SPATIAL DISTRIBUTION OF HEAVY METAL CONTAMINATION IN ROAD SIDE SOILS OF FAISALABAD- PAKISTAN

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ABSTRACT: Today, most urban areas of less developed countries are at the verge of multifarious environmental problems and vehicular transportation sector is considered to be significant contributor to this degradation in the urban environment. The current study is based on a detailed soil survey conducted for heavy metal's analysis in the road side soil of Faisalabad city. The heavy metal induced into the road side soil has been recognized as a serious threat to human health through ingestion and inhaling. Soil samples from sixteen points were taken at a depth of 5 to 15cm in the vicinity of some selected congested road sides. The heavy metal contents were analyzed through the ICP (inductively coupled plasma spectroscopy) for the Zn, Cu, Pb, Ni, As and Cd. Out of these six, two metals (As and Cd) were not traced by ICP. The study was conducted aiming at investigating the heavy metal contents in road side soil and to generate the spatial map for an in-depth analysis. The conclusion designed after descriptive statistics and distribution patterns of roadside soil delineated through the spatial interpolation of inverse distance weight using ArcGIS 10, which revealed that there were a number of hotspots for Zn, Cu, Ni and Pb with mean concentration ranged from 19.2-336.8, 11.25-73.20, 13.38-29.70 and0.00-27.05 mg/kg while a decreasing order of heavy metals mean values on all the selected roads are Zn>Cu>Ni>Pb.

Key words: Spatial, Heavy metal, Road side soil, IDW and Kriging analysis.

INTRODUCTION

The concentration of more than half of population of the world in the designated urban areas (UN, 2009) has significantly contributed in acceleration of pollution problems in urban centers (Wei *et al*, 2009). A dense population with ample economic activities has released numerous contaminations of all sorts in all spheres of urban environment such as air, water and soil. The soils of urban areas are generally affected by urban and industrial activities. Due to this several environmental issues have emerged in mega cities of the world, while as a result of urban and industrial growth, toxic metals in the urban soil are among the most severe of these problems (Chen *et al.,* 2010; Wong *et al*., 2006). The heavy metals have been added into urban soils through urban waste, chemical industries (Chaoyang *et al.,* 2009; Chang *et al.,* 2008) and most importantly through the vehicular emission (Xia *et al*., 2011). The urban road side soil has been recognized as an important repository of heavy metals. Moreover the road side soil containing heavy metal contents can discharge these pollutants into the air and water sectors of the city's environment. It is evident that the urban soil containing the heavy metal pose a serious threat to the safety of the human life by ingestion, inhaling(Wei and Yang, 2010) and through the direct contact with the soil on the road sides contaminated by heavy metal (Yang *et al.*, 2010).

A number of studies have indicated that such metals could be stored in fatty tissues of human beings and consequently affect the functions of the vital organs and disturb the nervous system &endocrine system (Yesilonis *et al.*, 2008; Ali and Malik 2010). Moreover, the road side soil containing heavy metal contents can eject these pollutants into the air and added into the water sectors of the environment (Nasser *et al.,* 2012).As a result, pollutants deposited in the road side soil severely disturbed the natural geochemical cycle of the urban ecosystem (Shi *et al.,* 2008; Yisa, 2010). The current research is an effort to determine the heavy metal distribution in the urban road side soil with help of geo informatics techniques and a field survey was conducted to assess the traffic volume on some selected road of Faisalabad city. The objectives of the study were to evolve spatial maps of heavy metal viz; Zn, Cu, Pb, Ni, Cd and as concentration patterns in urban road side soils of Faisalabad city and their likely effects on the people living in nearby areas.

MATERIALS AND METHODS

Study Area: Faisalabad city is located on the alluvial plains of northeastern Pakistani province of the Punjab, extending from between 30°42' and 31°47' north latitudes and 72°40' and 73°40' east longitudes (Fig.1). During the past few decades, this city has faced a rapid urban and industrial growth and has been transformed into a great

metropolitan center and industrial city since 1980's.The primary roads of Faisalabad city were selected for the road side soil sample collection. The numbers of vehicles on the primary roads of the city exceeded with rapid urban growth. The population of Faisalabad city has reached to 25, 52,000 (GOP, 2010) souls and this increased rate of population growth has caused significant environmental problems in this industrial city of Pakistan.

