International Research Journal of Biological Sciences _______________________________ ISSN 2278-3202
Vol. **4(4),** 12-21, April **(2015)** *Int. Res. J. Biological Sci.*

Quantitative analysis of Lead (Pb) in Soil and Grass Grown along Road side with Low, Medium and High Traffic Intensity

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Available online at: www.isca.in, www.isca.me
Received 1st October 2014, revised 28th December 2014, accepted 5th February 2015

Abstract

The current study was designed to quantify the concentration of Pb in soil and grass samples along different roadsides in and near Lahore, Pakistan. The purpose of the study was to analyze the impact of Pb pollution because of vehicular exhaust. For this reason roads with different traffic intensity and a control site were selected which include: G.T. Road, Mall Road, Cantt Colony and Lawrence Garden. Samples were collected during the months of April to June, 2013 from 1 to 2 pm using composite sampling methodology. Soil samples were analyzed for physical parameters including pH, electrical conductivity and moisture content. Standardized procedures were used for samples pre-treatment and then analyzed on Atomic Absorption Spectrophotometer for the analysis of Pb. Results were also compared with WHO (1996) permissible limits for Pb. Results had shown that Pb pollution was found significantly above the WHO permissible limit in both soil and grass samples along all roads except Lawrence garden (Control site). Comparison among sampling sites had shown that mean levels of Pb in soil samples along Mall Road were highest which could be attributed to the fact of increasing traffic congestion on the road. Whereas mean levels of Pb in grass samples were highest along G.T. Road. Different correlation patterns were observed in concentration of Pb in soil and its uptake by grass with highest correlation (r = 0.833) in samples from G.T. Road. It was therefore concluded from the study that Pb pollution from vehicular exhaust has become a growing ecological concern especially for urban areas.

Keywords: Pb pollution, vehicular exhaust, control site, traffic intensities, lawrence garden.

Introduction

A very significant source of atmospheric pollution in cities is automobile emission which is found in roadside soil ecosystem associated with lead (Pb) pollution[1]. The use of lead compounds as anti-knocking agent in gasoline is strictly prohibited in many countries[2]. But the goals could not be achieved due to increase in number of automobiles. Analysis of roadside soils and related vegetation for Pb contamination is important to determine the impact of vehicular emissions on environment[3].

Overwhelming metal pollution including Pb can genuinely influence the critical organisms in soil which are ultimately in charge of keeping up the ripeness of soil biological community[4]. Earthworms assume a paramount part in soil environment that incorporate keeping up the soil fertility and porosity, acting as consequential food source for many amphibians, birds, reptiles and mammals[5]. In a research study conducted by Zaltauskaitė and Sodiene[6] it was found that there was significant reduction in body weight of earthworms fed with soil having different lead concentrations than in control; similar results were analysed by Berthelot et al[7].

It was likewise discovered that risks of deaths of Earthworms additionally expanded with increasing Pb fixations in soil. Critical level of lead uptake from soil can occur by plants and vegetation at lower pH which can be further transferred to plants and animals in the food chain[3].

Material and Methods

Sampling sites: Roads with different traffic intensities were selected for sampling which included: Grand Trunk Road (G.T. Road) with Heavy Traffic Intensity, Mall Road with Middle Traffic Intensity, Cantt. Colony with Low Traffic Intensity and Lawrence Garden as Control. Soil and grass samples were collected from April to June, 2013 from 1 to 2 pm.

Sample Collection: Composite sampling methodology was adopted for the collection of both soil and grass samples[8] with five sub samples for each representative sample from the selected sites. All soil samples were collected from the depth of 0-6 cm whereas grass samples were collected with roots, stem and leaves to maintain the uniformity[9]. Total of 40 soil samples and 40 grass samples (10 from each sampling site) were collected and sealed in labelled polythene bags.

Analysis of Soil and Grass Samples: Soil samples were analysed for physical parameters of pH with pH meter (WTW multilab- 540), Electrical conductivity with conductivity meter (WTW infolab) and Moisture content according to the standardised procedures[10]. For the analysis of Pbin soil and grass samples pre-treatment steps were performed preparing them to run on Atomic Absorption Spectrophotometer (AAS).

Soil samples were manually removed with large stones, pebbles, leaves and grass samples were thoroughly washed with double distilled water to remove dust and dirt and then air dried. Soil samples were further sieved with 10 mm mesh size then both soil and grass samples were oven dried at 90^0C for 24 hours. Dried samples of grass were gently ground using an acid washed porcelain pestle and mortar. 1 g of soil and grass sample was treated with 10 mL of concentrated HNO_3 in a flask and heated on a hot plate (Wise Stir MSH-2017) till dryness. Then residues were dissolved again with 10 mL conc. HNO_3 followed by 10 mL 2M HCl and heated on hot plate till dryness. The residues thus left were warmed in 20 mL of 2 M HCl to re-dissolve the metal salts and then filtered (60-Wattman filter paper) final volume was adjusted to 25 mL with doubled distilled water[11]. Prepared solution was then transferred to labelled test tubes for Pb analysis on AAS (Thermosceintific Zeeman furnance).

Results and Discussion

Results for the Physical characteristics of soil had shown that mean levels of pH at all sampling sites was in the range of 7.07-8.5 (figure-1) within the standard limit of 8.0 by Agricultural Department of Punjab (ADP Standard, 2002). In a study, Pirzadaet al[12] had analysed Pb levels in soil, *Dalbergiasissoo* and *Cannabis sativa* on Islamabad highway and observed soil pH in the range of 7.47 to 9.30. According to WHO, 1996 the normal pH range for productive soil is from 6.5 to 8.4. Electrical Conductivity results (figure-2) for soil samples from all sites were highly above the ADP Standard, 2002 of 4 uS/cm for normal soil. Mean moisture % were in the range of 7.47-14.78 % (figure-3) for soil samples at all sites.

