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The distribution of some heavy metals in soils in areas around the derelict enyigba mines and its environmental implication

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ABSTRACT

This research establishes heavy metals pollution in soils in the areas around the derelict Enyigba Mines, including Enyigba, Ameka, and Ameri by consideration of metals distribution. Pb and Cd concentration in soils in the area are generally higher than the normal soil average of 35mg/kg and 0.35mg/kg respectively and attain toxic levels in majority of the samples. Cu and Zn concentrations are generally below toxic levels but attain toxic levels in a number of samples from Ameka. Nickel concentrations in majority of the samples are above the average for normal soil but do not attain the level of toxicity. The high concentrations of the metals in the direction of N-E, NE-SW and NW-SE suggest that the metals distribution probably followed fracture trends in the area. These levels of concentrations of metals in the area may lead to lower agricultural production, low quality of food and may affect human health.

Key words: Asu River Group, Mineralized veins, Heavy metals, pollution, tolerable limits, and mine tailings

INTRODUCTION

Enyigba and its surrounding villages of Ameri and Ameka is 14 km south of Abakaliki town, South East, Nigeria (Fig. 1). This is located within the Abakaliki Anticlinorium in the southern tip of the Benue Trough. The geology of the area comprises sequences of sandy shales, with fine grained micaceous sandstones and mudstones that is Albian in age and belongs to the Asu River Group (Fig.2). The shales are often calcareous and pyritic. There are also lenses of sandstone and limestone. The rocks are extensively fractured, folded and faulted. There are known in Enyiba and its environs, eight Pb-Zn lodes which make up a part of the Abakaliki Pb-Zn deposits (Fig. 1). Apart from the main Enyigba lode, others are Ameri, Ameka, Ikwo, Palmwine, Nine pence and Portuguese[1]. The closely jointed shales of the albian Asu River Group host the ore. The soils in the area fall within the reddish brown gravely and pale brown and clayey soils formed from shales, shallow pale brown soils derived from sandy shales. Generally, the soils are ferraltic soils of humid tropical climate with marked dry and wet seasons and vegetative cover. The potential for heavy metal contamination of soils in Enyigba is high because of factors of availability of these metals in the area and the presence of factors capable of mobilizing, distributing and storing them in pedologic systems. Geology and mineral resources are the major factors responsible for availability of these heavy metals. While the sulphide mineralisations have high concentration of these metals, the shale host rocks are capable of retaining them from the ancient seas. There had been indications that the Cretaceous black shales which are host to the Pb-Zn mineralization in Nigeria contain enhanced background values of Cd, Pb, Zn, especially close

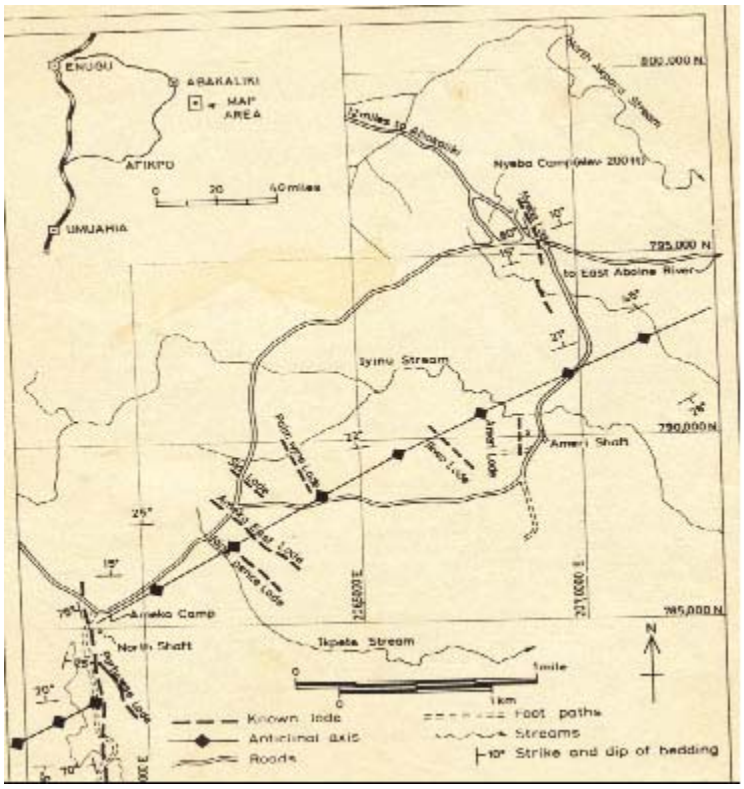

Fig. 1: The Geology of Enyigba Lead-Zinc Province[1]