Road Side Soil Sampling Strategy: All the samples were collected from the congested road sides of Faisalabad city and sixteen sites were selected on the primary, secondary and tertiary road sides of the city for the soil sample collection.

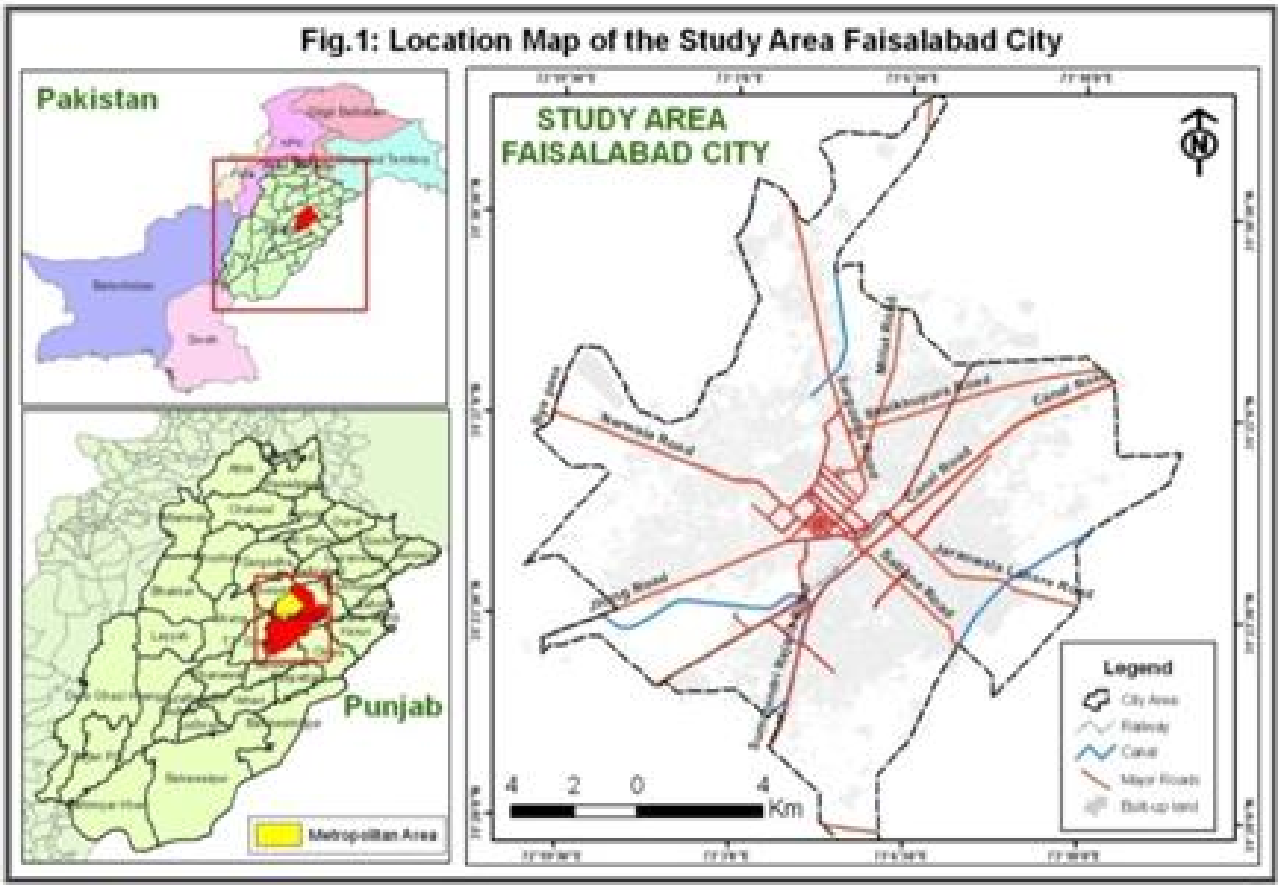


Table 1: Average value of heavy metals on roads and Sample Sites of Faisalabad city