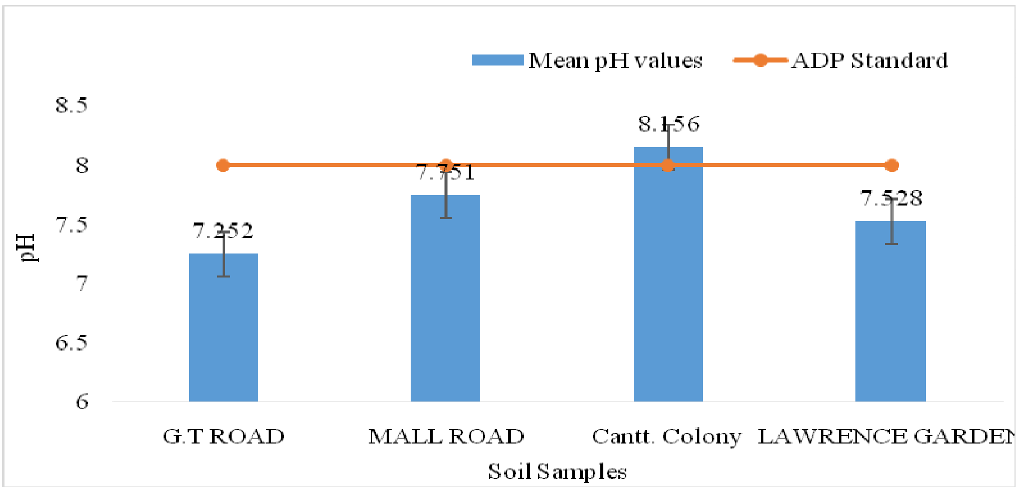

Figure-1

Mean pH values of soil samples of all sites compared with ADP Standard (2002)

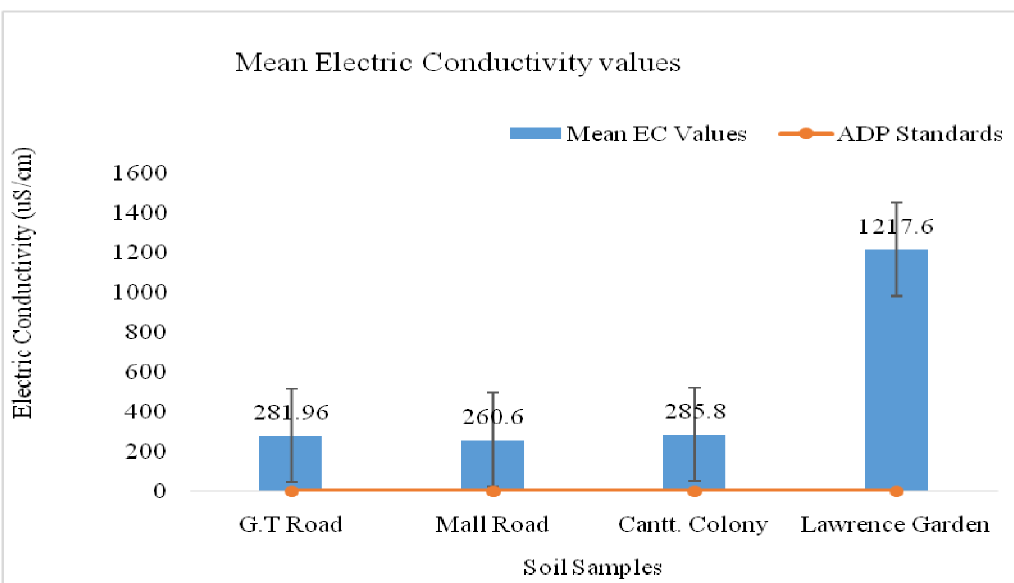

Figure-2

Mean EC values of soil samples of all sites compared with ADP Standard (2002)

Analysis of Pb in soil samples collected from all roadsides had shown that concentration of Pb was significantly above (P = 0.059) the WHO, 1996 permissible limit of 3mg/L except samples collected from control site (Lawrence Garden) which had shown Pb concentrations significantly below (P=0.013) the standard limit. Mall road had shown highest mean concentration of Pb (6.41 ± 3.33 mg/L) in soil samples (figure–4) that could be attributed to the fact that Mall road is a mid-city road and links main areas of the city which led to continuous heavy flow of traffic mainly consisting of cars. Kruger[13] conducted a study in the city of Cape Town and found higher concentration of Pb (226.77 ± 60.11 mg/kg) at site where road was moving uphill and caused traffic to get slow and in return released more Pb from the exhaust. Similarly Olukanni and Adebiyi[14] in their study to assess vehicular pollution along road side soil in Nigeria found highest Pb concentrations (0.33 mg/kg) at site which had heavy traffic resulting in slow flow of traffic.

