Journal of
Geography & Natural Disasters

Mondal, J Geogr Nat Disast 2012, 2:1
DOI: 10.4172/2167-0587.1000105

Research Article Open Access

A GIS Based Assessment of Heavy Metals Contamination in Surface Soil of Urban Parks: A Case Study of Faisalabad City-Pakistan

Parveen N[1]*, Ghaffar A[2], Shirazi SA[2] and Bhalli MN[3]

[1]Department of Geography, GC University Faisalabad, Pakistan
[2]Department of Geography, Punjab University Lahore, Pakistan
[3]Department of Geography, Govt. Postgraduate College Gojra, Pakistan

Abstract

The study investigated the environmental attribute of urban parks for risk assessment due to heavy metals mobilization into biosphere. Sixteen busiest urban parks located in the city of Faisalabad were analyzed for the Copper, Zinc, Nickel and Lead contamination. The research foundation was derived through the experimental observations. Analytical determinations of heavy metals contents were performed by ICP (Inductively Coupled Plasma) optical emission spectroscopy. Multivariate Geospatial analyses were performed, using GIS (Geographic Information System) techniques and statistical analysis with the help of SPSS 14. The investigations revealed that the metals mean concentration in the study area ranged from 25.02-111.15, 13.83-53.23, 9.30-26.00 and 0.00-18.93 mg/Kg for Zinc, Copper, Nickel and Lead respectively. One of the sites among the selected urban parks was reported to cross the acceptable limits for the Copper contamination in the soil which is pertinent to hepatic and basal ganglia degeneration.

Keywords: Soil contamination; Heavy metals; GIS; Urban parks

Introduction

Among many anthropogenic causes, rapid urbanization and industrialization are the two fundamental factors causing degradation of the environment [1,2]. Environmental pollution affects the quality of each of the spheres viz; pedosphere, hydrosphere, atmosphere, lithosphere and biosphere [3,4]. In recent era, environmental degradation and consequent problems of large cities and urban-industrial agglomerations is a subject of fundamental concern and debate among planners and policy makers. The world is turning towards an urbanized world and more than half of the population is living in urban areas. This trend is getting momentous increase and more people are shifting to urban areas. This is one way, or the other effects the city environment and ultimately because of the human activities, the urban environment tend to be degraded. As the world urbanization prospects suggested the world urban population will reach from current to 8.3 billion in 2030 [5].

Contamination of urban soils with heavy metals has been studied and documented all over the world and in many disciplines including geography. This phenomenon followed by massive research has created a major apprehension at local, regional and global level due to their implication on human health [6,7]. Heavy metals can cause surface and ground water pollution and are taken up by plants, released as gases into atmosphere or bond semi enduringly by soil components such as organic matter and clay particles which later affects human health [8]. Natural sources of heavy metals are weathering of parent rocks. Furthermore there are several point and non-point sources of heavy metals frequently related to the urban land use, economic, industrial and transportation set up [9].

Moreover Xia et al. [4], excogitate the soil heavy metals pollution a major environmental dilemma while Maas et al. [10] considered the soil a sink as well as a source of pollution and most significant entity for risk evaluation. Vehicular emission commercial fertilizers, atmospheric deposition of contaminants through dust and aerosol's, industrial and domestic waste, thermal power stations based on coal-fired and energy industry based on fossil fuel burning have also been sources of the huge amount of heavy metals contents in urban soil [10-12].

GIS is computer based information system which is a potent tool for the geochemical mapping of trace metals in the various compartment of the environment such as air, water and soil. Geographic Information System provides the techniques for measuring, modeling, manipulating, retrieval and analysis of spatial data. The interactions between the chemical contaminants such as trace metals and urban land features of the urban environment can be conducted with the help of overlaying analysis of the contaminants spatial distribution in the various urban landscapes [12-16]. Thus present research interrogates the spatial distribution of heavy metals in urban parks soil of the study area i.e.; Faisalabad city.