Roads	Sample Sites	Zn mg/kg	Pb mg/kg	Cu mg/kg	Ni mg/kg
Sargodha Road	Drain, Crescent mill, Sitara chemical drain, Jia textile, Hina-Sana textile, sui gas Main store	43.49	3.6	20.6	15.8
Sumandari Road	Pepsi beverages	55	8.75	20.9	13.37
Jaranwala Road	NFC	85.45	2.5	21.7	23.3
Canal Road	Steam power station	19.17	1.4	21.5	24.97
Sheikhupura Road	Crescent Sugar mill, Gandha Nala	336.75	17	42	21
Jhang Road	Nuclear Institute of Agriculture and bio	44.67	0	22.2	29.7
Susan road	Refhan Maize Product	87.27	12.2	18.62	16
Club Road	Ibrahim Group of Industries	26.55	0.95	11.25	14

Source: Parveen, 2011.

The road side soil from a depth of 5–15 cm to estimate the influence of traffic emission on the soil pollution from Shiekhupura, Sargodha, Jaranwala, Sumandari road sides were collected in the polythene bags. The soil was also sampled from other road sides and places where industrial installation and vehicular emission was observed to be in excess. The places included in this are: Crescent textile mills, inside *Gandha Naullah* (drain line), Jia textile, Sitara mills drain and the Sui gas store situated on the Sargodha road. The Faisalabad- Sargodha road is a major area where a number of industries have been located and as a result, environmental degradation is apparent and significant. In addition to this, Crescent sugar mills situated on Shiekhupura road, a Textile mill near seam *naullah* and drain on Millat road were selected for spatial sampling. A soil sample was also collected from the club road near the Ibrahim Group of companies. One sample was also taken from Sumandari road near Pepsi beverages and the other one was taken up from Jaranwala road near NFC. In order to have a wider areal coverage, two more soil samples were collected from the canal road and the food processing factory near the Steam power station (Fig. 1).

Sample Processing: The soil sample digestion was performed with strong acid digestion through the following steps (Lee *et al.*, 2004), the pre-weighed 2g of soil sample put into a titration flask and then 10 ml of HNO_3added and heated in low black at 80^o- 90^oC for the night and then entered into the tubes into tall blocks and heated up to temperature ranging 125^oC - 130^oC for 24 hours. After this all the soil was cooled and added 1ml HNO_3 along with 4ml $HClo_4$ and then again heated between temperatures 200^oC - 210^0C to dry it with funnel condenser. The same process of cooling was carried out and then an addition of 4ml of HCl and 50ml of water were made .After that the same soil sample were again heated up to $70^oC$for one hour and after that soil's residue was rinsed with 1% HNO_3 and volume make up with 1% HNO_3.

Methods of heavy metal pollution assessment by ICP: The research is based on an extensive field work and is derivative in nature. It is augmented by the experimental examination of soils found in many parts of the City, while heavy metals were analyzed by ICP inductively coupled plasma optical emission spectroscopy, Perkin Elmer 2100 DV (Lee *et al.*, 2004; Bhattarai, 2006) in the Nuclear Institute of Agriculture and Biology (NIAB) Laboratory for Cd, As, Ni, Zn, Pb, and Cu.

Geo statistics methods and mapping of metal concentration: Data analysis and mapping of heavy metals contents on 16 sites of urban road dust were performed through the Kriging/ IDW (Inverse Distance Weight) interpolating technique by using Arc GIS 10. Moreover the descriptive statistics and box plot were generated with help of the software SPSS version 19.

RESULTS AND DISCUSSION

As stated earlier, the spatial analysis maps were produced, using the inverse distance weight analysis (IDW) for the road side soil .The findings of present research has also been providing a comparison of the permissible level of heavy metal detected in road side soil (Table 2).The investigated level of Zn contamination observed in the road side soil ranged from 19-86.9mg/Kg (Fig.3). The Zn emission is concerned from the automobile and human activities (Yesilonis *et al.*, 2008; Lourenico *et al.*, 2010; Akbar *et al.*, 2006). The maximum amount of Zn 336.75 mg/Kg was observed in the soil sample of Shiekhupura road side which is much beyond the WHO acceptable limits. This soil sample was picked up from the vicinity of a drain which is receiving disposal from the nearest urban settlements.

