Sindh Univ. Res. Jour. (Sci. Ser.) Vol.46 (1) 41-46 (2014)

SINDH UNIVERSITY RESEARCH JOURNAL (SCIENCE SERIES)

Road Deposited Sediments and dust particles of selected roads of Hyderabad, Sindh, Pakistan

K. A. MEMON, M. H. AGHEEM, S. H. SOLANGI, I. SIDDIQUI, H. NAZ, I. A. BROHI

Centre for Pure and Applied Geology, University of Sindh, Jamshoro, Pakistan

Received 6th December 2013 and Revised 11th February 2014

Abstract: Hyderabad is seventh largest city of Pakistan and second largest city of Sindh located on the left bank of Indus River with rapid growth of infrastructure and automobiles. Recently the city holds a large number of automobiles in the total area of 3198 square kilometers. Road deposited and suspended air sediments were collected and analyzed to check the degree of pollution, if any. This study indicates that the heavy metals exhaust from automobiles are not only contaminating air but have also adverse effect on surface and subsurface water systems. Present data indicates that the studied locations are contaminated in the form of heavy metals such as the Cu, Co, Ni and Zn but their concentrations are not above the tolerance limit except of zinc **to** some extent. Along with above heavy metals; the major elements and their sources are also determined. The major elements determined are: Si, Ca, Al, Fe, Mg, O, and K. Among these silicon and calcium are in huge concentrations and these huge concentrations are because of the winds blowing from west and carrying fine sediments from the river bed of Indus and limestone deposits of Laki Limestone. This study indicates that the studied locations are not hazardous due to heavy metals though contamination is there in both air as well as road-deposited sediments.

Keywords: *Road Deposited Sediments, dust particles, Hyderabad*

1. INTRODUCTION

World population and urbanization is continuously increasing and in a review Charlesworth *et al.* (2010) and UNESA (2008) pointed out that urban population increased from 30% in1950 to 50% in 2007 and it will approximately be 70 % in 2050. Due to this increasing rate, the health problems of urbanization are also increasing simultaneously. Along with other health hazards, road dust particles and sediments are also considered as a health problem. Among the fine particulate materials less than 10 and 2.5 μm present within the air are of particular concern because of their effects on human health such as the respiratory issues and social well-being in the form of visibility and odour (e. g., Ostro *et al.* 2006; Jiménez *et al.* 2010; Capelli *et al.* 2010). Road dust particles are originated by the interaction of solid, liquid and gaseous materials generated by different sources (Irvine *et al.,* 2009; Behera *et al.,* 2011). Among such sources, the vehicular emissions, power generation plants, oil burning, waste incineration, construction and demolition activities are noteworthy (Salim *et al.,* 1993; Naim*et et al.,* 2003; Ahmed and Ishiga, 2006; Trang, 2006; Poleto *et al.,* 2009; Zhao *et al.,* 2010). Though some of the metals are vital for living organisms including humans but their excess to threshold values is harmful (Juvanovic *et al.,* 1995).Metals such as the Cr, Co, Cu, Ni, Zn, Fe, and Pb; along with other sources are also produced by certain anthropogenic activities (Elik, 2003). Though all of the metals are not hazardous but some are essential for good health, some are unacceptable to human body. For example, for certain enzymes to function in proper order, molybdenum is essential but its excess can cause to gout. Chromium which is obtained from food is healthy but the chromium which is released from anthropogenic activities is a toxic material and can expose the human health to risk. The slightest level of Lead (Pb) is unacceptable to the human and can cause several unwanted effects on human body and can be consumed by children through hand to mouth activities. The sources of these contaminants are anthropogenic and are driven from human activities. The source of lead can be Petrol combustion, paint, smelters, and coal combustion. Tyre wear, abrasion of vehicles, galvanized roofs, lubricating oils, and alloys can produce zinc and cadmium. The source of iron can be corrosion of vehicle body work and car exhaust particulates. Chromium and nickel can be produced from engine wear, vehicle plating and alloys road surface wear and metal industry.