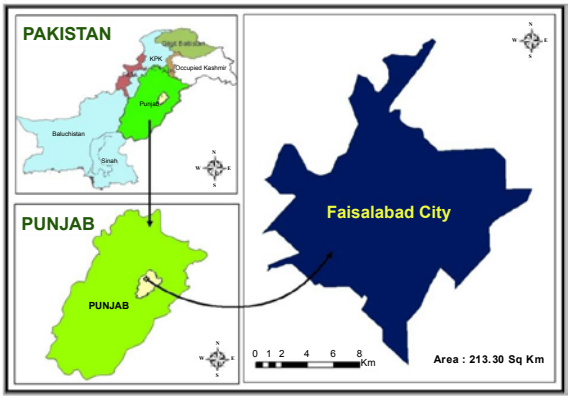

Figure 1: The study area.

***Corresponding author:** Parveen N, Department of Geography, GC University Faisalabad, Pakistan, E-mail: nusratgcuf@gmail.com

Received May 16, 2012; **Accepted** June 20, 2012; **Published** June 25, 2012

Citation: Parveen N, Ghaffar A, Shirazi SA, Bhalli MN (2012) A GIS Based Assessment of Heavy Metals Contamination in Surface Soil of Urban Parks: A Case Study of Faisalabad City-Pakistan. J Geogr Nat Disast 2:105. doi:10.4172/2167-0587.1000105

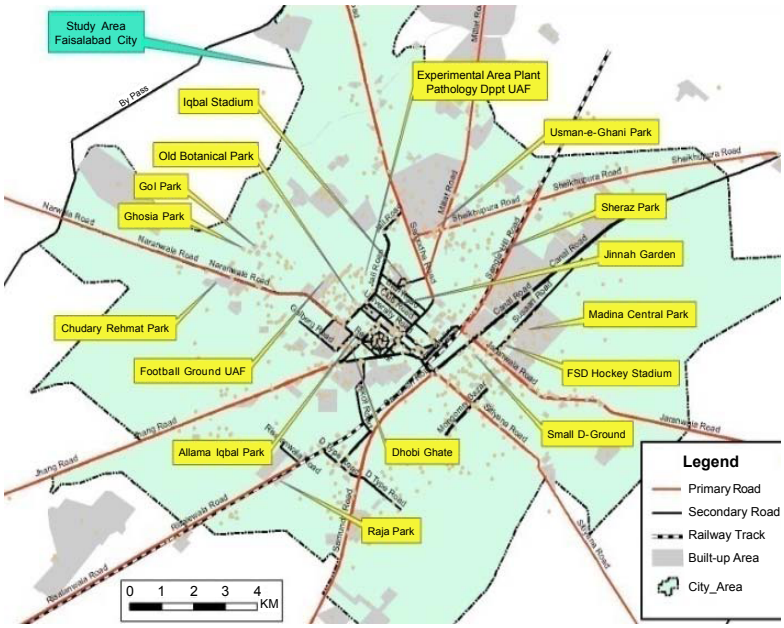

Figure 2: Location of soil sample sites urban parks, Faisalabad city.