Fig. 2: The general geologic map of S.E. Nigeria[2]

to mineralized zones, where there is strong enrichment due to primary dispersion[3]. The same author indicates that cadmium contents in the sphalerites from the mineralized zones are high, with values exceeding 2500 ppm. The factors capable of mobilizing heavy metals from these substances include heavy rainfall, low undulating relief, activities associated with agriculture and mining and the presence of brine springs. These factors increase the rate at which the rocks and minerals weather and thus liberate heavy metals content into the soil. In terrestrial ecosystem, soils are the major recipient of heavy metals[4]. The concentration of these heavy metals in soils in the area is a factor in the health of the inhabitants, agricultural production and quality of food generated in the area. There are thus the concerns about the potential harmful effects of these metals in soils in the area.

METHODS

Samples were picked from the bottom of holes about 15cm deep deliberately made by use of picks and cutlasses. About 100g of fine fractions was put in a polyethylene bags and labelled. Gamin eTrex GPS was used to locate each point. A total of 20 samples were collected. The sample locations are shown in Appendix 1. The samples were dried, homogenized and passed through 100 mesh nylon screen. The samples were digested by use of aqua regia. The aliquot was analysed by use of Buck Scientific Atomic Absorption Spectrometer 205 for Pb, Zn, Cu, Cd, Ni and As in the laboratories of Ideyi Consults, Port Harcourt, Nigeria.

RESULTS

The result of analyses for Pb, Zn, Cu, Cd, Ni and As in soils from Enyigba are shown in Table1. Fig. 3 is a bar chart showing the distribution. Figs. 4 to 9 are the contour maps of the distribution of Pb, Zn, Cu, Cd and Ni respectively.

Lead is highly dispersed in soils in the area. The range of concentration of Pb in the samples of soils from Enyigba is 60.50 – 15519 mg/kg with mean concentration of 1093.71 mg/kg. The lowest concentration was recorded in one of the samples from Enyigba, while the highest concentration was recorded at Ameka. Zn concentration in soils ranges from 75 – 1878.50mg/kg with a mean of 609.00 mg/kg. Some areas with significant levels of Zn

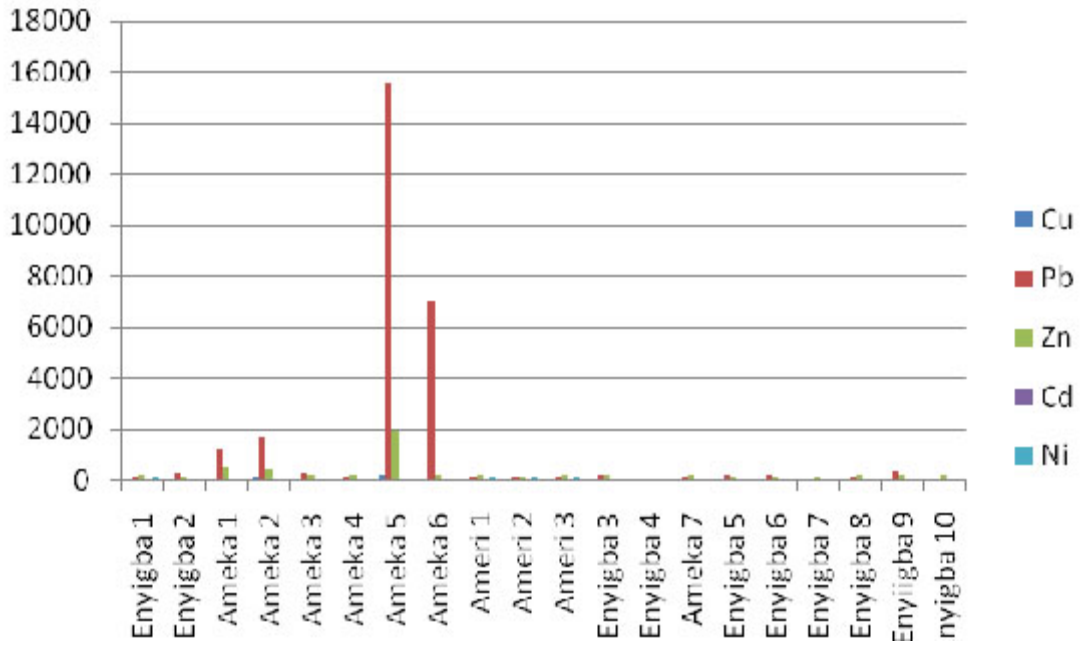

Fig. 3: The distribution of Cu, Pb, Zn, Cd, Ni and As in soils in Enyigba and Abakaliki.