Table 2: Descriptive Statistics

Elements	Acceptable Limits (mg/Kg)	Descriptive statistics				Standard Deviation
		Minimum	Maximum	Range	Mean	
Zn	135-150	19.18	336.75	19.2-336.8	66.2000	74.89
Pb	30-40	.00	27.08	11.25-73.2	5.0938	7.15
Cu	85-450	11.25	73.20	0.00-27.05	23.8891	14.85
Ni	30-70	13.38	29.70	13.38-29.7	19.7328	4.956

Source: Parveen, 2011

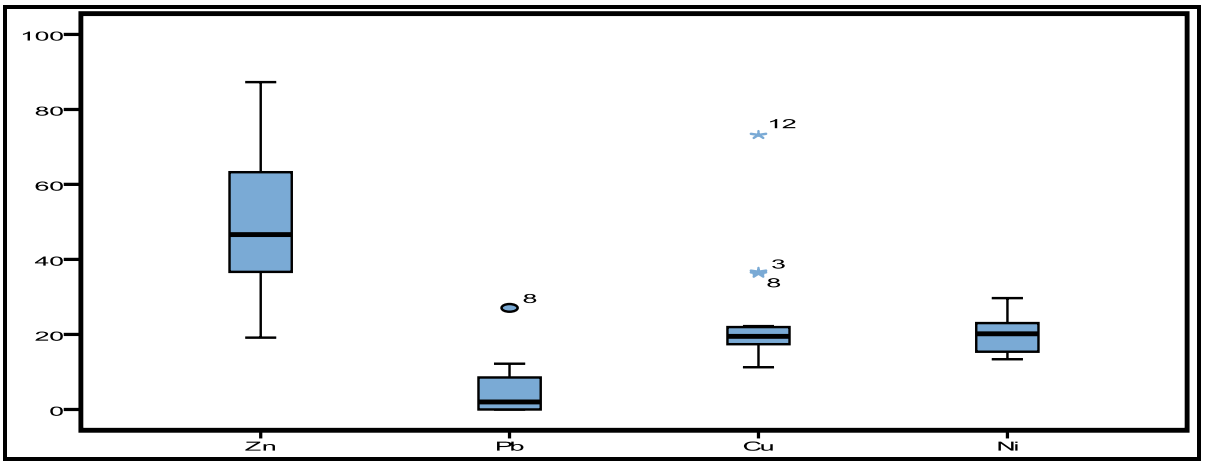
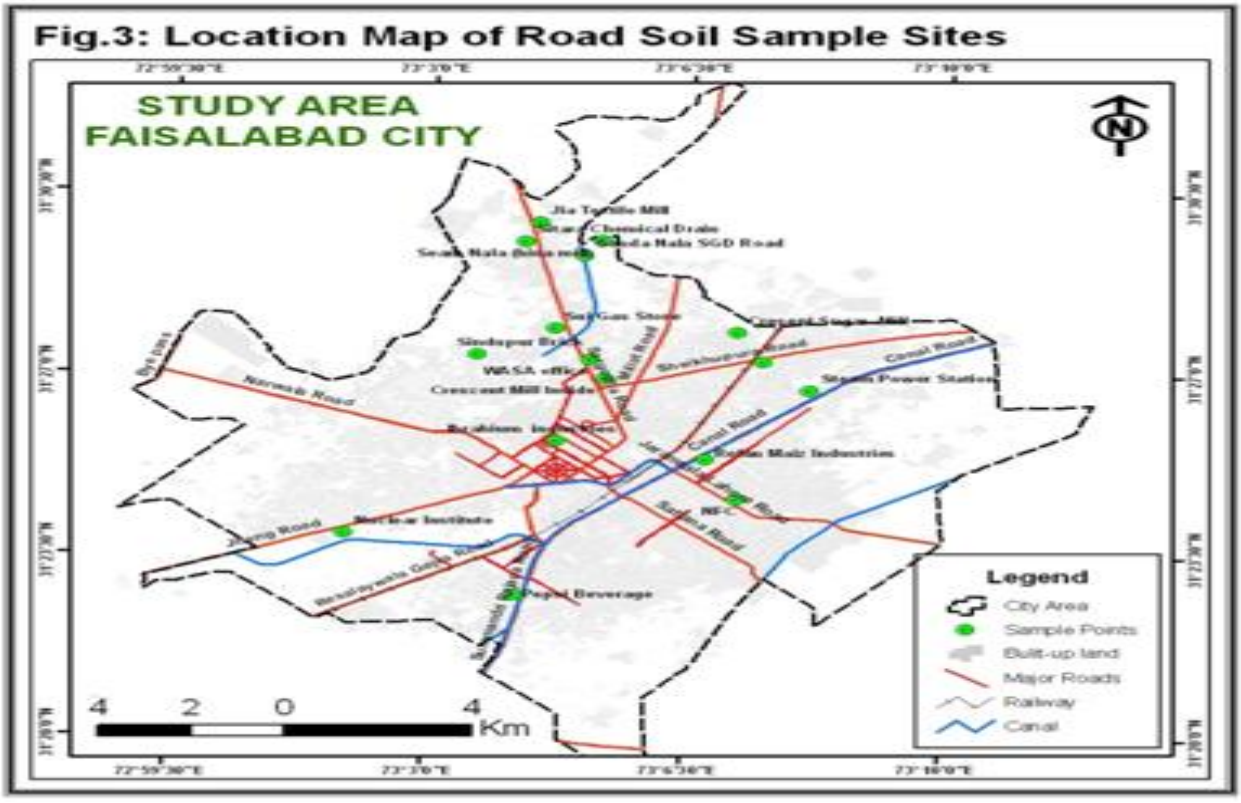