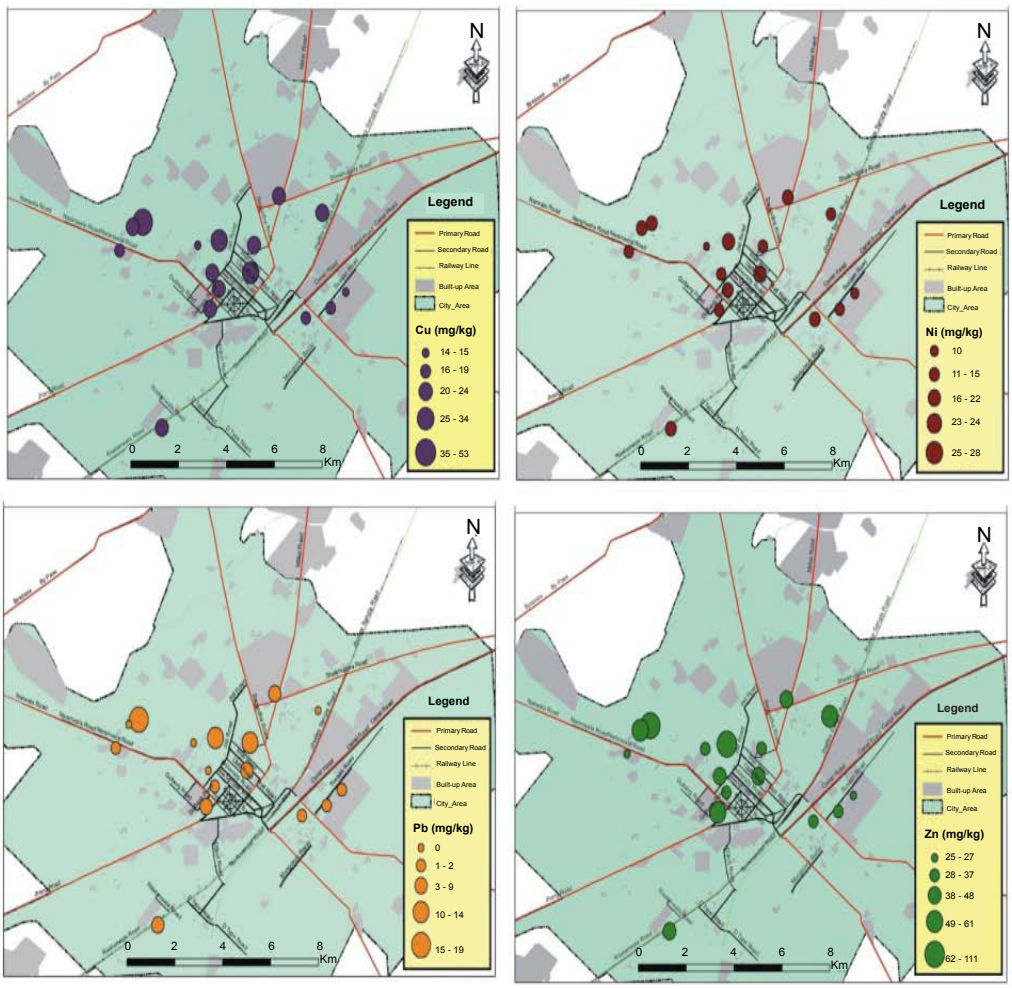

Figure 3: Spatial analysis of Cu, Ni, Pb and Zn urban parks in Faisalabad city.

Aims and objectives of the study

The aim of study is to examine the spatial variation of the the heavy metals contents in surface soil of the study area by using GIS techniques.

a) To assess the environmental quality of urban parks by analyzing the pollution level of heavy metals in the urban soils of Faisalabad city.

b) To evaluate Spatial Risk of the heavy metals on human health.

Study Area

The study area Faisalabad, "the Manchester of Pakistan" lies between longitude 73˚ to 74˚ east, latitude 30˚ to 31.5˚ north. The city's elevation is 605 feet above mean sea level. Faisalabad is the third largest city in terms of population size and ranked third in the national hierarchy. Present population of the city is 25,53,000 souls. The districts surrounding Faisalabad have not been separated from the city by any natural and physiographical feature. Faisalabad is bordered by Sheikhupura, Okara and Sahiwal districts, towards the east and south east while on the west and south west has been bounded by district Jhang and Toba Tek Singh. In the north and northeast it is surrounded by Hafizabad and Sheikhupura districts. Because of population size as well as industrial concentration, all the compartments of the environment needs to be thoroughly examined and researched with the help of latest techniques currently used in geography.

Presently, City District Faisalabad consists of eight Towns, which are as follows: Lyallpur Town, Medina Town, Jinnah Town, Iqbal Town, Samundri Town, Tandlianwala Town, Jaranwala Town, and Chak Jhumra Town City Motorway are linked to city through M-3 section boundaries. The research work was conducted in four towns namely Lyallpur town, Iqbal town, Medina town and Jinnah town and the areal extent of sample sites was 213 sq Km (Figure 1). The soil in the Faisalabad city is calcareous in nature with alluvial deposition by two adjoining rivers *viz*; River Chenab, which flows 30 km northwest and river Ravi, 40km away from the city [17].

