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Lead concentration in urban dust and in leaves of street plants, Karachi

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Abstract

Lead concentrations were investigated in roadside dust at 29 different designated sites of Karachi and compared them with earlier available studies from Karachi. The study reveals that the lead concentrations in the dust of the city range from 73.47 $\pm$ 3.79 mg/kg to 998.66 $\pm$ 11.09 mg/kg. Presently, greater lead concentrations are found in the areas that have higher number of shops of welding, soldering, printing and battery recycling. Earlier, gasoline powered vehicles were the main source of environmental lead. Currently, vehicular emission is no longer a significant source of environmental lead in Karachi, since compressed natural gas has almost completely replaced gasoline for fueling motor vehicles over the last fifteen years. Moreover, lead has been completely phased out from the gasoline in Pakistan. Lead concentrations in the leaves of four different species of plants, growing extensively in Karachi were also investigated. Statistically, significant difference was not found among the lead concentrations in the leaves of the four different species. Statistically significant correlation was not found between lead concentrations in leaves and dust of different sites. The study will help to reduce the environmental lead, particularly in the neighbourhoods that have greater lead concentration, so as to mitigate it from human exposure.

Keywords: Acid lead battery; Karachi; lead pollution; leaves; urban dust.

1. Introduction

Exposure to lead from urban dust is an important pathway that increases blood lead levels in humans, particularly in young children (Demetriades *et al., 2*010; Mielke *et al.,* 2011; Laidlaw & Taylor, 2011; Gulson *et al.,* 2013) and causes many physiological and mental disorders (Toscano & Guilarte, 2005; Papanikolaou *et al.,* 2005; Patrick, 2006; Lidsky & Schneider, 2006; Taylor *et al.,* 2010; Nava-Ruiz *et al.,* 2012). Lead causes toxicity even at its very low exposure (Telišman *et al.,* 2007; Bellinger, 2008; Olympio *et al.,* 2009).

Consequently, many studies have been conducted across the world to determine the lead concentrations in dust over the last few decades (Wang *et al.,* 2006; Caravanos *et al.,* 2006; Anagnostopoulou & Day 2006; Quraishi *et al.,* 2009: Rauch & Fatoki, 2010; Hunt *et al.,* 2012; Deocampo *et al.,* 2012; Wilson *et al.,* 2015). Few earlier studies on lead concentrations in the dust of Karachi are available (Yousufzai, 1991; Shams & Beg, 2000). Nevertheless, the concentrations in the dust of the city have not been studied, since its complete removal from gasoline in 2004 for fueling the motor vehicles operating in Pakistan. However, blood lead levels in children living in Karachi city are sufficiently studied over the last few years (Rahbar *et al.,* 2002; Ali *et al.,* 2014). All the studies demonstrate that children of the city are currently exposed to high level of environmental lead.

A decade earlier, the emissions from gasoline-powered vehicles were the most important source of environmental lead in the urban areas of Pakistan. Shams & Beg (2000) reported lead concentrations in the particulates, which were deposited in the leaves of roadside plants. They found statistically significant correlation ($p < 0.05$) between lead concentrations in the particulate deposits and the number of passing gasoline-powered vehicles in different designated sites of Karachi. However, in 2002, the lead from the gasoline has been completely removed in Pakistan mainly due to its hazardous nature (Paul *et al.,* 2003). Consequently, the concern regarding lead in dust has reduced over the years in Karachi. Nonetheless, there are many other sources of environmental lead in Karachi, such as, paint manufacturing, battery recycling, paper printing and welding shops. However, rapid increase of recycling shops of acid lead batteries along the busy streets of Karachi (Haider & Qureshi, 2013) persuaded us to study the lead concentrations in dust of different designated sites of Karachi. The present study investigates the level of lead concentration in the street dust and the leaves of plants, which are extensively cultivated in Karachi. Furthermore, the study compares the present data with the earlier available studies of the city.

2. Materials and methods

2.1 Study area

Karachi is situated between 24°45' N to 25°37' N and 66°42' E to 67°34 E along the coastline of Arabian Sea. It is the largest city of the world by populations within city limits and 11th largest urban agglomeration (City Mayor's statistics 2011). Currently, over 20 million people live in Karachi, which spread over an area of 3,530 Km^2 (Karachi Metropolitan Corporation 2015). The city is financial capital of Pakistan. It generates around two-third revenues for the country. Globalization and World Cities Research Network (GaWC 2010) ranks Karachi as world's beta city. Kottek *et al*. (2006) has classified the study area as arid hot desert. It is naturally a shrub land. It has low average precipitation (annual average, 250mm). The seasonal temperature usually varies from 13 °C to 36 °C.

