Lead Pollution Measurement Along National Highway and Motorway in Punjab, Pakistan

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Abstract: A study was conducted to determine qualitative and quantitative lead contamination in soil and vegetation along two major roadsides of Pakistan using Atomic Absorption Spectroscopy. There has been a rapid increase in vehicles on the highways using petroleum products, which has caused considerable raised the quantity of lead in the atmosphere increasing the risk to health. Laser Induced Breakdown Spectroscopy (LIBS) was used as multi elemental analysis technique to cross confirm the lead contamination in the samples. The samples of soil and grass were collected from each location 100m away from the edge of roads at every 25m. The levels of lead were found to be 125mg/kg to 87mg/kg respectively in soil and grass. Hence there is high accumulation of lead in roadside soil and vegetation of linking roads of highly populated cities of Pakistan, Faisalabad and Lahore.

Keywords: LIBS, Atomic Absorption Spectroscopy, vehicular emission, lead contamination.

INTRODUCTION

The determination of lead in soil samples is important as its presence in excess amount in the soil can cause various physiological and chemical changes in the living organisms and moreover public health risk is also associated with it. Lead as a soil contaminant is a widespread issue. Vehicular emission is considered one of the major sources of lead contamination. Pollution caused by traffic activities is a great threat to the urban environment. It has been reported that vehicular emissions change the electrical conductivity of soil due to change in metal concentration in the soil [1]. With a rapid increase in the number of motor vehicles on roads, the risk of lead contamination is being increased in roadside soils and vegetation [2].

Lead is a normal constituent of the earth's crust therefore its trace amounts are found naturally in soil, plants and water [3]. It has a long environmental persistence and never loses its toxic potential [4]. Practically it is immobile, however, once mined and transformed into man-made products which are dispersed throughout the environment, becomes highly toxic. It has become the most widely scattered toxic metal in the world [5-6]. A number of studies have shown a correlation between lead in air and that in corresponding vegetation [2].

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The risk of lead poisoning through food chain increases as the soil lead level rises. Studies have shown that lead can cause various health risks like anemia, neurological disorders and hyperactivity and enzyme changes in human beings. Lead has non-biodegradability and cumulative nature which cause irreversible changes in the body particularly in the central nervous system resulting in lowering IQ level and learning problems. It has neurotoxic impact on children and is strongly associated with problems that are extremely costly to society including learning deficits, socialization, violent behaviour and other health problems [7]. Lead contamination in soil is potentially toxic threat to children and adults as it has long term adverse effects on human health particularly on the growth and intelligence of children because children are more susceptible to toxic elements [4,8]. Lead contents present in soil are correlated with the lead level present in children's blood [9]. Another pathway for Pb into humans is *via* ingestion of contaminated vegetables and fruits [9]. There is an exponential increase in lead emission in the atmosphere since industrialization started [3,10]. Contaminated roadside soil is tracked into homes by shoes, family pets and deposition of Pb dust, which penetrates interiors of homes and directly or indirectly affect the adults and children [7,9]. Heavy metals including Pb in soil and roadside dust can be accumulated in human body *via* direct inhalation, ingestion and dermal contact absorption [11]. Long term exposure to lead or its salts can cause

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nephropathy, and colic-like abdominal pains. Lead is considered to be particularly harmful for women's ability to reproduce. Higher concentration of Pb affects the living organisms including birds. Long range transport is the main source of lead exposure in different bird species [12].

Lead poisoning can also have hematologic and endocrine effects in the human body. Lead can cause irreversible damage to the body's nervous system. Most of the dysfunctions produced by the absorption of lead are due to lead's ability to mimic and inhibit the actions of calcium. In humans the lead is directly absorbed, distributed and excreted. Once it enters the bloodstream, it is distributed into blood, soft tissue (kidney, bone marrow, liver, and brain), and mineralized tissue (bones and teeth). It affects nervous system, poor muscle coordination, behavioural problems, attention deficit, hearing damage, fertility problems, high blood pressure, memory and concentration problems. The nervous system seems to be the most sensitive to lead poisoning [5,13]. In this research work both quantitative and qualitative analysis of lead pollution in soil and Vegetation due to vehicular emission were investigated by Atomic Absorption Spectroscopy which were cross confirmed by the LIBS technique**.**

MATERIALS AND METHODS

In this work, a quantitative measurement of lead pollution in soil and grass from vehicular emission was investigated by Atomic Absorption Spectroscopy and LIBS**.** Lahore and Faisalabad are at 2^{nd} and 3^{rd} largest cities in population while are at 3^{rd} and 2^{nd} largest cities in heavy industry. Roads selected are linking roads of these major cities of Punjab, Pakistan. Cites selected for sample collection are away from industrial areas to avoid the industrial affects. Soil and grass samples were collected from four locations, two from each road namely Motorway and National Highway. Different types of vehicles are running on these roads such as buses, trucks, and motor cars etc which are consuming fuels such as natural gas, diesel and petrol. Selected sites are suitable for quantitative analysis of vehicular emission lead contamination in soil and grass because there is no permanent habitation, small or big industry nearby.