Fig. 2: Box-Whisker Plot of heavy metals (Zn, Pb, Cu, Ni mg/kg) contamination in road soils

Source: Parveen, 2011

Refhan Maize factory on Susan road, Crescent Sugar Mill, NFC and Jaranwala road have Zn values ranging from 56mg-87mg/Kg after ICP examination was carried out. Comparatively least concentration were observed for soil samples on Sumandari road near Pepsi Beverages whereas Drain on Sargodha Road and Sitara Chemical Drain have Zn value ranged 48- 55mg/Kg. The soil samples which were picked up from the Sargodha road near the Sui Gas Main store, Jia textile, Hina-Sana Textile, Jhang road near the NIAB and WASA Office soil samples (fig. 3) have Zn contamination ranged from 30-47mg/Kg and have been interpolated through the IDW analysis. It was delineated that the following soil sample Sindupura Brick Kiln, Canal road soil sample in the vicinity of the Steam Power Station and Sargodha road sample in the neighborhood of Crescent Mill were slightest polluted with Zn (Fig.4). The Box-Whisker Plot provides accurate knowledge for Q1, median, Q3 and interquartile range. Road dust (Zn mg/Kg Contamination) median is 46.6375, and the interquartile range is 34. An outlier appears at 12. Furthermore the average quantity of Zn is higher in the Road side soil.