Hyderabad being the seventh largest city of Pakistan and second largest city of Sindh is selected for this study. The increasing number of exhausts from automobiles in the form of heavy metals may be the major source (along with others) of many diseases in the city especially in last ten years with rapid economic

growth. Because heavy metals exhausting form automobiles are not only responsible for contaminating air, soil but may have also adverse effect on surface and subsurface water systems of any area. Along with this; clean air, soil, and water are also considered to be the source of life and upon contamination; it could be the one reason of fatal diseases. The present study is being carried out to assess the degree of contamination of heavy metals along with major elements and their sources in both air and road deposited sediments of Giddu Chowk and Gari Khatta areas of Hyderabad city **(Fig 1).**

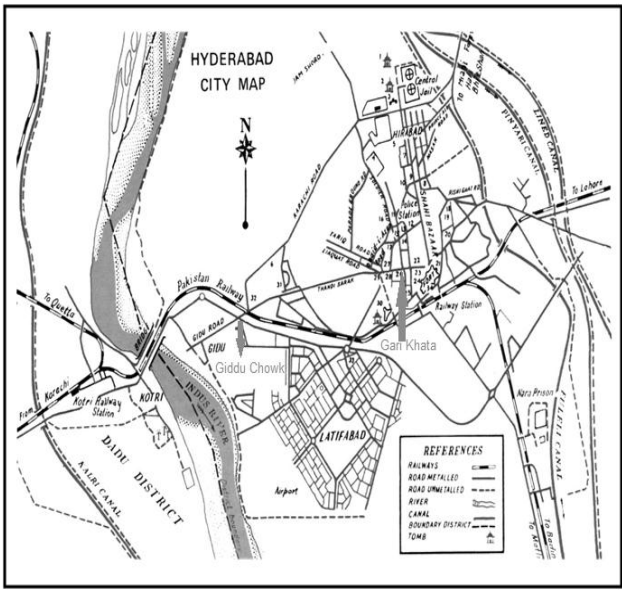

Fig. 1 Map showing the locations of sampling areas.

2. MATERIALS AND METHODS

Two main and important sampling sites for road dust and air sediments were selected in Hyderabad city based on traffic density. These roads are well noted for high and every type of vehicular movement including cars, motorcycles, rickshaws, vans, buses, trucks. The road of GidduChowk links Kotri, Hussainabad, Qasimabad, Wahadat Colony, Latifabad to main Hyderabad city while the GariK hatta road is in the hub of main Hyderabad city connecting all the surrounding areas of Hyderabad city and all the other small towns of Sindh regarding their business, commercial, social and economical activities. During the collection of data, traffic density of about 6000 vehicles/day was observed **(Table-1).**

Samples were collected from these two roads during October to November, 2011. The collected samples were carefully labeled and stored in sealed polyethylene bags. First of all ten liters of distilled water was poured into the middle size tub. It was then placed on the ground at the distance of one meter from the road at both selected sites for forty eight hours. Another middle size tub filled with distilled water was hanged at the nose level from ground in order to collect suspended particulates of air. In the meantime, with the help of stop watch traffic activity was counted. Traffic activity includes light vehicles, heavy vehicles and public transport. Twelve ground samples and six air samples were taken from Giddu Chowk and sixteen samples of ground position and seven samples of air position were obtained from Gari Khatta area.

The collected samples were dried at room temperature for twenty four hours (Banerjee, 2003)and then at 105ºC in the oven for four hours. Afterwards these were analyzed on the Scanning Electron Microscope equipped with Energy Dispersive X-Ray Spectrometer (EDS) at the Centre for Pure and Applied Geology, University of Sindh, Jamshoro. The procedure was initialized with the smooth spreading of sample grains on sample stub of SEM, using a conductive double sided carbon solution tape. The sample stub then was mounted in the sample chamber of JEOL- JSM-6490 LV Scanning Electron Microscope. Suitable operational parameters for SEM-EDS were optimized to determine elements. The elemental composition was determined in the form of different peak heights for qualitative study and at the same time the results were achieved in tabular form the quantitative analysis as well.

In addition, all the collected samples after acid digestion method were also analyzed on Flame Atomic Absorption Spectrophotometer (Perkin Elmer AAnalyst-800) for selected heavy metals (e.g. Co, Cu, Ni, and Zn).

3. RESULTS AND DISCUSSION

Giddu Chowk (25° 22´ 36.5´´N 68° 19´ 59.9´´E) is a residential as well as commercial area connecting all the other areas of its outskirt. Main commercial and other activities of this area are auto-shops, plumbing, petrol pumps, tyre shops, restaurants, hotels, shopping complexes, franchises of mobiles phones, hospitals, under construction buildings, vans, rickshaws, and bus stops. The traffic activity at Giddu Chowk was divided into six major divisions and according to increasing number these were: Motorcycle> Car> Rickshaw> Suzuki> Truck> Bus **(Table 1).**

Table 1. Number of automobiles passed during 48 hours at Giddu Chowk.