Soil and grass samples were taken from four transects running perpendicular to the direction of the roads in the downwind direction. Grass samples were also collected from the same place where soil samples were collected. Samples of each species were taken from the road's edge at different regular distances of 25m, 50m, 75m and 100m. The samples were collected in the month of April with a core extractor of 2.5cm diameter up to the depth of 9 to 15cm. 2kg soil from each site was collected in polythene bags for different analysis. Soil was air dried at ambient temperature and then sieved. Further material was crushed in a small ceramic mill prior to chemical analysis. Soil sample was put in digestion block and heated for absolute digestion to compute Pb concentration by well calibrated Atomic absorption spectrometer. All readings were taken in triplicate and then took their mean. Similarly, grass samples were washed with deionised water to eliminate dust, dirt etc and then air dried and powdered.

Atomic absorption spectroscopy technique is preferred because it is highly specific for the elemental study, less spectral interferences, wide detection bandwidth, easily removable Interferences, changeable detection limits and instrumentation is extremely simple to operate. It has a lower limit of determination (LLD) of about 0.5mg/kg [14-18]. Samples were prepared and data were collected from atomic absorption spectroscopy technique of each of soil and grass samples. Two datasets were developed, one for roadside soil and other for grass. Data were compiled and tabulated for statistical analysis using SPSS-11. LIBS is another attractive tool for analyzing different materials in the environmental, biological and industrial fields. This technique was used to cross confirm the presence of Lead in the samples. For this purpose, a Q-switched Nd:YAG laser (Quantel Brilliant) of 4ns pulse duration, 10Hz repetition rate and of 532nm wavelength was focused on the target soil samples to take the emission spectra of generated plasma. Highly resolved Aventus Spectrometer (0.07nm resolution) attached to the computer system was used to capture the emission spectra.

RESULTS AND DISCUSSIONS

Traffic density did not significantly change the basic properties of soil such as pH, texture and organic matter except the metal concentration [1]. This research is useful to check the health risk factor involved for living organisms and for agriculture land along the both sides of roads and to determine the trends on transects along the other roads in the country due to lead contamination in soil and vegetation.