Materials and Methods

GIS is one of the key tools for soil, water, air and land pollution assessment widely used amongst researchers in various disciplines. Since, Faisalabad is an industrial city and more prone to contaminants therefore by considering, conducting and monitoring heavy metals contamination in surface soil of urban parks is as an important debt in academic circles. The current research work preceded with collection soil data from the selected sites in urban parks of Faisalabad city (Figure 2). Soil Samples were taken at 15 cm depth because top soil lies in this depth while hand held GPS was used to record the global co-ordinates of each selected site for spatial analysis. The selection of urban parks was based on maximum number of visitors per park and sixteen most popularly visited urban parks, playgrounds and green areas in the Faisalabad city were selected for heavy metals Zinc, Copper, Nickel and Lead analysis (Figure 3). The logic behind this was the greater exposure of human population in these parks meaning more the visitors more they will be prone to be affected by soil contamination. Analytical determinations of heavy metals contents were performed by Inductively Coupled Plasma (ICP), Optical Emission Spectroscopy, Perkin Elmer 2100 DV [15,18].

Heavy metals were analyzed by ICP spectroscopy in the Nuclear Institute of Agriculture and Biology (NIAB) laboratory for Ni, Zn, Pb, and Cu. Spatial maps of pollution assessment were designed with the help of Geographic Information System. Spatial distribution maps of heavy metals were created by using the quantities technique of graduated symbols method with help of ArcGIS 9.3 Software. Various statistical measures such as cluster analysis were performed in order to have an insight to the level of pollution of each parameter and their comparison with each other. The secondary data regarding the health condition prevalent in the study area was collected from the District Health Office, Faisalabad (DHO, 2011).

Result and Discussion

The concentration of Zn found in the soil of the urban park the study area range from 25 mg/Kg to 111 mg/Kg (Figure 3 and Table 1). The presence of Zn is strongly related to the uncontrolled solid and liquid waste from industrial, domestic and sewerage as well as other anthropogenic activities [11,19]. The maximum concentration of Zn (mg/Kg) 62-111 was recorded in Gol Park, Gousia Park and Plant pathology experimental area of UAF which has crossed the world average values Zn concentration (Table 2). Sheraz Park, Dhobi Ghat were reported to have 49-61 (mg/Kg) of Zn. Alfateh Ground, Jinnah Garden, Raja Park and Usman-e-Ghani Park have 38-48 mg/Kg of Zn contamination whereas, the 28-37 range were found in the urban parks Allama Iqbal, D-Ground, Hockey stadium, Foot Ball Ground, Iqbal Stadium. There were two places Madina Central Park and Kaleem Shaheed Park with minimum concentration of Zn i.e., 25-27 mg/Kg (Figure 3). Diarrhea is 2nd most common disease in Faisalabad district in the month of January & February 2011 (Figure 4). Gastrointestinal infections are results of Zinc excessive exposure (Ghishan et al., 2006). Spatial variation of Cu contamination found in the soil of urban parks in the study area ranged from 14mg/Kg to 53mg/Kg and has been depicted through spatial map created by using the quantities technique of graduated symbols. The maximum quantity of Cu within the range 35-53 (mg/Kg) and above the acceptable limit (Table 1) and far beyond the world average quantity of Cu (Table 2) was investigated and reported in Gol Park.

While, Cu in plant pathology experimental area of University of Agriculture Faisalabad and Jinnah Garden ranges from 25 mg/kg to 34 mg/kg above the world average (Table 1). Raja Park, Dhobi Ghat, Alfateh Ground, Gousia Park, Iqbal Stadium, Sheraz and Allama Iqbal Park have Cu contamination of 20-24 (mg/Kg). Hockey stadium and D-Ground have Cu contamination of 16-19 mg/kg. While the 28-37 range captured

Parameters	Acceptable Limits (mg/Kg)	Mean value. mg/kg
		Urban Parks
Zn	135-150	25.02-111
Cu	30-40	13.83-53.23
Pb	85-450	0.00-18.93
Ni	30-70	9.30-26.00

Table 1: Comparison of heavy metals values with the acceptable limits.