2.2 Experimental practices

The dust and the leaves of plants were collected from 29 different roadsides of the city (Fig. 1). The dust was taken from window sills of roadside cabins, girders of pedestrian bridges and other frontage of concrete structures, which were available along the streets at one meter height at each location.

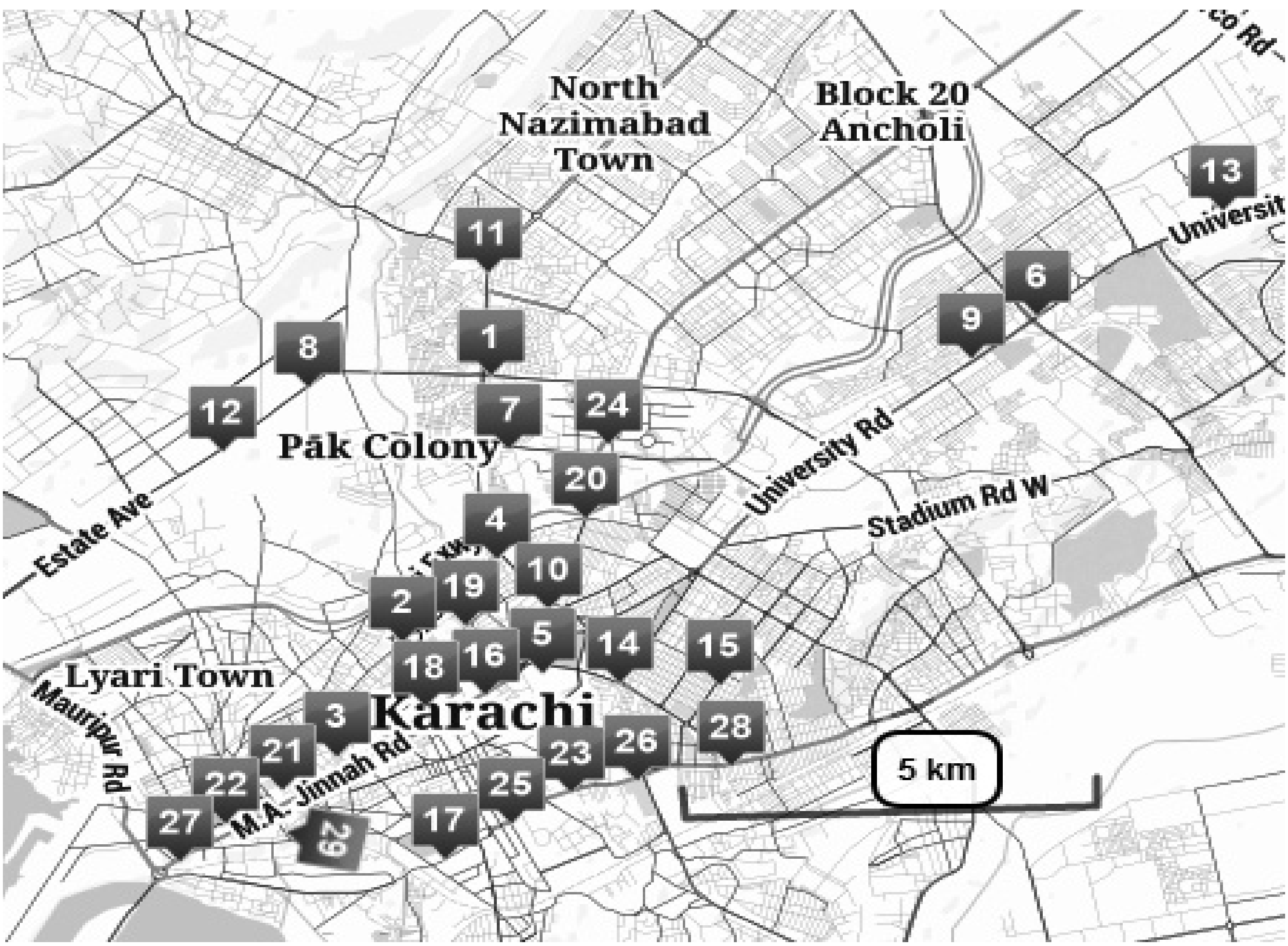

Fig. 1. Dust and Leaves Collection Sites in Karachi. (1-Nazimabad # 2, 2-Pakistan Quarters, 3-Tibet Centre, 4-Lasbella, 5-Numaish, 6-National Institute of Public Administration, 7-Nazimabad # 1, 8-Habib Bank, 9-Aziz Bhatti Park, 10-Grumandir, 11-Nazimabad # 7, 12-Seimens Chowrangi, 13-University of Karachi, 14-Quiad's Tomb, 15-Tariq Road, 16-Karachi Adventist Hospital, 17-Commissioner's Office, 18-Plaza Cinema, 19-Soldier Bazar, 20-Teen Hatti, 21-Jama Cloth, 22-Denso Hall, 23-Finance and Trade Centre, 24-Dakkhana, 25-Queens Road, 26-Mehdi Tower, 27-Mereweather Tower, 28-Sindhi Muslim Society, 29-Shahrah-e-Liaquat)

The collected dust of each location was dried at 104 °C for 4 hours in an oven to remove moisture. One gram of dried dust from each of the 29 sites were used for the analysis. The dust samples were digested with 25 ml of concentrated HNO_3 and 5 ml of concentrated HCl at 250 °C (Štrok & Smodiš, 2011). Just before drying, distilled water was added to boil the sample. The sample was then diluted with distilled water in a 25 ml conical flask.

The leaves of four different species of plants viz. *Guaiacum officinale*, *Conocarpus erectus*, *Ficus virens* and *Ficus benghalensis* were plucked at one meter height for lead analysis. These plants were usually found growing along the streets in Karachi. The leaves were plucked just before their senescence to demonstrate the accumulation of leaves over a period from their emergence to senescence. The leaves were washed with running tap water and rinsed with distilled water to remove the sticky dust particles. The dust-free leaves were dried at 104 °C for 4 hours in an oven to remove moisture. One gram of dehydrated leaves for each of the 29 sites were taken for the analysis. However, the leaves samples were digested with 25 ml of nitric acid (HNO_3) and 1-2 ml of perchloric acid ($HClO_4$) (Garcia & Millán 1998). Three replicates were taken for each sites in each category.