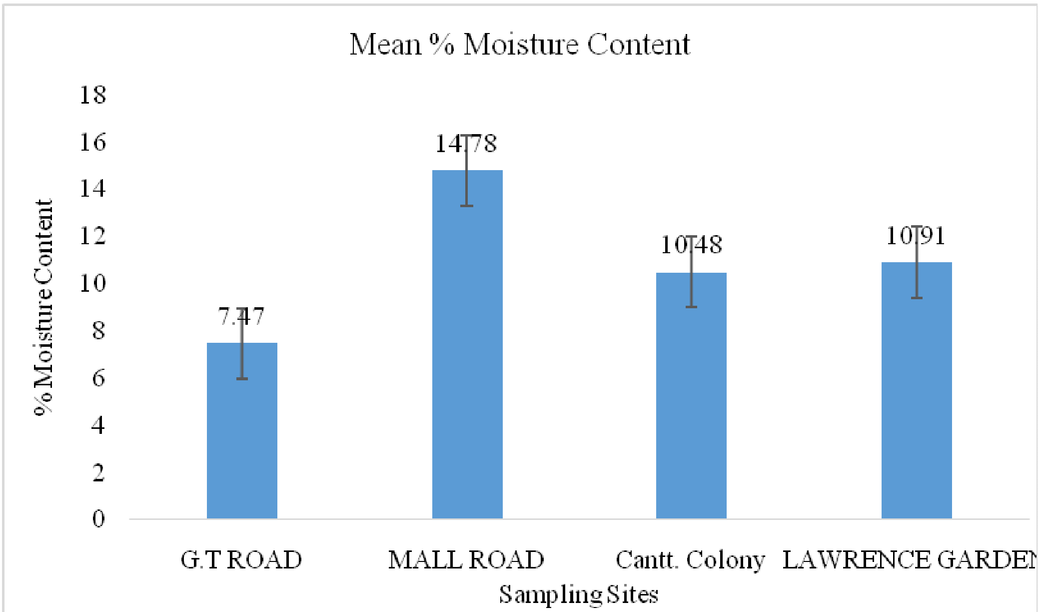

Figure-3
Mean Moisture Content (%) of soil samples of all sites

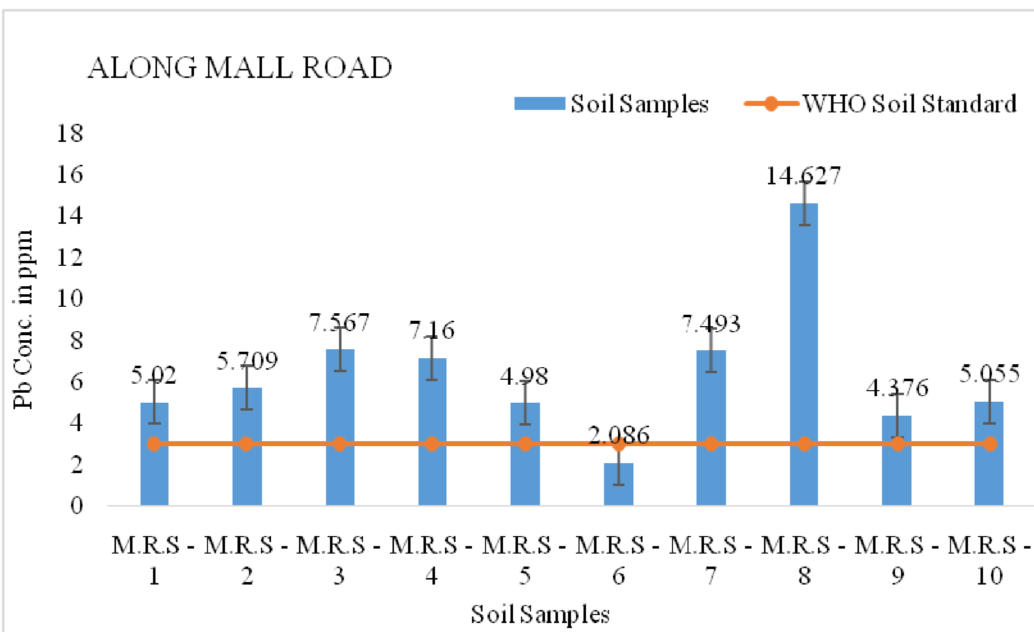

Figure-4
Concentration of Pb in soil samples of Along Mall Road compared with WHO Permissible limit (1996)

G.T road also had high mean concentration of Pb (4.125 ± 1.649) in soil samples (figure-5) as it serves a mini garage for buses, trolleys, trucks and passenger vehicles and as a highway and receives continuous heavy flow of traffic. In a study carried out by Kruger[13] Pb concentration along different highways in Cape Town with varying traffic density were investigated. It was found that at two sites Pb levels were (208.08 ± 59.96 mg/kg) and (226.77 ± 60.11 mg/kg) respectively because as highway these sites received morning and afternoon peak hour traffic and outgoing and incoming sides of the road were situated close to busy intersections.

Highest mean concentration of Pb (2.571 ± 0.742mg/L) were analysed in grass samples collected along G.T road (figure-6) with most of the sites having concentrations significantly above (P=0.038) the WHO, 1996 permissible limit of 2mg/L; also a very strong correlation factor (r = 0.833) existed between Pb concentration in soil and its uptake by the grass (figure-7). This result is similar to that reported by Farooq et al[15] who investigated Pb concentration along National Highway and Motorway in Punjab, Pakistan. He found lead concentration in vegetation was positively correlated with total Pb concentration in soils, suggesting that Pb in soils was readily transferred into plants.