include Ameka, 2,528.00mg/kg. The range of concentration of Cu in soils in the area ranges from 9.50-188.50, with mean concentration of 39.97 mg/kg. The concentration of Cu is well distributed with 76% of the samples containing Cu in the range 9.5 – 39.0mg/kg. Cd is also well dispersed and was recorded in all the sampled soils. The concentration of Cd in soils ranges from 1.50 – 26.50mg/kg with mean concentration of 5.00mg/kg. Ni was also recorded in all the samples of soil from Enyigba. Ni concentrations in soils range from 2.50 – 74mg/kg with mean of 38.00mg/kg. The concentration of As in most of the sampled soils is below the detection limit of the analytical equipment. The highest concentration of 2.5mg/kg was recorded at Enyigba.

DISCUSSION

Appendix 2 shows the tolerable limits set by various standards for the analyzed metals. As shown, the tolerable concentrations of Cu, Pb, Zn, Cd, Ni and As in normal soils are Cu, 30mg/kg; Pb, 35mg/kg; Zn, 90mg/kg; Cd, 3mg/kg; Ni, 30mg/kg and As, 20mg/kg.[5] The concentration of Cu in soil is below toxic level[6], except in some areas where there is local enrichment (Fig. 4 and Table 1). These areas include Ameka where concentration attains 188.50mg/kg and some parts of Enyigba-78mg/kg. The concentration of Pb in soils in Enyigba tends to be higher than in normal soil (Fig. 5). Only in few samples e.g. Ameri where concentrations are 115 – 126mg/kg are Pb slightly below toxic level. The distribution of Zn in soils in the area are higher than in normal soil and attains toxic levels in the majority of soil samples (fig.6 and Table1). Cd concentration in soils is also higher than in normal soil and attains toxic levels at Enyigba 6- 8mg/kg. In places like Ameka, and some parts of Enyigba, the toxicity level is marginal or slightly close to toxic level. The concentration of Ni is below toxic level (Table1, Fig. 8) (30-60mg/kg in Enyigba,

Appendix 1: Sample Index for soils in Enyigba

	Location		
Sample No	**Easting**	**Northing**	**Address**
1.	403934	685429	Enyigba1
2.	405629	684578	Enyigba 2
3.	401569	680488	Ameka 1
4.	401534	680848	Ameka 2
5.	401664	681107	Ameka 3
6.	401421	682359	Ameka 4
7.	402744	682200	Ameka 5
8.	403310	682813	Ameka 6
9.	402873	683310	Ameri 1
10.	404910	682563	Ameri 2
11.	403535	682125	Ameri 3
12.	402709	682933	Enyigba 3
13.	402751	683786	Enyigba 4
14.	403601	681660	Ameka 7
15.	404688	684699	Enyigba 5
16.	404854	684435	Enyigba 6
17.	405383	683412	Enyigba 7
18.	405890	683672	Enyigba 8
19.	405100	683777	Enyigba 9
20.	402815	683541	Nyigba 10

Appendix 2: Tolerable limits by the various established standards for soils

Metal	**Normal soil (Bowen (1979).**	**Tolerable level (Kabata – Pendias, (1984)**	**Ecological investigation levels (NEPC, (2003)**	**E.C. (1982)**	**ANZEC (2000)**
Cu	30 mg/kg	100 mg/kg	60 mg/kg	50 – 140mg/kg	60mg/kg
Pb	35 mg/kg	100 mg/kg	300 mg/kg	50 – 3001mg/kg	300mg/kg
Zn	90 mg/kg	300 mg/kg	200 mg/kg	150 – 300mg/kg	200mg/kg
Cd	0.35 mg/kg	3.0 mg/kg	3.0 mg/kg	1 – 3mg/kg	3mg/kg
Ni	15 mg/kg	30 mg/kg	60 mg/kg	30 – 75mg/kg	60mg/kg
As	6.0 mg/kg	20 mg/kg	20 mg/kg	-	20mg/kg