Each sample was analyzed by Hitachi Z-8000 atomic absorption spectrophotometer (graphite furnace type). The lamp and the current was adjusted to get maximum light. The wavelength was adjusted to 283.3 nm and the slit was adjusted to 1.3 nm.

Analysis of variance (ANOVA) was performed to determine, whether the concentrations of lead in the dust from various sites differed significantly with each other and to determine whether the lead accumulation by the four plant species differed significantly.

3. Results and discussion

The results demonstrates that lead concentrations in the dust from different sites of Karachi were significantly different ($p < 0.001$). Figure 2 shows that the highest concentration of lead in dust (998.66±11.09 mg/Kg) was found at Nazimabad # 2, which was followed by Pakistan Quarters (888.20±5.06 mg/Kg) and Tibet Centre (589.63±5.66 mg/Kg), while the lowest concentration of lead (73.47 ± 3.79 mg/Kg) was found in the dust of Shahrah-e-Liaquat.

Table 1. Mean concentration of lead in leaves of various species

Species	Family	Mean Concentration of Lead (mg/Kg)
Conocarpus erectus L.	Combretaceae	6.53 ± 4.88
Guaiacum officinale L.	Zygophylaceae	6.00 ± 3.37
Ficus virens Dryand in Ait., Hort	Moraceae	5.02 ± 2.91
Ficus benghalensis L., Sp. Pl.	Moraceae	4.27 ± 1.05

Main source of lead in the dust of these designated sites seems to be the roadside workshops of welding, soldering, printing press and particularly the recycling shops of acid lead batteries. The used acid lead batteries of motor vehicles are generally recycled and repaired in the shops along busy streets of inner city area of Karachi. Due to continued interrupted supply of electricity in Karachi over the last few years, the demand of recycled batteries for uninterruptable power supply (UPS) has increased dramatically. Inner city areas have over one thousand recycling shops of used acid lead batteries (Bhatti, 2010). There is no formal site in the city for recycling and repairing of used batteries of motor vehicles.

The repaired acid lead batteries are connected with the units of UPS for uninterrupted supply of electricity. The UPS units are used extensively in homes, offices, shops and schools of Karachi, whenever there is an interruption of normal supply of electricity from Karachi Electric. A unit of charged UPS usually supplies electricity for up to two hours, depending upon the size and the number of the batteries. The recycled batteries generally work for a year.