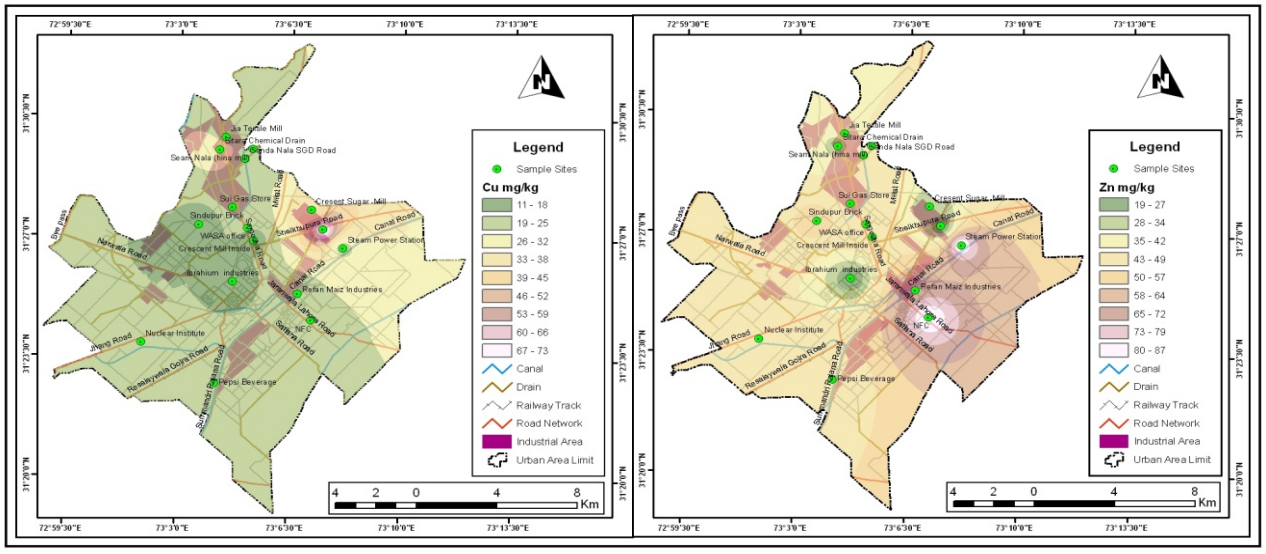


Fig. 4: IDW map of Cu and Zn contamination in Road Side Soils

Source: Author

The Cu (mg/Kg) contamination in road side soil has the level rangedupto11-73mg/Kg. The chemical equilibrium of Faisalabad's urban ecosystem seems to be endangered due to industrial activities and road side soil (Akbar *et al.*, 2006).The maximum quantity of Cu 73 mg/Kg is far beyond the acceptable limits (Table 2) and found in the road side soil of Shiekhupura road which is clearly depicted through IDW map. The Crescent sugar mill and Sitara chemical drain share the equal quantity of Cu pollutants when compared with other sample sites. The remaining surveyed sites on the road side have not shown great deal of spatial variations for Cu as apparent through the map (Fig.4).Metals value fluctuates due to industrial existence on roads. The box plots statistics represents median as 19.4875, and the interquartile range is 4.78 for Cu mg/Kg contamination whereas two outliers are visible at 8 and 12 (Fig.2).