Location	Giddu Chowk	Gari Khatta
Type Of Transport	**Total Number**	**Total Number**
Motorcycle	15962	16156
Car	11927	12102
Rickshaw	6817	7808
Suzuki	2533	3023
Truck	1791	------
Bus	1387	------

Another field camp was organized at Gari Khatta (25° 23´ 07.1´´N 68° 21´ 55.6´´E). This road is in the centre of Hyderabad city for commercial activities because mostly the people from other small towns of Sindh visit this area regarding their commercial and shopping activities. It is also a residential area with thick population in the small area. Main commercial and other activities at Gari Khatta are auto shops, plumbing, petrol pump, tyre shops, restaurants, hotels, shopping complexes, franchises of mobiles phones, under construction buildings, van and rickshaw stops. The traffic activity at Gari Khatta was divided into four major divisions. According to increasing number these were: Motorcycle> Car >Rickshaw>Suzuki **(Table 2).**

Table 2. AAS heavy and trace element data for Giddu Chowk and Gari Khatta area

Location	Giddu Chowk		Gari Khatta	
Element	Ground (mg/L)	Air (mg/L)	Ground (mg/L)	Air (mg/L)
Co	3.764	BDL	13.78	BDL
Cu	BDL	10.14	4.989	38.39
Ni	4.241	4.112	4.203	3.966
Zn	47.48	240.4	31.52	134.7

In both kinds of samples, the major elements along with some selected heavy metals (i.e., Co, Cu, Ni and Zn) were analyzed and are given in Tables 2 and 3. Sediment is only considered contaminated when certain chemicals are present in excess. It may usually caused by accidental releases of chemicals or the improper disposal of hazardous waste in or onto the surface of the earth. The level of heavy metal concentration along roads depends on traffic density, population, presence of galvanized crash barriers, quality of the fuel used, wind, type of pavement, proximity of the sampling location to the road, and type of the sample etc (Sezgin *et al.* 2003; Banerjee 2003). In this regard, though the concentrations of heavy metals of studied roads of Hyderabad are below the hazardous limit but the sediments are contaminant in both types of samples. This contamination may be attributed especially to traffic density because pollution from overland transportation is an unavoidable environmental effect of increasing industrial and commercial activity in developing countries, especially in large metropolitan cities. Moreover, there is no industrial unit in the vicinity of studied points. In this context, numerous pollutants in the form of heavy metals emissions to the atmosphere and their deposition to nearby roadside soils are increased because of the rapid growth in overland transportation activities worldwide. So far, Cu, Ni and Zn are also present in both air and ground samples at both locations of Hyderabad city. In these the concentration of Zn in air samples is greater than ground samples at both locations. This higher concentration may be because of huge traffic and other anthropogenic activities. In addition, tyre wear, abrasion of vehicles, lubricating oils, and alloys may have contributed for such higher concentration of zinc at studied points. Tire wear and corrosion of roadside safety fences are also considered as contributing agents of zinc pollution (Blok 2005).While leaded gasoline is mainly responsible for the lead exposure (Chen *et al.* 2005).

Certain studies (e.g., Sezgin *et al.* 2003; Banerjee 2003) have indicated that the most common heavy metals introduced to the environment by overland transport are zinc, copper and lead. Copper is largely released from the wear of brake linings that is also an essential source of lead and zinc ((Elik, 2003). These three metals are usually deposited in the form of dust and may also form aerosols when re-suspended ((Elik, 2003; Han *et al.* 2007). In addition, platinum group elements have also been reported in limited amounts in highway dusts and plants (Djingova *et al.* 2003; Guney *et al.,* 2010). The levels of Zn and Cu at both studied locations is not high as to be considered as an environmental threat but contamination is there and Zn is relatively higher than that of Cu (Table 2). When the concentrations of zinc and copper are compared with some other studies of world metropolitan cities (e.g., Banerjee, 2003; Chen *et al.,* 2005;Guney *et al.,* 2010) it became evident that in Hyderabad, the contamination of these metals is at minimum level.

Among the major elements, silicon is in higher % and its concentration is high both in air and ground samples. At Giddu chowk silicon is (16.07 and 12.54 wt. %) in air and ground samples respectively**.** Such higher percentage of silicon may be attributed as windblown particles from nearby Kotri bank of river Indus and due to wind direction; higher percentage of silica has blown to this area. After silicon, calcium is the next most abundant element at both sampling sites. At Giddu Chowk its concentration in air is (12.56 wt. %) while at ground level (9.33 wt. %) as settled particles **(Table 3).** Likewise, at Gari Khata calcium is also high in air as well as ground (10.06 wt.% 5.54 wt.%) respectively. This higher % of calcium can be attributed to the dust blowing from Laki Limestone to the west of Hyderabad.