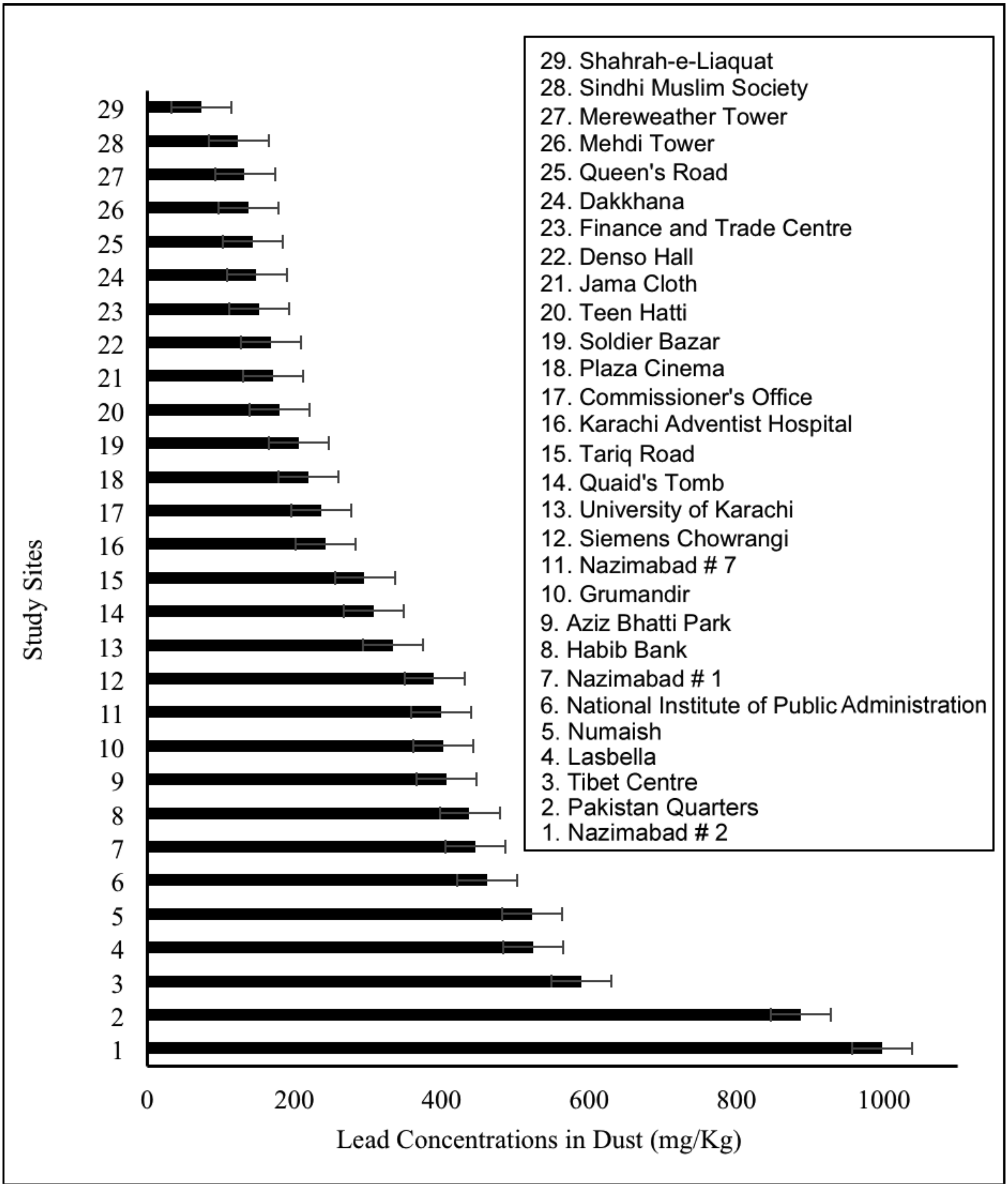

Fig. 2. Lead concentration in dust of different sites of Karachi

Currently many sites in the inner city areas demonstrate higher concentrations of lead in the dust, which may be due to rapid increase of battery recycling shops in their vicinity. Earlier in year 2000, these sites exhibited lowest to moderate concentrations of lead in the dust (Shams & Beg, 2000) because the localities did not have large number of battery recycling shops. Moreover, less number of gasoline-powered vehicles were operated in the inner city areas during both the study years (2000 and 2013). The proportions of diesel-powered vehicles were greater compared to gasoline-powered vehicles in those localities (Traffic Engineering Bureau 1992). Diesel does not contain lead.