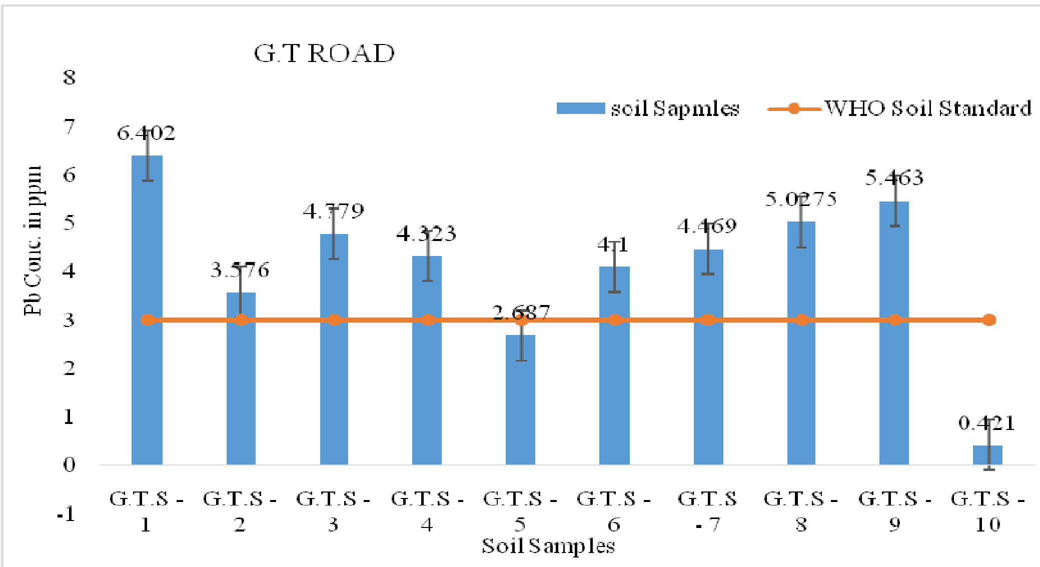

Figure-5
Concentration of Pb in soil samples along G.T. Road compared with WHO Permissible limit (1996)

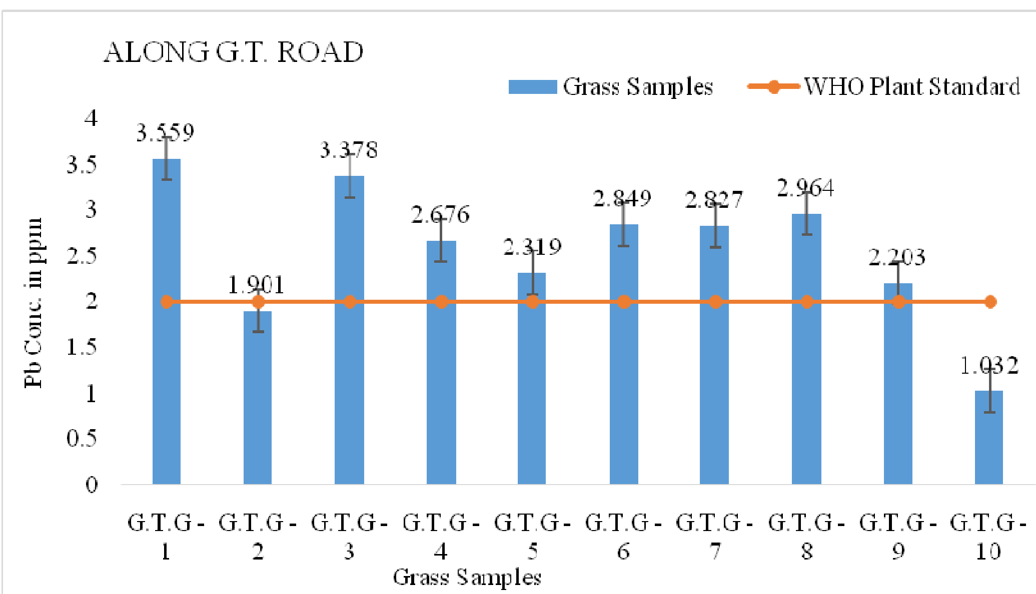

Figure-6
Concentration of Pb in grass samples along G.T. Road compared with WHO Permissible limit (1996)

Along Mall road mean concentration of Pb (1.891 ± 1.393 mg/L) in grass samples was within the WHO, 1996 permissible limit of 2mg/L with only two sites showing Pb levels significantly (P= 0.811) above the WHO permissible limit (figure-8). Moderate correlation existed between soil and grass samples at this site suggesting that Pb in soils was partially transferred into grass (figure-9). In another study conducted by Yan et al[9] it was indicated that with increase in concentration of heavy metals in soils its uptake level by correspondence grass had decreased. This could be because heavy metals directly accumulate into the roadside soils whereas the grasses partly absorb heavy metals from the soils.