Table 3. Elemental Analysis (Wt %) Of Road Deposited Sediments/Dust Particles At Giddu Chowk And Gari Khatta, Hyd. (NOTE: The Given Concentrations Are Average Values).

Sample Location	Giddu Chowk		Gari Khatta	
Element	**Air {wt. %} n= 6**	**Ground {wt. %} n= 12**	**Air {wt. %} n= 7**	**Ground {wt. %} n= 16**
Magnesium	0.82	0.83	0.95	1.09
Aluminum	4.14	3.5	3.77	5.05
Silicon	16.07	12.54	16.81	21.73
Potassium	1.74	1.4	1.45	1.71
Calcium	12.56	9.33	10.06	5.54
Iron	7.04	4.89	6.45	5.97
Tantalum	9.57	9.31	--------	10.9
Carbon	0.55	6.1	1	--------
Oxygen	47.52	40.93	59.52	48.02
Boron	------	11.16	------	------

Iron is the most abundant metal element in road dust/sediments (Hopke, 1980). Iron as a road dust particle is added either from nearby soils and rocks (lateritic etc) rich in it (Al-Khashman, 2007) or this may be derived from anthropogenic processes, for instance industrial activities, wear of brake lining material in the form of brake dust and the corrosion and wear of vehicles (Garg *et al.*, 2000; Adachi and Tainosho, 2004; Singh, 2011). At both studied areas, the concentration of iron is high (Table 3) and having higher specific gravity the amount of ground position iron should be high but because of round O'clock automobile exhaust and workshops, its concentration in suspended air (7.04 wt. %) is high then that of ground position (4.89 wt. %).After iron, aluminum is the most abundant dust particle and is almost equally suspended in air and settled down on ground e.g. 4.14 and 3.5 wt. % (Table 3). This is because of heavy traffic from all three sides at Giddu Chock. At Gari Khatta Al has settled down as compared to air. The data shows that about same concentration/amount are also suspended in air, the reason may be the business activities concerned with automobile shops, tyre shops, and mechanical shops.

Potassium with slightly higher percentage (i.e.1.74%) is found in air as suspended particles, however (1.40 wt. %) of it settled down at ground level. At Giddu Chowk area, magnesium is found in very minute concentration i.e. 0.82 and 0.83 wt. % respectively in both air as well as ground level. The concentration of Mg at Gari Khatta is higher as compared to its concentration at Giddu Chowk . This shows that the Mg has settled down and very fine particles are suspended in air. It is a highly mobile and easily soluble element and its concentration in road-deposited sediments/ dust varies upon the geology of area, availability of the source materials and activities existing in the area. Tantalum is equally present as suspended and settled down on ground level (i.e. 9.57 wt. %) and (9.31wt. %) at Giddu Chowk but it is only detected in ground samples and absent in air at Gari Khatta area (Table 3). It is probable that at Giddu Chowk, which is an open area and winds are blowing there freely and therefore Ta is detected in both air as well as ground samples while Gari Khatta having huge buildings which create hindrance for air and in the result because of high specific gravity, Ta is found only at ground level. Carbon because of airy area, the most of the automobile carbon (6.10 wt. %) has settled down at ground level and small percentage (i.e. 0.5 wt. %) carbon is found as suspended in air. At Gari Khatta, the data shows that most of the carbon particles are suspended in air rather than settling down on ground.

It is very strange that boron is detected in ground level samples only at Giddu Chowk (11.16 wt. %) while it is absent in air as well as ground samples at Gari Khatta area. About/nearly same amount of K is found suspended in air, however little higher concentration. i.e. 1.71 wt% is found at ground level that has settled down due to high specific gravity.

4. CONCLUSION

Present study indicates that both type of samples (road-deposited and air sediments) of Giddu Chowk and Gari Khatta, Hyderabad are contaminated by heavy metals (i.e., Cu, Ni, Co and Zn) but the concentrations are not above the tolerance limit. Moreover, the higher concentration of Zn in air samples is attributed mainly to huge traffic activity.

Silicon and calcium are the most abundant major elements in all analyzed samples and such higher concentration may be attributed to dust blown from Indus river and limestone deposits of Laki Formation exposed in the west of Hyderabad. Iron concentration is higher in air samples than ground samples and it is because of round O'clock huge traffic.

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