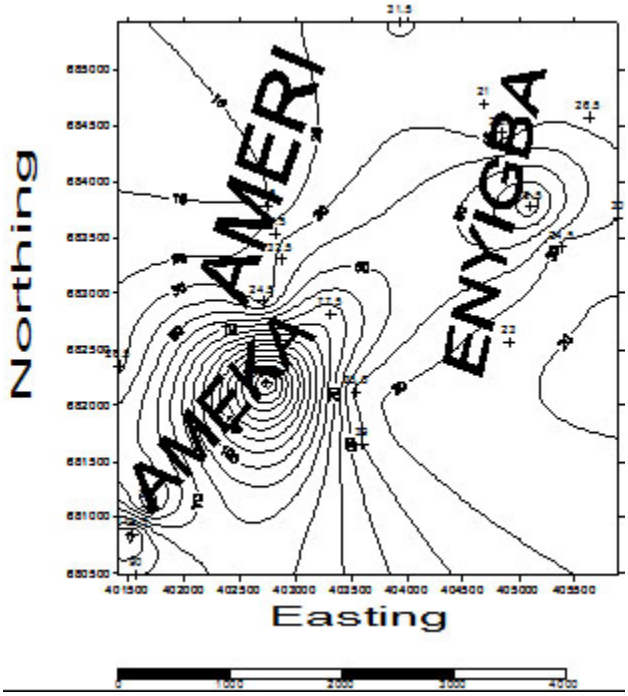

Fig. 4: Contour map of distribution of Cu in spoils in Enyigba

Table 1: The concentration of Cu, Pb, Zn, Cd, Ni and AS in soils in Enyigba

Location	Hevy Metals concetration in mg/kg					
	Cu	Pb	Zn	Cd	Ni	As
Enyigba 1	31.50	133.50	195.50	4.50	60.50	< 0.01
Enyigba 2	26.50	307.50	151.50	4.00	50.50	< 0.01
Ameka 1	90.00	1210.50	528.00	4.00	26.50	< 0.01
Ameka 2	114.50	1740.50	493.50	3.50	31.00	< 0.01
Ameka 3	33.00	304.50	197.50	3.00	36.50	< 0.01
Ameka 4	26.50	143.00	163.00	4.00	43.50	< 0.01
Ameka 5	188.50	15519.00	1878.50	6.00	30.00	< 0.01
Ameka 6	77.50	7068.00	271.00	4.50	49.00	< 0.01
Ameri 1	32.50	126.00	198.50	5.00	70.00	< 0.01
Ameri 2	23.00	143.00	146.50	4.50	59.50	1.00
Ameri 3	35.50	115.00	189.50	5.00	74.00	1.00
Enyigba 3	24.50	265.50	189.50	5.00	40.50	< 0.01
Enyigba 4	9.50	60.50	75.00	6.00	23.00	< 0.01
Ameka 7	39.00	96.00	187.00	6.00	53.00	< 0.01
Enyigba 5	21.00	178.00	142.50	3.50	51.50	1.00
Enyigba 6	25.50	232.50	148.50	4.50	45.50	0.50
Enyigba 7	24.50	87.00	146.00	4.50	44.00	< 0.01
Enyigba 8	30.00	114.50	154.50	4.50	36.00	0.50
Enyigba 9	76.50	694.50	227.00	8.50	38.00	2.50
Enyigba 10	27.50	80.50	155.50	3.50	46.00	0.50