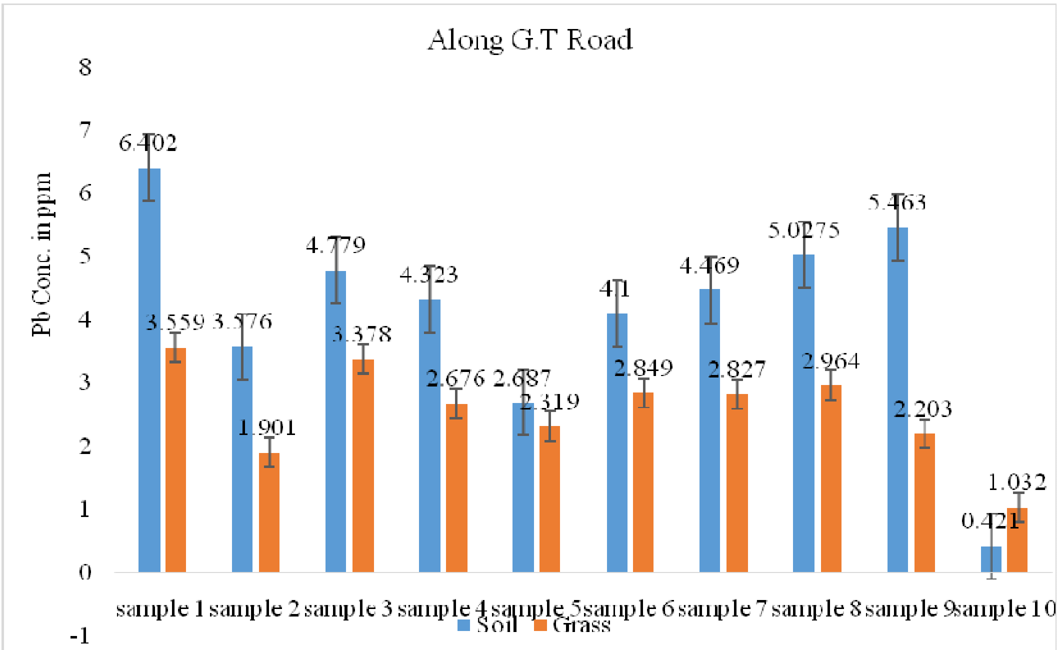

Figure-7

Showing the correlation of Pb uptake by grass from the soil in samples collected along G.T. Road

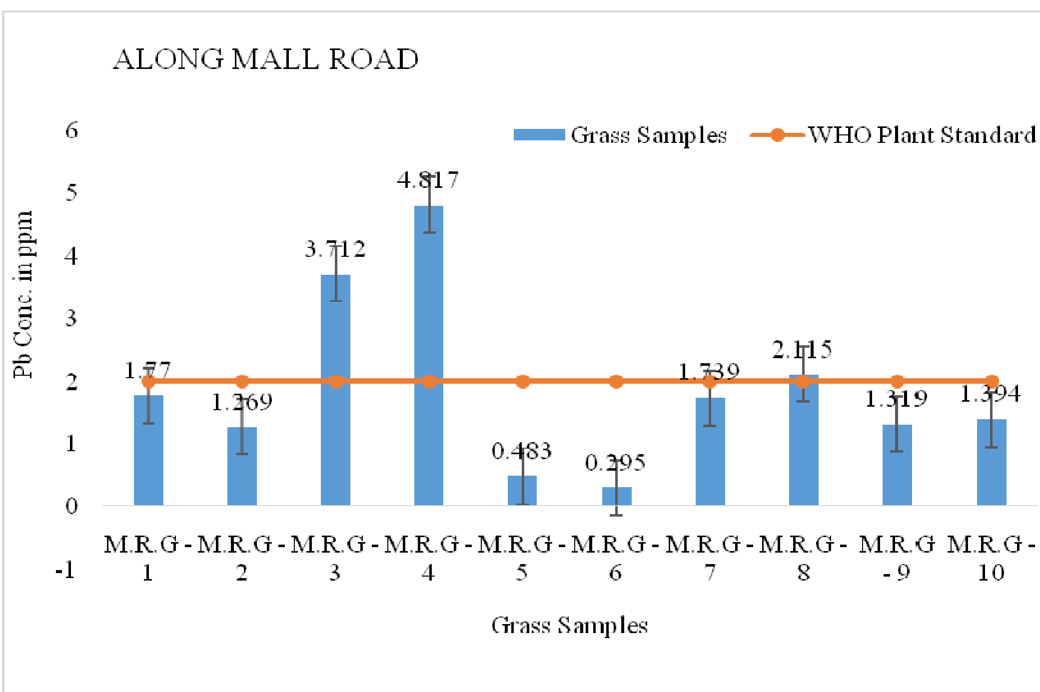

Figure-8

Concentration of Pb in grass samples Along Mall Road compared with WHO Permissible limit (1996)

While mean Pb concentrationin grass samples (0.456 ± 0.385 mg/L) in Cantt. Colony were found to be significantly within (P=0.000) the WHO permissible limit, 1996 of 2mg/L (figure-10). Also for most of the sites Pb concentration in soil samples were below (figure-11) the WHO permissible limits (1996) of 3mg/L with a mean value of 3.095 ± 2.048mg/L. Less concentrations of lead in soil samples might be because Cantt. Colony is a residential area and hasa restricted traffic due to army headquarters. Similar results were reportedby Olukanni and Adebiyi[14] in Nigeria where they found lower concentration (0.11 mg/kg) of Pb at site coded as G because of the least volume of vehicles recorded on that site. A very weak and negative correlation (r = -0.026) was found among Pb concentration in soil and grass samples at this site (figure-12) which could be attributed to the fact that soil at this site had alkaline pH and generally most of the heavy metals are not readily available to plants under alkaline conditions[16].

