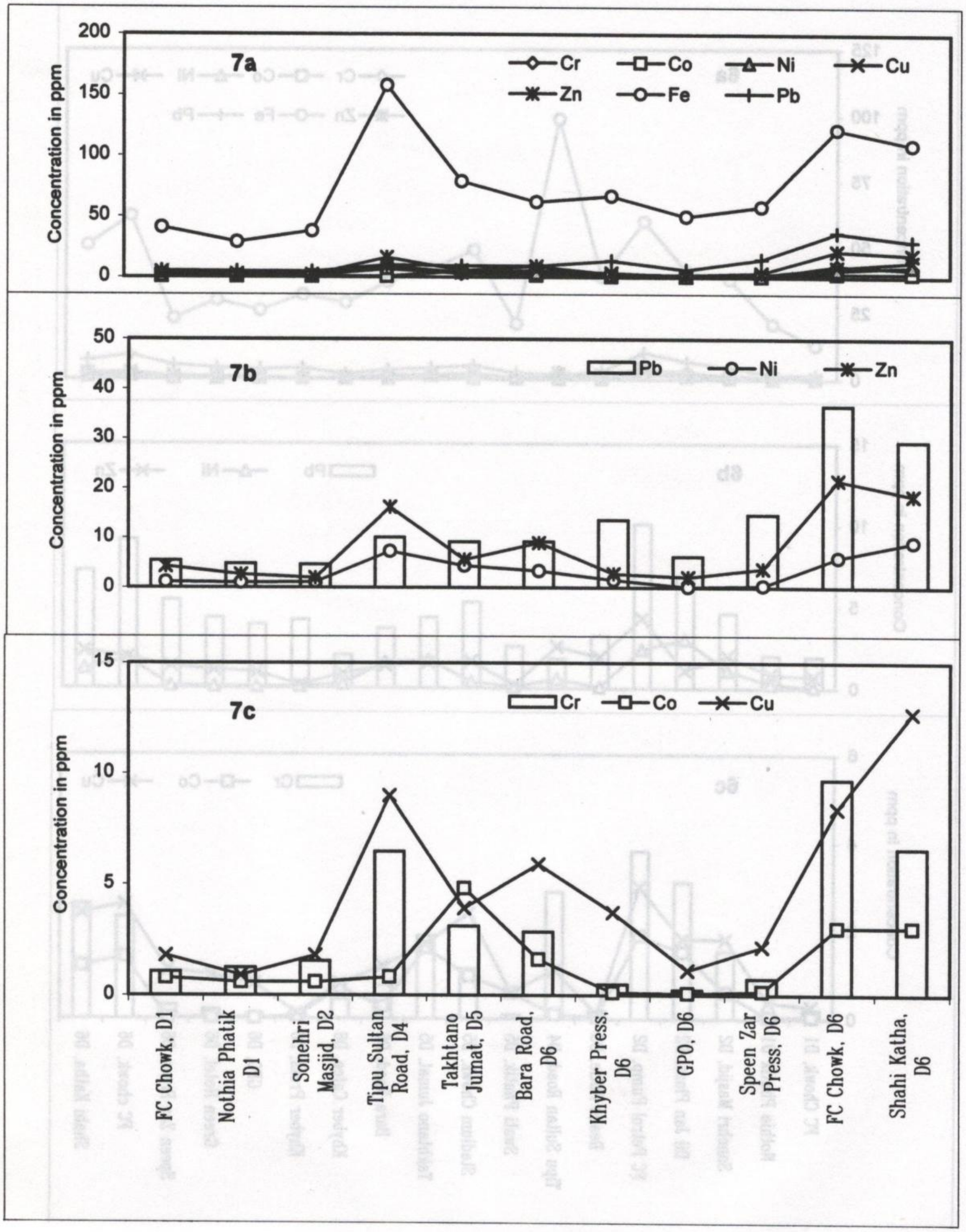

Fig. 7: Graphs of sewerage-mud samples from various locations of Pewhawar cantonment and west.