	Cu	Zn	Ni	Pb
Mean	24.08	48.57	21.44	21.44
Median	22.8875	44.23	22.27	3.9
Standard Deviation	9.17459	22.20	4.18	5.6
Variance	84.173	493.03	17.48	31.37
Maximum	53.225	111.15	26	26
Minimum	13.825	25	9.3	9.3
W.A.	20	50	40	10

Table 2: heavy metals concentration in (mg/kg) in urban park soil of Faisalabad city (N=16).

Source: A world average adopted from Odewande and Abimbola [11].

in the urban parks namely Allama Iqbal, D-Ground, Hockey stadium, Foot Ball Ground, Iqbal Stadium. There were two places viz; Foot Ball Ground and Madina Central Park, which have minimum quantity of Cu contamination i.e. 14 to 15 mg/Kg (Figure 3). Copper cause acute form of lungs diseases, hepatic and neurological diseases even liver failure and basal ganglia [20]. Lead causing the abdominal pain, developmental diseases and genes deregulation [21]. The Pb contamination in urban park's soil of the study area ranged between 0 mg/Kg to 19 mg/Kg. Although Pb is related to human activities [22], but urban parks have least quantity of Pb because of minimum vehicular impact [6]. The maximum quantity of Pb with the one largest circle 15-19 (mg/Kg) was reported in the Gol Park.

There are two sites with second largest range of 10-14 while four sites have Pb in the range of 3-9. There were five places where Pb ranged from 1-2 mg/kg while minimum quantity of Pb contamination with value less than 1 mg/kg was found in four of the samples sites (Figure 3).

The spatial distribution of Ni contamination found in urban parks' soil of the study area ranges from 9.3 mg/Kg to 25.75 mg/Kg (Table 1). In soils, Ni naturally occurs in rocks and is usually present in the organically bound form which can increase its mobility and bioavailability [6,23]. It has been delineated through spatial analysis that the level of Ni contamination in the study area is highest from 26 mg/Kg to 23 mg/Kg for plant pathology experimental area, University of Agriculture Faisalabad, Jinnah Garden, Allama Iqbal Park Gousia Park, Raja Park and Gol Park. Comparatively lower quantity was observed in Iqbal Stadium, Kaleem Shaheed Park, and Hockey stadium, D-Ground, Dhobi Ghat, Alfateh Ground and Madina Central Park ranging from 15-22 mg/kg. The minimum value for Ni was found in the Foot Ball Ground (Figure 3). Excessive exposure to Ni through inhaling, ingestion and dermatitis can cause the cardiovascular, kidney and lungs disorders (Alessio, 2011). Pulmonary infection is the most commonly prevalent diseases in sample areas with maximum percentage in Faisalabad district (Figure 4). The mean concentration of Zn, Cu, Pb and Ni in mg/Kg in urban parks soil of the study area was found to be 48.4, 24, 5.46 and 21.4 respectively (Table 2).

Box-Whisker Plot diagrammatically provides the statistical calculation of Q1, median, Q3, inter quartile range (Figure 5). The clusters 1 (Zn mg/kg) and 3 (Pb mg/kg) joined with 95.78% of similarity level while Cluster 1 (Zn mg/kg) joined with cluster 2 (Cu mg/Kg) with the similarity level 92.19%. Moreover Cluster 1 also joined with cluster 4 with 76.8% similarity level (Figure 6 and Table 3).

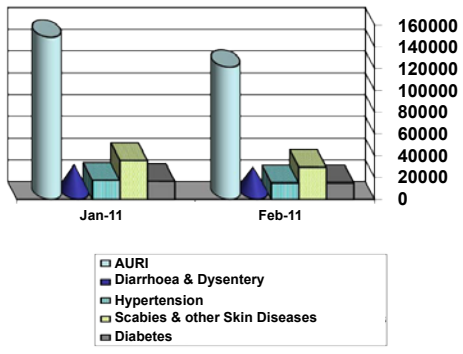

Figure 4: Chronic diseases incidence in Faisalabad district during the month of March, 2011.

Source: District Health Office. Faisalabad, 2011.