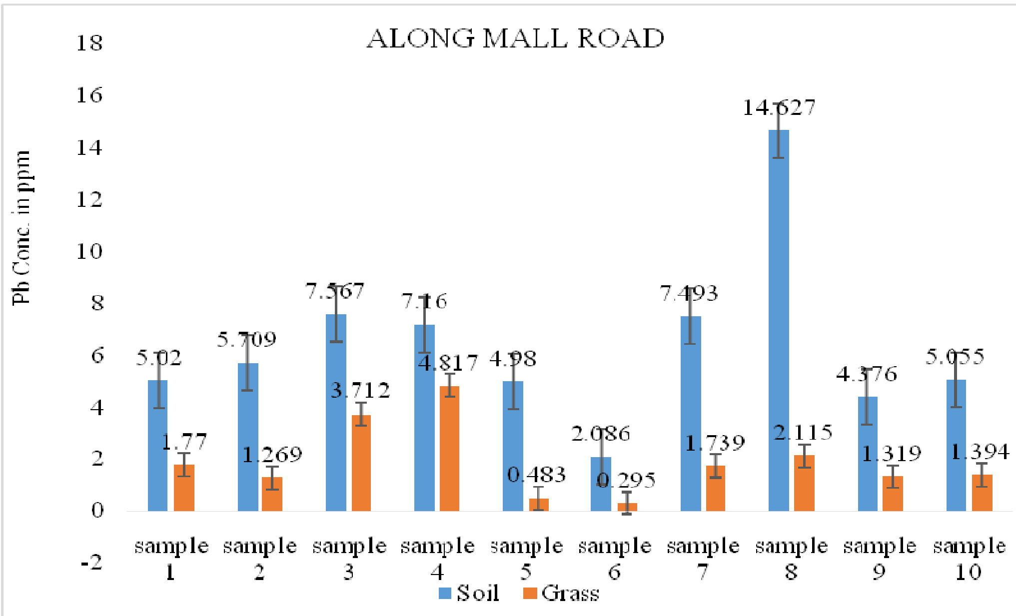

Figure-9
Showing the correlation of Pb uptake by grass from the soil in samples collected along Mall Road

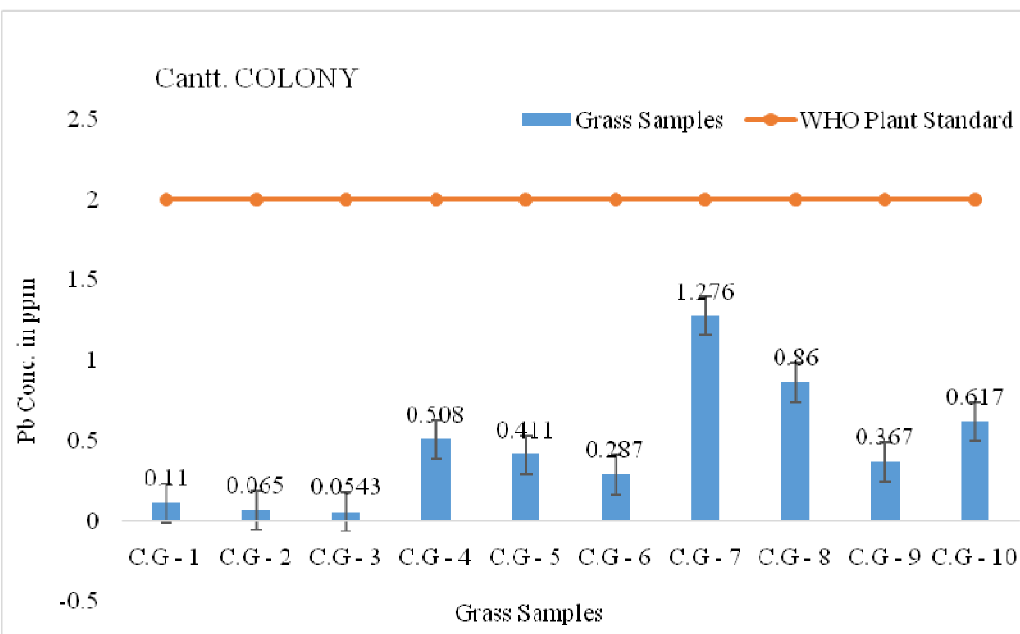

Figure-10
Concentration of Pb in grass samples of Cantt. Colony compared with WHO Permissible limit (1996)

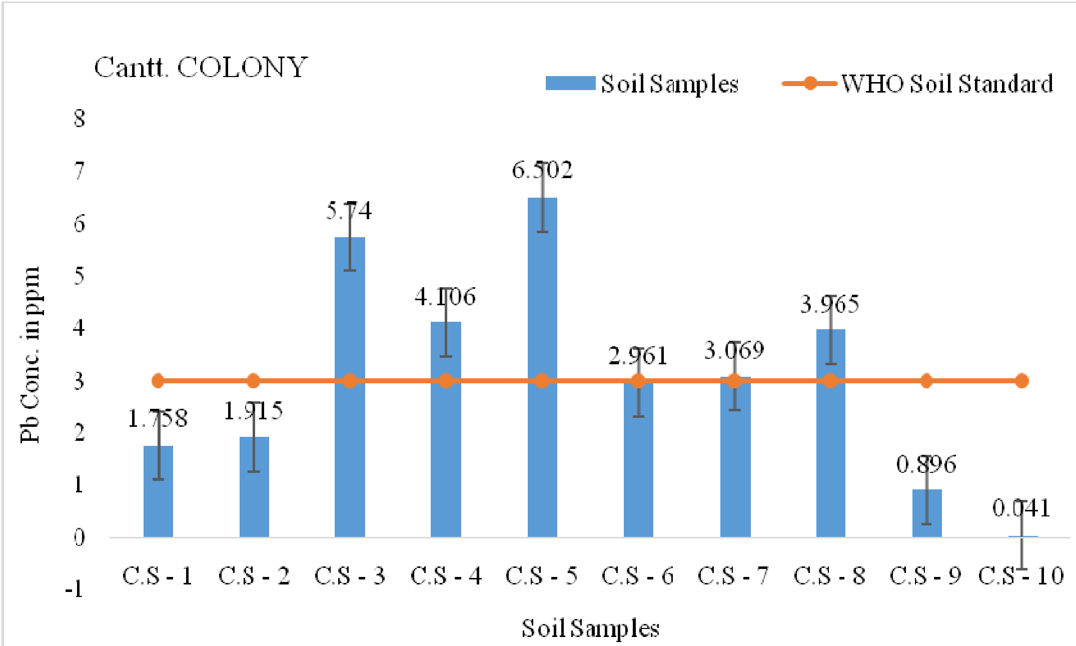

Figure-11
Concentration of Pb in soil samples of Cantt. Colony compared with WHO Permissible limit (1996)