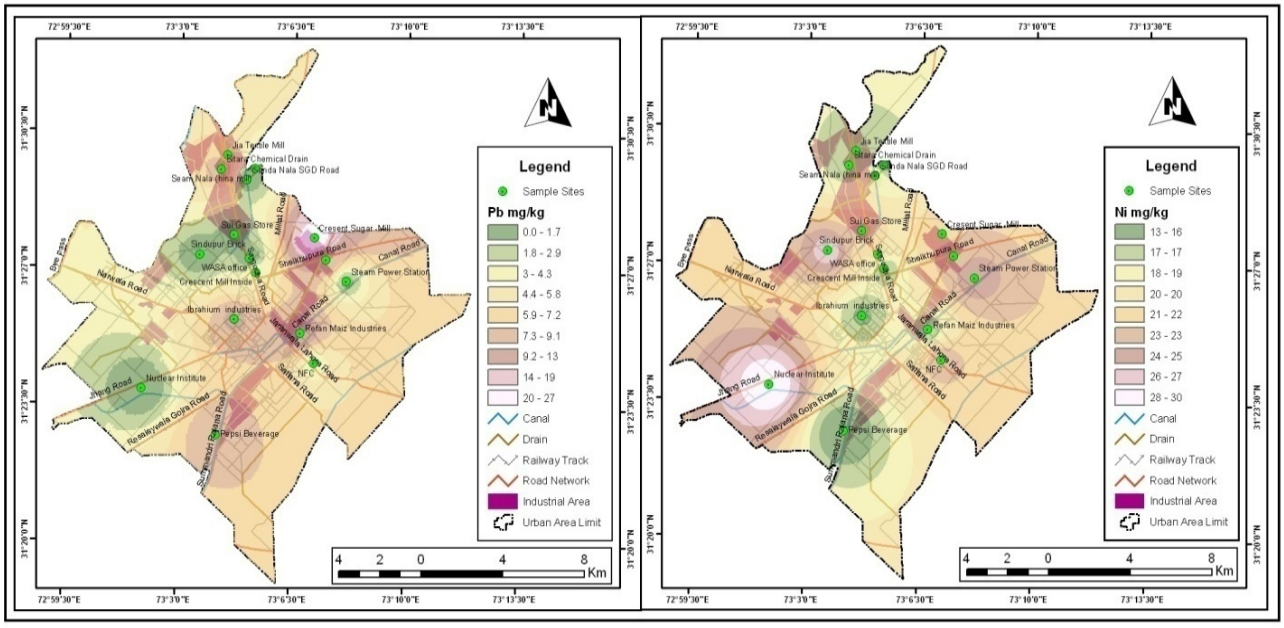


Fig. 5: IDW map of Pb and Ni contamination in Road side soils

Source: Author

The Pb (mg/Kg) contamination level is mainly caused by industrial and motor traffic (Jankiewicz and Adamczyk, 2007) and interpolation of data through IDW shows that the range of Pb in the study area is 0-26.9mg/Kg (Fig. 5) The maximum extent of Pb (26.9 mg/Kg) was observed in the soil of Club road side near Ibrahim group of industries revealed by the map. The second major concentration of Pb was examined in the soil of Sargodha road side form inside of Crescent mill. An inverse distance weight analysis map shows six sites having less than 1 while 4 sites have 2-4, 1 site has 5-8, and 9-12 range has 3 road sides soil samples (Fig. 4). It is agreed that the Pb inflow into the soil is strongly associated with traffic emission (Maas *et al*., 2010; Adija *et al*., 2008). The box and whisker plots shows that the median is 1.9875, while the interquartile range is 8.64 and outlier come out at 8 for Pb mg/kg in roadside soil (Fig.2).

The IDW maps depicted the intensity of Ni observed in the road side soil ranged from 13-29.9mg/Kg (Fig. 5). The maximum amount of Ni (30mg/Kg) was in the soil sample near NAIB (Nuclear Institute of Agriculture and Biology) on Jhang road whereas the Sindupura Brick Kiln soil has comparatively less quantity of Ni metal. Besides these few sites, rest of the road side soil sampled areas such as, Crescent sugar mill soil sample, Refhan maize product sample on Susan road side and NFC on Jaranwala roadside, Sumandari road soil sample in the vicinity of Pepsi beverages and Sitara chemical drain, Sui gas main store, Textile units of Sargodha road sides sample such as Hina-Sana, Jia textile and canal road side soil has Ni contamination ranged from 15 to 25 mg/Kg which is within the allowable level (Fig. 4, Table 2). Road side soil median is 20.1750, and the interquartile range is 7.9 for the Ni mg/Kg Contamination (Fig.2).

Conclusion: This research is based on an extensive soil survey in urban localities of Faisalabad, Pakistan, to assess the existing status of heavy metal contamination in the road side soils. The research is more an experimental work to analyze the heavy metal contamination related to Zn, Cu, Pb, Ni, as and Cd in road side soil. The heavy metal contents were analyzed through the ICP (inductively coupled plasma spectroscopy). The geographical and statistical analyses (Inverse Distance Weight) were performed through the Arc GIS 10. The concentration of these heavy metals in the urban environment can mainly be attributed to heavy traffic flow and consequent emission of smoke onto the road side soil. It has been observed that metal like Zn, Cu, Ni and Pb showing mean concentration ranging from 19.2-336.8, 11.25-73.20, 13.38-29.70 and0.00-27.05 mg/kg respectively. The findings of this study will be useful for policy makes, city managers and environmentalist as monitoring of the soil's heavy metal contents are regarded as an essential component for the quality assessment, ensure the safeguard for human health and guaranteed sustainable development of the urban geochemical environment of Faisalabad. These research results can provide essential background for the future work to be undertaken by researches of various disciplines. It is recommended that the future research activities of this nature would be to conduct on larger geographical areas and shall encompass on more soil surveys. Therefore it is recommended for the urban planners to design the further industrial expansion in out skirts of the city in order to minimize the risk factor. It is further suggested for academicians that number of metals to be analyzed for pollution assessments of the urban topsoil in Faisalabad should be more in number and types. Finally, future researchers should also emphasize more on impacts of soil contamination on the human health and analyzed the same for urban ecological stability within this industrial city of Pakistan-Faisalabad.

Acknowledgment: This is an excerpt of first author's unpublished M. Phil Geography thesis. She did her research work in the Department of Geography, GC University Faisalabad Pakistan. The authors are also thankful to the Lab (NIAB) staff for technical support in soil analysis. We pay our special gratitude to Dr. Yasin Ashraf of NIAB who helped us in the soil analysis.

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