In year 2000, samples from the roadsides at Shahrah-e-Faisal, such as Finance and Trade Centre, Mehdi Tower and Queen's Road demonstrated the highest concentrations of lead, which was primarily because of the operation of high volume of gasoline-powered vehicles at Shahrah-e-Faisal (Traffic Engineering Bureau 1992). Shams & Beg (2000) found statistically significant correlation between the number of passing gasoline-powered vehicles and the concentration of lead in the samples. In year 2000, tetraethyl lead was added in gasoline as an anti-knock agent for smooth functioning of the vehicles, which were operated in Karachi.

However, lead has been completely removed from gasoline for fueling the motor vehicles running in Karachi with the beginning of new millennium. Moreover, the pattern of consumption of fuel type in transport sector has changed substantially over the last fifteen years in Karachi. Earlier, gasoline was the most extensively used fuel in transport sector of the city (Pakistan Energy Year Book 2000). Currently, compressed natural gas, popularly known as CNG, is the most commonly used fuel type in motor vehicles operating in Karachi (Pakistan Energy Year Book 2014).

Presently, compressed natural gas is used as a fuel in almost entire public transport, such as auto-rickshaws, taxis, motorcars, light duty vehicles and even in the large buses operating in Karachi. Pakistan has second largest population of CNG powered vehicles in the world (NGV Joint Report 2012). The compressed natural gas is a lead-free fuel. The fuel does not require any addition of lead for increasing its octane number. Therefore, the emission from the motor vehicles is not an important source of lead in the dust of Karachi. However, the recycling of batteries of motor vehicles may be the significant source of lead in the dust of the city.

For the reasons stated earlier, the localities that have even high volume of motor vehicles, do not necessarily exhibit higher concentrations of lead in the soil. However, the localities that have higher number of workshops of welding, soldering, printing press and battery recycling, may demonstrate higher concentrations of lead in the soil.

Figure 3 reveals that lead concentrations in the leaves of the four different plant species are not significantly different. Lead concentrations in the leaves of the four different species of plants ranged from 2.72 ± 0.67 mg/kg to 12.16 ± 1.57 mg/kg. The highest concentrations of lead were found in the leaves of *Conocarpus erectus*, which was growing at Dakkhana (sites # 24), while the lowest concentration was found in the leaves of *Guaiacum officinale* at Quiad's Mausoleum (site # 14). Average highest concentration of lead was found in the leaves of *C. erectus,* while average lowest concentration of lead was found in the leaves of *Ficus benghalensis* (Table 1). Statistically significant correlation was not found between the lead concentrations in the leaves of the plants and in the dust of different areas of Karachi.

Conclusion

The used lead-acid batteries should not be recycled in the roadside workshops, which are located in the densely populated areas of the city. These recycling workshops contribute to increase the environmental lead, particularly in the roadside dust of the city, which causes a number of blood and brain diseases to the larger number of the exposed human population. The used lead-acid batteries should be transferred to the factories, where the batteries are manufactured, for their proper recycling and proper disposal. The batteries manufacturing factories are located in the Industrial Zones of Karachi.

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تركيز الرصاص في الغبار وأوراق نباتات الشارع في المناطق الحضرية، كراتشي

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خلاصة

تم فحص تركيزات الرصاص في الغبار على جانبي الطريق في 29 موقعاً مختلفاً من كراتشي وتمت مقارنتها مع الدراسات السابقة. وتوضح الدراسة أن تركيزات الرصاص في الغبار في المدينة يتراوح من 73.47 ± 3.79 ملغ / كغم إلى 998.66 ± 11.09 ملغم / كغم. وحالياً، تم العثور على تركيزات أكبر في المناطق التي بها عدد أكبر من محلات اللحام والطباعة وإعادة تدوير البطاريات. سابقاً، كانت السيارات التي تعمل بالبنزين هي المصدر الرئيسي للرصاص البيئي. أما حالياً، لم تعد الانبعاثات الصادرة من المركبات مصدراً هاماً للرصاص البيئي في كراتشي، منذ تم استبدال البنزين بالغاز الطبيعي المضغوط كوقود للسيارات خلال السنوات الخمسة عشر الماضية. علاوة على ذلك، تمت إزالة الرصاص تماماً من البنزين في باكستان. تم أيضاً فحص تركيزات الرصاص في أوراق أربعة أنواع مختلفة من النباتات التي تنمو على نطاق واسع في كراتشي. إحصائياً، لم يتم العثور على اختلاف كبير بين تركيزات الرصاص في الأربعة أنواع المختلفة من الأوراق. ولم يتم العثور على ارتباط إحصائي ملحوظ بين تركيزات الرصاص في الأوراق والغبار من مواقع مختلفة. لذلك تساعد الدراسة على تقليل التلوث البيئي.