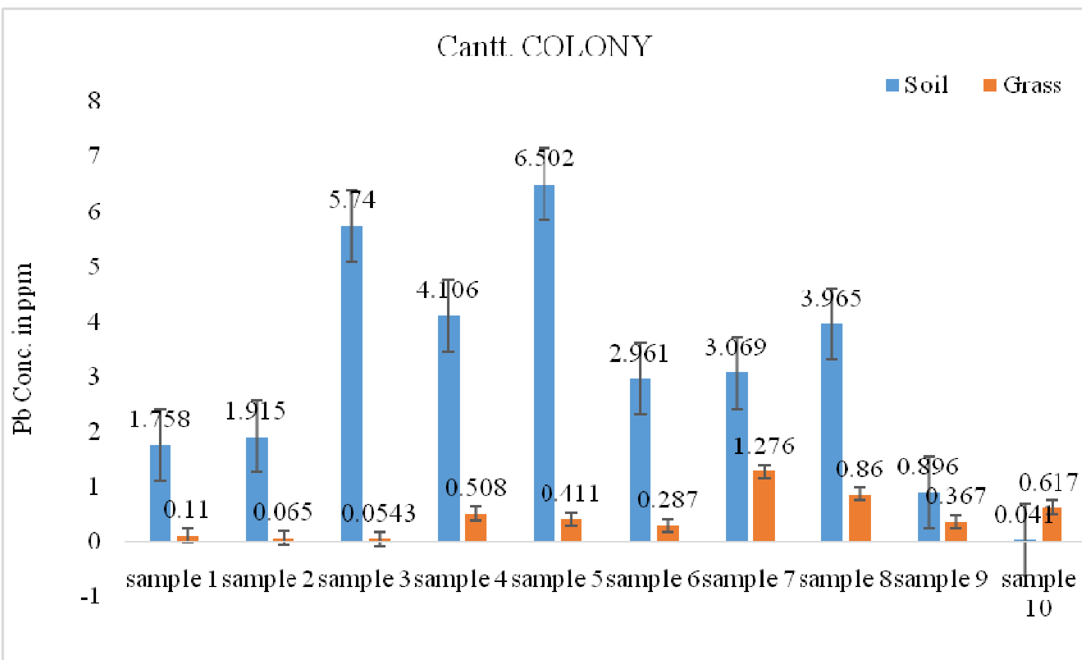

Figure-12
Showing the correlation of Pb uptake by grass from the soil in samples collected along Cantt. Colony

Lawrence Garden was taken as a control site for the collection of soil and grass samples as it has an area of 141 acres and there is no major vehicular movement within the garden. Both soil (0.5736 ± 0.0680 mg/L) and grass samples (0.1984 ± 0.1133 mg/L) collected from the control site had mean concentrations of Pb significantly below (P =0.013) the allowable limits (figure-13 and 14). This finding is in accordance with other studies that found lower lead concentrations in the areas relatively farther away from high traffic activity zones. A perfect correlation (r = 1.000) existed between Pb concentration in soil and grass samples (figure-15). This correlation results are in accordance with one reported by Kruger[13].

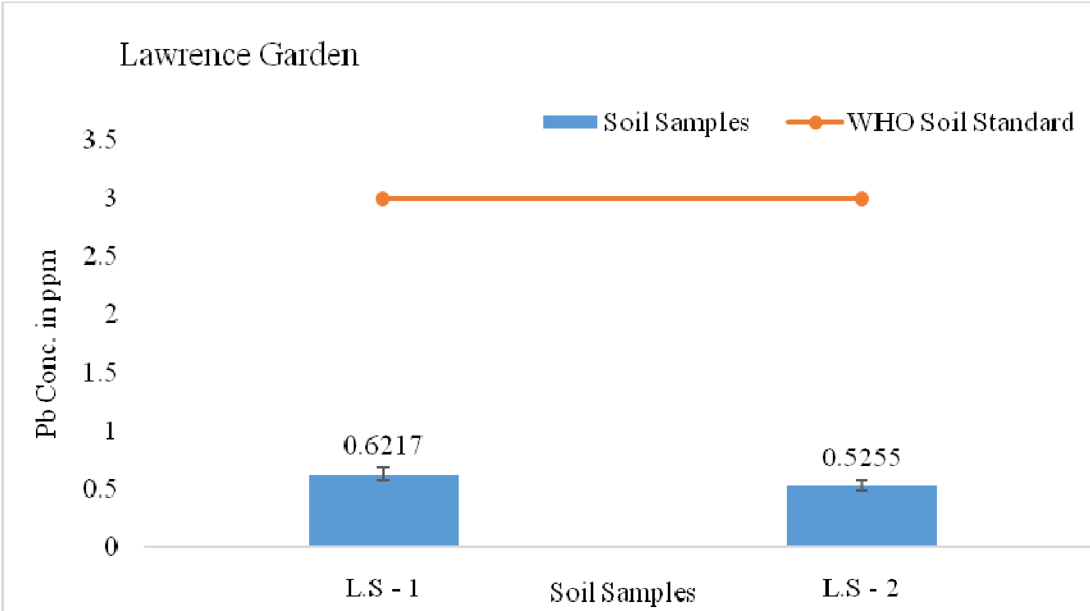

Figure-13
Concentration of Pb in soil samples of Lawrence Garden compared with WHO Permissible limit (1996)