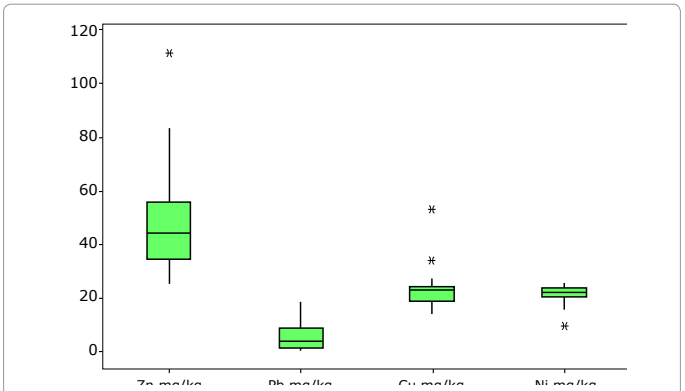

Figure 5: Boxplot of Zn, Pb, Cu, Ni (mg/kg) in urban parks soil of Faisalabad city.

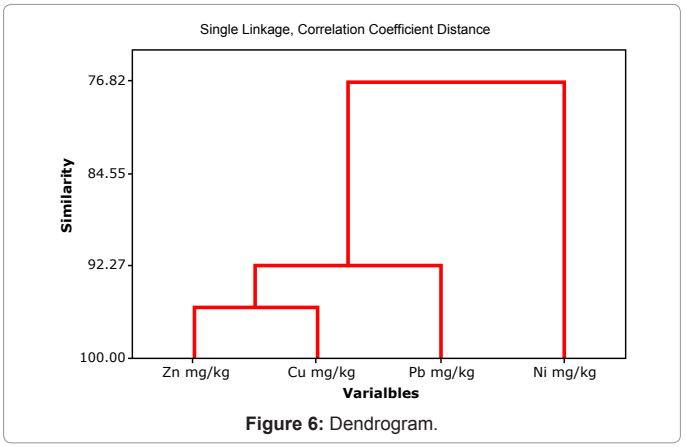

Figure 6: Dendrogram.

step	No. of Cluster	Similarity level	Distance level	Cluster joined	
1	3	95.78	0.084	1	3
2	2	92.19	0.156	1	2
3	1	76.8	0.46	1	4

Table 3: Cluster Analysis of Variables: Zn, Pb, Cu, Ni (mg/Kg).

Conclusion

During the last few decades industrial development and momentous urbanization are the two significant factors in Pakistan as well as many large cities of the country which are considered to be the potent causes of environmental degradation. Since all the major cities are suffering from various environmental problems and Faisalabad is by no means an exception. As the city of Faisalabad is 2nd largest industrial city of the country and shares all the environmental issues of such cities in Pakistan as well as in the world. Faisalabad has long been a source of influx of several pollutants, particularly heavy metals into its urban environment. Undeniably, there is a rising concern and apprehension among the people of Faisalabad over the prospects of pollution of urban soils with heavy metals. Hence, an extensive soil survey was conducted in urban parks of Faisalabad city, Pakistan, to assess the existing status of heavy metal contamination. Urban and industrial influences triggered the heavy metals pollution in the study area with the mean concentration ranging from 25.02-111.15, 13.83-53.23, 9.30-26.00 and 0.00-18.93 mg/Kg for the Zn, Cu, Ni and Pb respectively. The decreasing order for the calculated variance about the analyzed parameters is Zn>Cu>Ni>Pb. Gol Park and plant pathology experimental area University of

Agriculture Faisalabad urban parks reported to have crossed the acceptable limits for the Cu contamination in the soil which is pertinent to hepatic and basal ganglia degeneration among the people living nearby. It is recommended that there should be appropriate legislations to make certain effectiveness in the disposal method which is crucial to the sustainable development of urban environments. In order to reduce the rate and extent of future pollution problems in the city regular monitoring of heavy metal pollution in soil is essential.