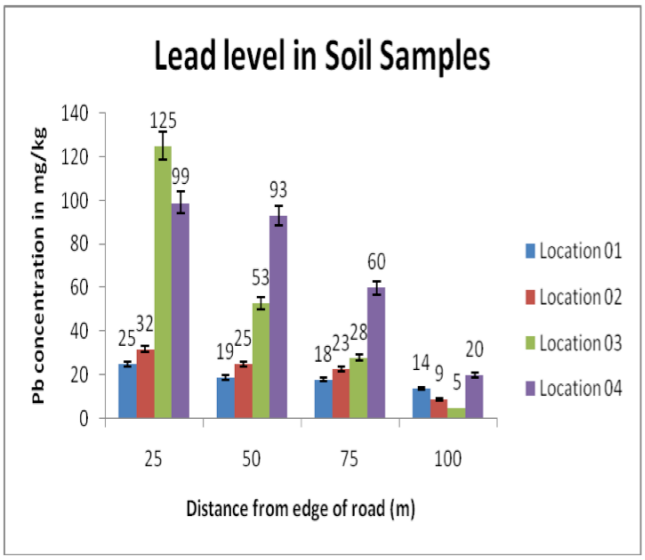

Figure 1: Lead level in roadside soil samples

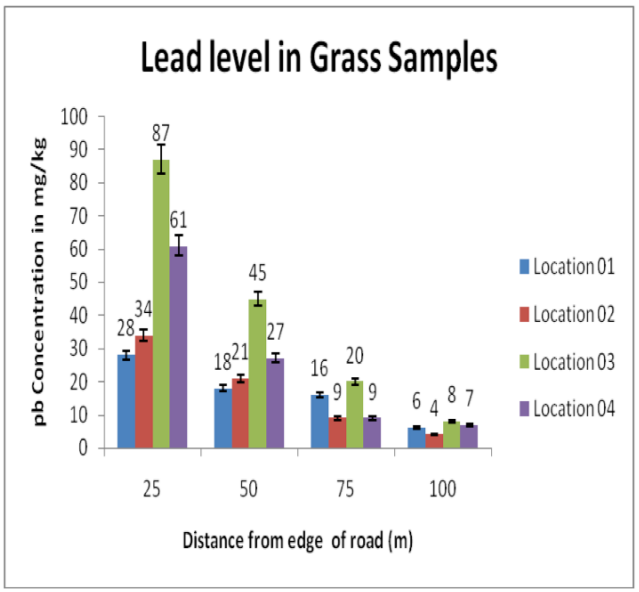

Figure 2: Lead level in roadside grass samples

Figure **1** shows that the Pb concentration in soil decreased with the increasing distance from the edge of roads. This result is broadly similar to those obtained by [1,19]. Pb concentration is higher at road sites than the background values which showed that the vehicular emission is the major source of lead as reported by [20]. Multivariate analysis indicated that the level of roadside lead pollution is highly positively correlated to traffic density and is negatively correlated with distance from the roadway. A similar effect has been reported by [21]. The more gradual fall-off of excess lead in the soil is an indication of the influence of secondary dispersal processes, e.g; surface soil mobilization by wind, operating over long periods of time after initial discharge and settling of emissions. Direction of wind flow affects the lead contamination in the roadside soil as reported by [5,13]. Pb excel in soil is due to the roadside vehicular emission. Similar result also reported by [8]. It was concluded that Lead was the key pollutant in road dust as reported by [22]. Pb concentration decreases with the increase of depth from the soil surface**.** Soils have been contaminated due to the use of Pb in gasoline. A large percentage of the Pb emitted from automobiles has been deposited within approximately 50m of the roadside. Soil lead decays exponentially away from the roadside as reported by [9]. Consequently, the promotion of unleaded petrol will drastically decrease lead concentrations in the atmosphere. This result is similar to that reported by [23].

Figure **2** shows that the Pb concentration in grass decreases as the distance increases from the edge of roads. Deposition of metals and their levels in vegetations decrease with increasing distances from the highway. This result is similar to the result reported by [19]. Distribution of Pb in roadside vegetation was highly affected by the distance and traffic density. This result is good agreement with the data reported by [1]. Lead concentration in vegetation was positively correlated with total Pb concentration in soils, suggesting that Pb in soils was readily transferred into plants. This result is similar to that reported by [24]. Pb concentration was significantly positively correlated with the traffic volume, moreover, Pb concentration in soil and grass is higher on Highway than that of Motorway because age of Highway is higher that of Motorway. This result is in strong agreement with the result published by [7]. Lead in roadside soil is co-equal to the Pb in roadside grass with little variation. Coefficient of skewness was revealing the positively skewed distribution which indicated some relatively high values of Pb existed in the data as reported by [25]. Moreover, the presence of Lead in the samples was cross confirmed by LIBS as shown in the Figure **3** which showed the presence of Silicon and lead in the soil samples.

CONCLUSIONS

Lead contents mainly originated from Vehicular emissions. Long term traffic exposure caused the lead contamination in roadside soil and plants. Lead contamination has found widely spread in soil and grass along these roads in Punjab, Pakistan. Lead concentration was decreased with increasing the distance from roads on both sides which reflected a decrease in rate of aerial deposition. Pb concentration

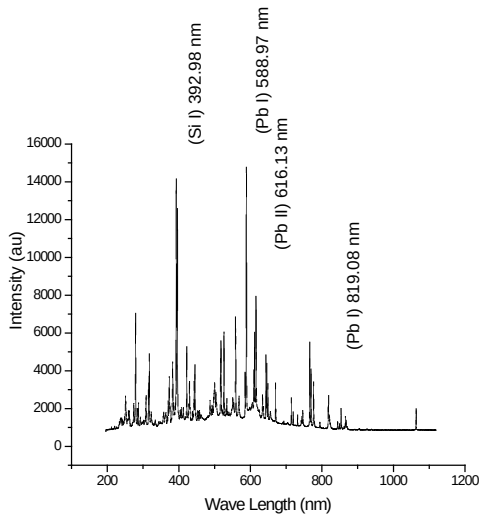

Figure 3: LIBS spectrum of soil sample indicating the presence of Pb and Si.

on Highway is higher than that of Motorway because of age of road affects the Pb concentration in roadside soil. Pb could move with wind along the wind direction and Pb concentration was higher at the downwind direction. The results showed that all the concentrations of Pb in soil and grass are higher than their background values in Pakistan. It is predicated that the Lead pollution in Pakistan will become more severe in the near future years.

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