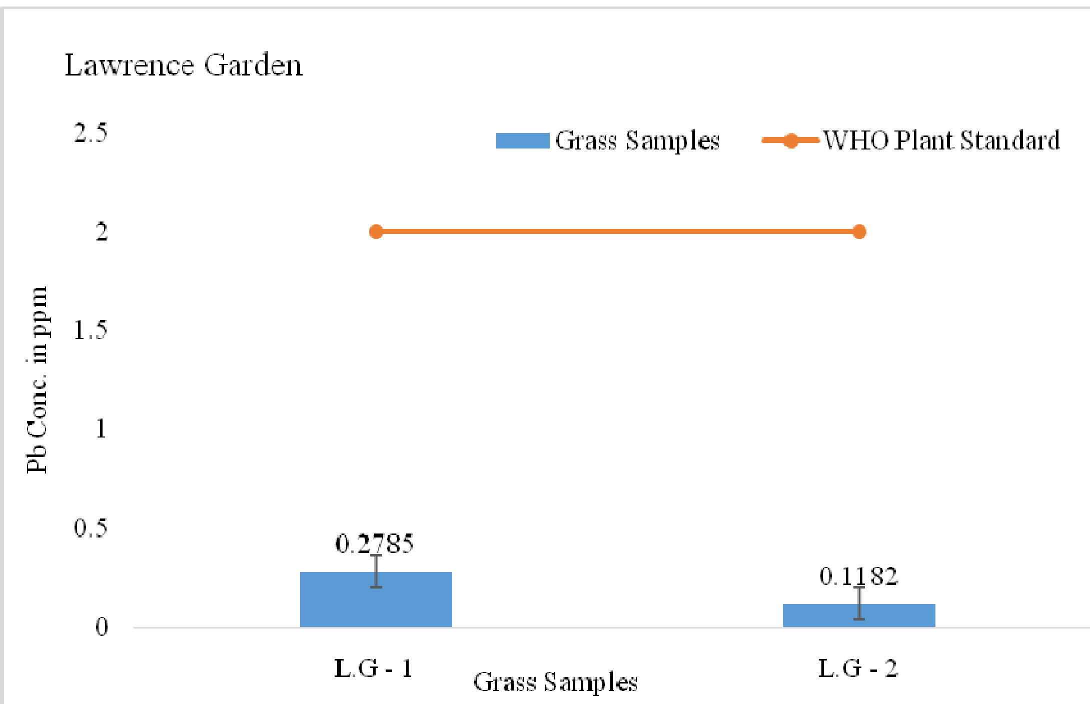

Figure-14
Concentration of Pb in Grass samples of Lawrence Garden compared with WHO Permissible limit (1996)

Conclusion

The results showed that the concentrations of Pb in soil and grass are mainly 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. The impacts of vehicular emissions on soil and other aspects of the environment are presently alarming. Though this problem has been a characteristic of the developed country, it has been found that the impact could be more hazardous in the developing countries such as Pakistan. This is due to the fact that no proper consideration has been given to soil pollution and its implications.

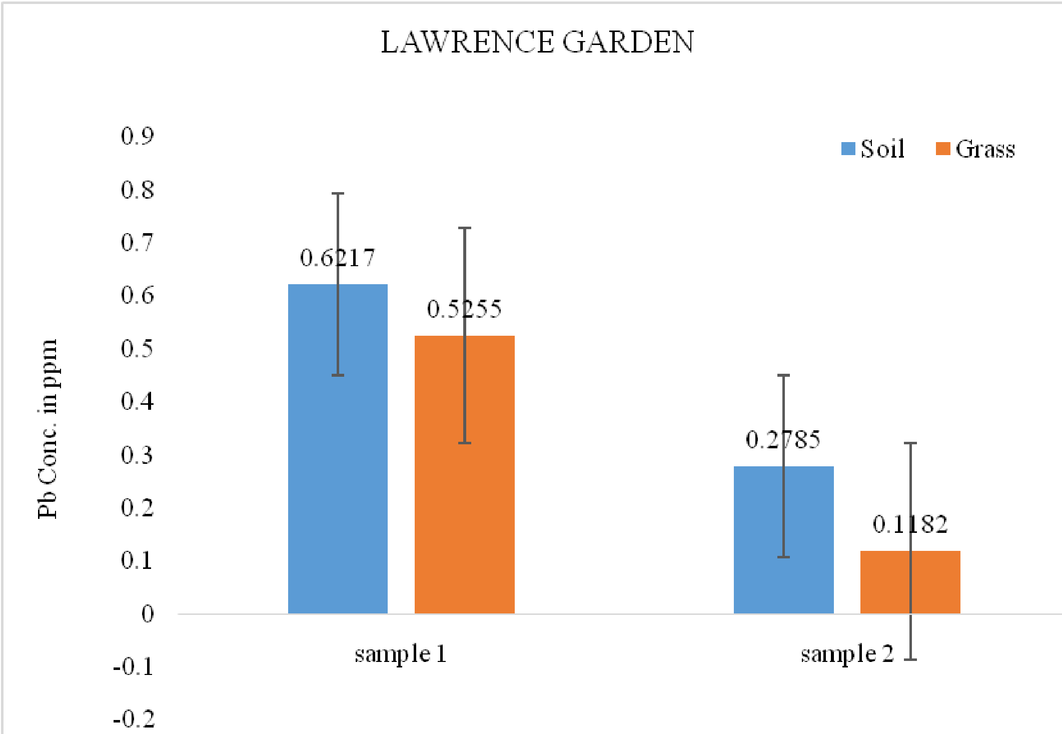

Figure-15

Showing the correlation of Pb uptake by grass from the soil in samples collected from Lawrence Garden

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