References

1. Tume P, Bech J, Sepulveda B, Tume L, Bech J (2008) Concentrations of heavy metals in urban soils of Talcahuano (Chile): a preliminary study. Environ Monit Assess 140: 91-98.
2. Yang Z, Lu W, Long Y, Bao X, Yang Q (2011) Assessment of heavy metals contamination in urban topsoil from Changchun City, China. J Geochem Explor 108: 27-38.
3. Lourenço RW, Landim PMB, Rosa AH, Roveda JAF, Martins ACG, et al. (2010) Mapping soil pollution by spatial analysis and fuzzy classification. Environ Earth Sci 60: 495-504.
4. Xia X, Chen X, Liu R, Liu H (2011) Heavy metals in urban soils with various types of land use in Beijing, China. J Hazard Mater 186: 2043-2050.
5. Wong CS, Li X, Thornton I (2006) Urban environmental geochemistry of trace metals. Environ Pollut 142: 1-16.
6. Ali SM, Malik RN (2011) Spatial distribution of metals in top soils of Islamabad City, Pakistan. Environ Monit Assess 172: 1-16.
7. Alloway BJ (2004) Contamination of soils in domestic gardens and allotments: a brief overview. Land Contamination & Reclamation 12: 179-187.
8. Krishna AK, Govil PK (2007) Soil contamination due to heavy metals from an industrial area of Surat, Gujarat, Western India. Environ Monit Assess 124: 263-275.
9. Fong FT, Chee PS, Mahmood AA, Tahir NM (2008) Possible source and pattern distribution of heavy Metals content in urban soil at Kuala Terengganu town Center. The Malaysian Journal of Analytical Sciences 12: 458-467.
10. Maas S, Scheifler R, Benslama M, Crini N, Lucot E, et al. (2010) Spatial distribution of heavy metal concentrations in urban, suburban and agricultural soils in a Mediterranean city of Algeria. Environ Pollut 158: 2294-2301.
11. Odewande AA, Abimbola AF (2008) Contamination indices and heavy metal concentrations in urban soil of Ibadan metropolis, southwestern Nigeria. Environ Geochem Health 30: 243-254.
12. Cheng W, Zhang X, Wang K, Dai X (2009) Integrating classification and regression tree (CART) with GIS for assessment of heavy metals pollution. Environ Monit Assess 158: 419-431.
13. Li X, Poon C, Liu PS (2001) Heavy metal contamination of urban soils and street dusts in Hong Kong. Appl Geochem 16: 1361-1368.
14. Davis HT, Aelion CM, McDermott S, Lawson AB (2009) Identifying natural and anthropogenic sources of metals in urban and rural soils using GIS-based data, PCA, and spatial interpolation. Environ Pollut 157: 2378-2385.
15. Lee CS, Li X, Shi W, Cheung SC, Thornton I (2006) Metal contamination in urban, suburban, and country park soils of Hong Kong: a study based on GIS and multivariate statistics. Sci Total Environ 356: 45-61.
16. Yesilonis ID, Pouyat RV, Neerchal NK (2008) Spatial distribution of metals in soils in Baltimore, Maryland: role of native parent material, proximity to major roads, housing age and screening guidelines. Environ Pollut 156: 723-731.
17. Government of Pakistan (2004) City Report of Faisalabad 1998. Population Census Organization, Statistics Division, Islamabad, Pakistan.
18. Bhattarai S (2006) Spatial Distribution of Heavy Metals in Louisiana Sediments and Study of Factors Impacting the Concentration. Louisiana State University, USA.
19. Malik RN, Jadoon WA, Husain SZ (2010) Metal contamination of surface soils of industrial city Sialkot, Pakistan: a multivariate and GIS approach. Environ Geochem Health 32: 179-191.
20. Saudubray JM, Berghe GVD, Walter JH (2012) Inborn Metabolic Diseases: Diagnosis and Treatment. (5th Edn), Springer-Verlag, New York, USA.
21. Tollefsbol T (2012) Epigenetics in Human Disease. (1st Edn), Elsevier Inc., Netherlands.
22. Krishna AK, Govil PK (2008) Assessment of heavy metal contamination in soils around Manali industrial area, Chennai, Southern India. Environ Geol 54: 1465-1472.
23. Chen TB, Zheng YM, Lei M, Huang ZC, Wu HT, et al. (2005) Assessment of heavy metal pollution in surface soils of urban parks in Beijing, China. Chemosphere 60: 542-551.