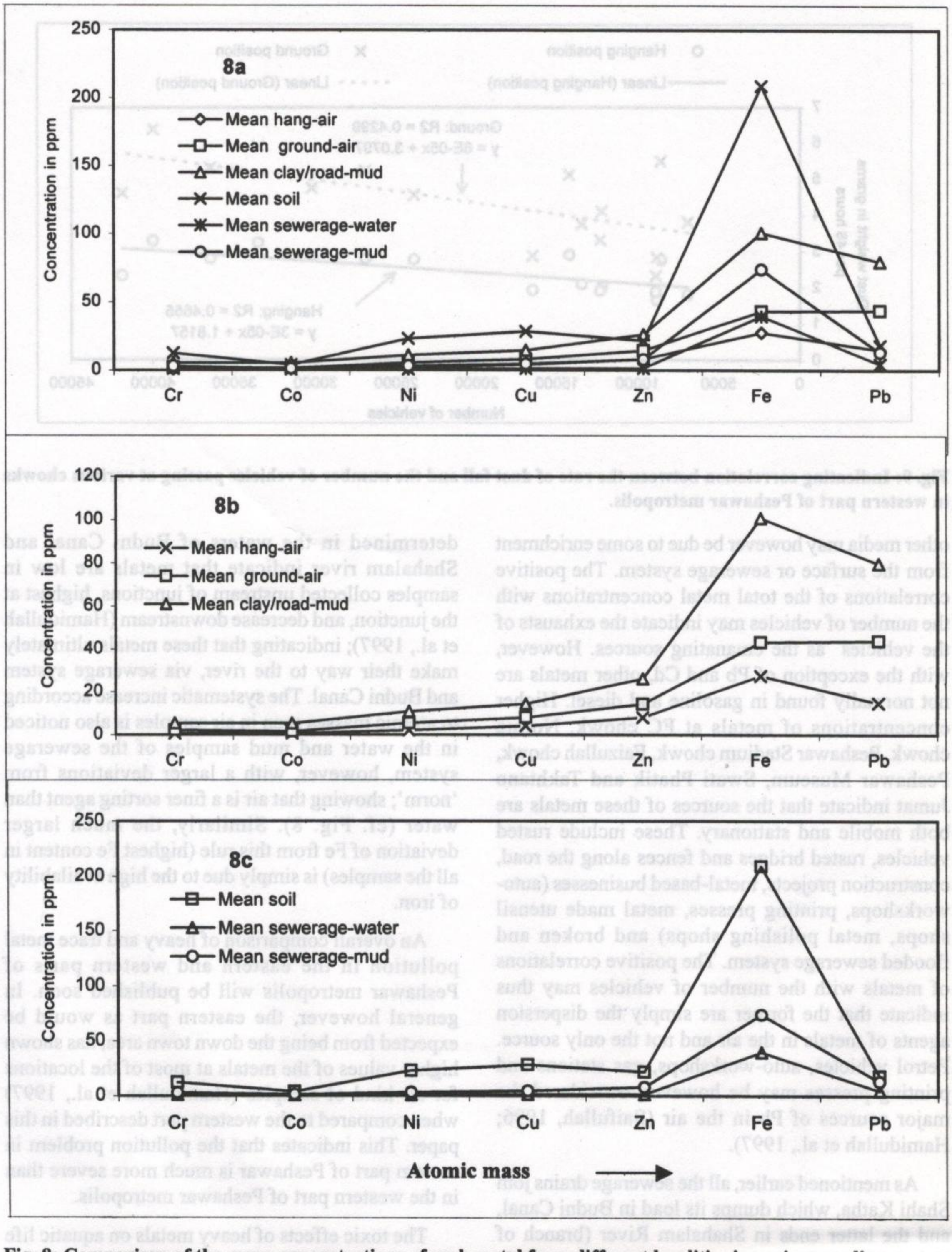

Fig. 8: Comparison of the mean concentrations of each metal from different localities in various media.

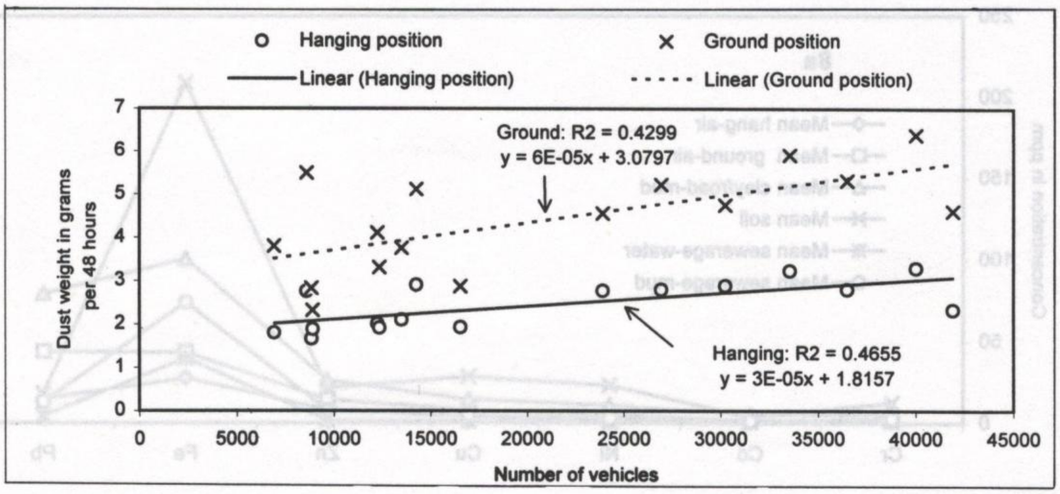

Fig. 9: Indicating correlation between the rate of dust fall and the number of vehicles passing at various chowks in western part of Peshawar metropolis.

other media may however be due to some enrichment from the surface or sewerage system. The positive correlations of the total metal concentrations with the number of vehicles may indicate the exhausts of the vehicles as the emanating sources. However, with the exception of Pb and Cd, other metals are not normally found in gasoline and diesel. Higher concentrations of metals at FC chowk, Nothia chowk, Peshawar Stadium chowk, Faizullah chowk, Peshawar Museum, Swati Phatik and Takhtano Jumat indicate that the sources of these metals are both mobile and stationary. These include rusted vehicles, rusted bridges and fences along the road, construction projects, metal-based businesses (auto-workshops, printing presses, metal made utensil shops, metal polishing shops) and broken and flooded sewerage system. The positive correlations of metals with the number of vehicles may thus indicate that the former are simply the dispersion agents of metals in the air and not the only source. Petrol vehicles, auto-workshops, gas stations and printing presses may be however, considered the major sources of Pb in the air (Saifullah, 1996; Hamidullah et al., 1997).

As mentioned earlier, all the sewerage drains join Shahi Katha, which dumps its load in Budni Canal, and the latter ends in Shahalam River (branch of Kabul River). Sage curves constructed for metals determined in the waters of Budni Canal and Shahalam river indicate that metals are low in samples collected upstream of junctions, highest at the junction, and decrease downstream (Hamidullah et al., 1997); indicating that these metals ultimately make their way to the river, via sewerage system and Budni Canal. The systematic increase according to atomic masses seen in air samples is also noticed in the water and mud samples of the sewerage system, however, with a larger deviations from 'norm'; showing that air is a finer sorting agent than water (cf. Fig. 8). Similarly, the much larger deviation of Fe from this rule (highest Fe content in all the samples) is simply due to the high availability of iron.

An overall comparison of heavy and trace metal pollution in the eastern and western parts of Peshawar metropolis will be published soon. In general however, the eastern part as would be expected from being the down town area, has shown higher values of the metals at most of the locations for all kind of samples (Hamidullah et al., 1997) when compared to the western part described in this paper. This indicates that the pollution problem in eastern part of Peshawar is much more severe than in the western part of Peshawar metropolis.

The toxic effects of heavy metals on aquatic life are numerous, in this area and well documented by many workers (Allen and Steinnes, 1979; Berlin, 1986; Goyer, R.A. 1986; Baranowska, 1993). This study has revealed the presence of heavy metals in the air, sewerage and water systems of the western part of Peshawar metropolis. Some of these metals, for example lead, are dangerously high at certain locations. Mitigation of this pollution is urgently needed.

CONCLUSIONS

Heavy metals including Cr, Co, Cu, Ni, Zn, Pb and Fe have dangerously polluted the atmosphere and sewerage system of Peshawar cantonment and Jamrud road area.

Heavy metal content in air decrease with height, i.e. low at nose level, intermediate close to surface and high in clays/rod-mud.

The major sources of these pollutants are both stationary and mobile, including rusted vehicles, rusted bridges and fences by the sides of the roads, construction projects, metal-based businesses (auto-workshops, printing presses, metal made utensil shops, metal polishing shops), and broken and flooded sewerage system. As iron is the dominantly used metal in all these sources it shows highest concentration at all levels.

Vehicles mobility play a major role in keeping the metals especially pb and cd constantly in air.

The dispersion and deposition of these metals is mainly controlled by their relative atomic masses, availability and the type of sorting agent, i.e. air or water.

For heavy metals both air and water are the sorting agents.

The heavy metals from the ground make their way to the sewerage system, from where they reach Shahalam/Kabul River via Budni Canal.

RECOMMENDATIONS

Auto workshops, metal and metal related shops and industries should be shifted out side the cantonment and must run according to strict environmental laws.

Heavy metals dumping into sewerage system may be restrained and their reprocessing must be encouraged.

Vehicles with faulty engines and exhaust systems must be strictly abandoned.

Lead addition in fuel must be stopped. immediately and use of lead free fuels must be encouraged.

Play grounds, shops and small cabins should be constructed away from very busy roads sides.

Food business and long stays at busy chowks expoil food items and creat health hazard.

Sewerage water used for irrigation purposes should be stopped.

Sewerage drains should be paved and regularly repaired.

Work on Peshawar ring road must be accelerated to minimise the traffic load in the city centre.

Rigorous plantation schemes mustbe implemented in the city.

Strict environmental laws should be made and implemented.

To control dust, water-spray on roads must be declared as an important part of the activities of Peshawar Cantonment Board, Peshawar Development Authority and Peshawar Municipal Corporation.

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