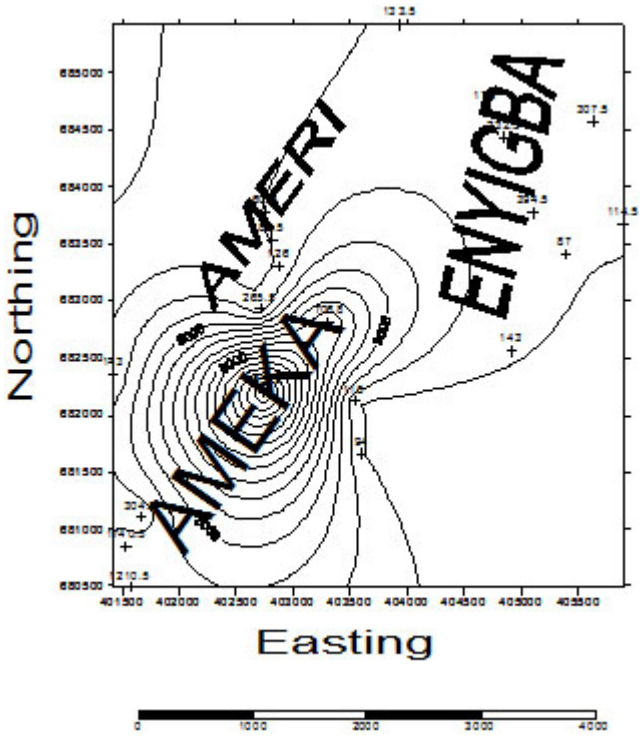

Fig. 5: The contour map of distribution of Pb in soils in Enyigba

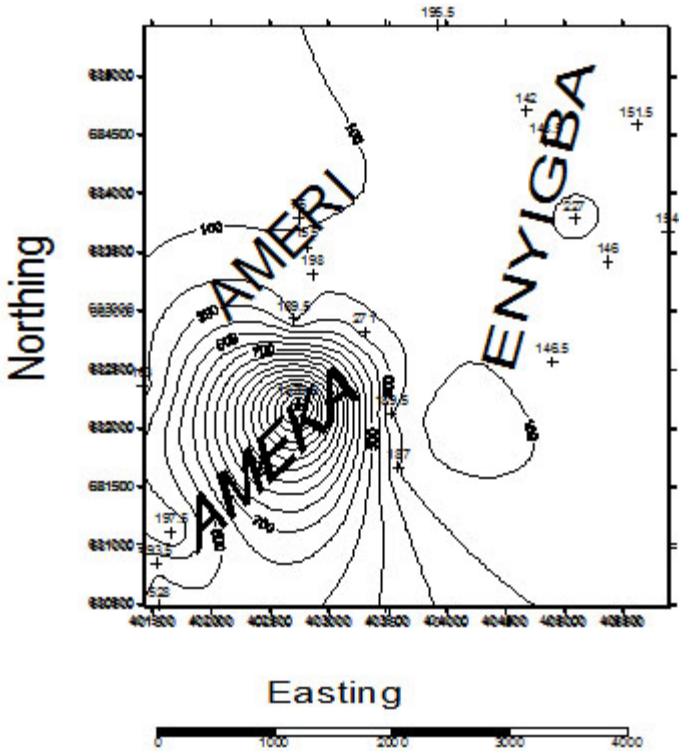

Fig. 6: The contour map of distribution of Zn in soils in Enyigba

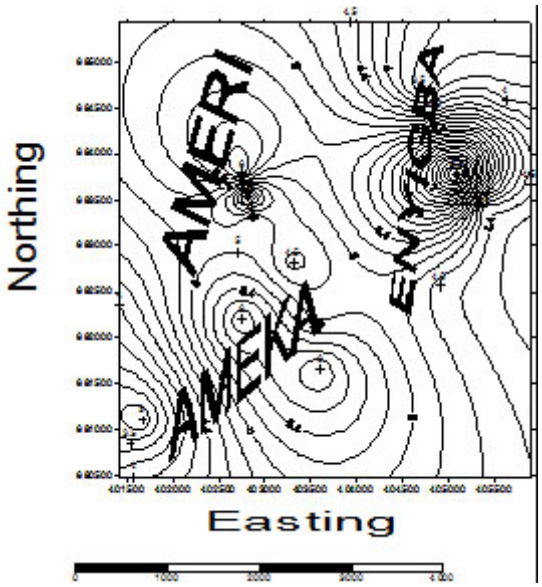

Fig. 7: the contour map of distribution of Cd in soils in Enyigba

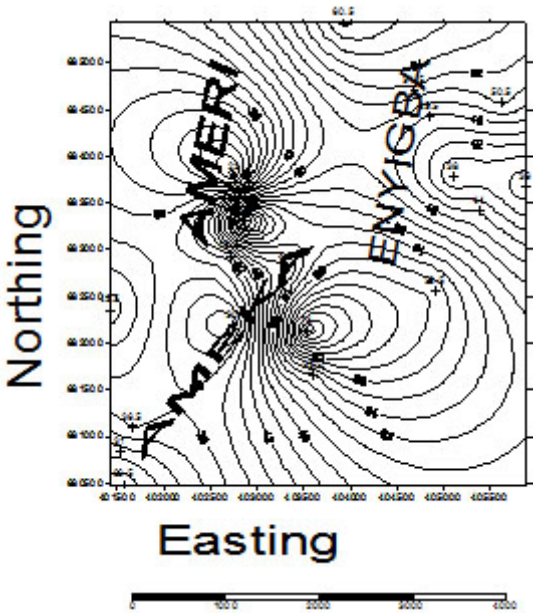

Fig. 8: The contour map of distribution of Ni in soils in Enyigba

28-70mg/kg in Ameka). Thus, Pb, Zn and Cd constitute polluting metals in the area.

The Consequences of the established distribution

The established pollution of soils by Pb, Zn and Cd in Ameka, Enyigba and Ameri has both long and short term consequences on agriculture. Inferences can be drawn from the results of studies carried out in various other countries such as the United Kingdom, the Netherlands and Australia[7-10].

The effect of heavy metals pollution on agriculture could be summarised as follows.

1. Direct toxicity on plants and animals that eat forage and occasionally ingest soils as part of nutrients.
2. Interference with nutrient uptake in plants and agricultural animals giving rise to apparent elemental deficiency resulting to a number of physiological defects.
3. Interference with proper soil functions because of effect on soil micro organisms.
4. Crop and animal contamination.
5. The propagation of concentrated amounts of metals throughout food chain.

The net effects of these is lower agricultural production and low quality foodstuff. Tubers absorb heavy metals about ten times faster than other food plants[11]. The major food crops in the area are yams and cassava and are major staples in the area. They may become major sources of heavy metals to humans in the study area. It has also been reported that grazing livestock involuntarily ingest fair quantities of soil by-passing the soil-plant-animal pathway[8]. Cattle may ingest soil from 1 to 10% of their dry matter intake, and even 30% or more in sheep that graze close the ground[12]. In Enyigba, where livestock is grown free range, the threat of these heavy metals polluting the soil being passed into livestock grazing in the areas, via vegetation and by direct soil ingestion should be taken seriously. The effect on humans depends on ingested dosage and specific characteristics of the metals and may include:

1. Excessive shyness.
2. Change sensory perceptions.

3. Simple stomach ailments, nausea and diarrhoea.
4. Blood, lung, kidney, brain, pancreas and bone complications/diseases.
5. Immune and nervous system impairment.
6. Reduced fertility.
7. Spontaneous abortion
8. Death.

CONCLUSION

Enyigba and the surrounding villages of Ameka and Ameri present good cases of heavy metals pollution. These levels of metal concentration may have direct toxicity on plants and animals in contact with the soils, interfere with their nutrient uptake and soil functions. It may also have adverse effect on wild life; contaminate crops and animals leading to propagation of food with concentrated amounts of metals throughout the food chain. These will lead to lower agricultural production and low quality food. Humans who may ingest the polluted food grown on contaminated soil may also be affected. Effect may range from simple ailments to serious changes in sensory perceptions, immune and nervous system impairments, damage of vital internal organs, reduced fertility, spontaneous abortion and fatality.

REFERENCES

1. Orajaka, S., The Geology of Enyigba, Ameri and Ameke Lead-Zinc lodes Abakaliki Eastern Nigeria-A Reconnaissance. *Journal of Mining, Geology & Metallurgy* **2**(2): 65 -69 (1965).
2. Hoque, N., Petrographic Differentiation of Tectonically Controlled Cretacious Sedimentary cycles, S.E Nigeria. *Sedimentary Geology,* **17**: 235 -245 (1977).
3. Olade M.A. and Morton, R.D., The origin of Lead-Zinc mineralisation in the southern Benue Trough, Nigeria-Fluid inclusion and trace element studies. *Mineralum Deposita,* **20**: 76-80 (1989).
4. Sparks, D.L., Toxic metals in the environments: the role of surfaces. *Elements* **3**: 193-197 (2005).
5. Bowen, H.J.M., Environmental Geochemistry of the Elements. Academic Press, London (1979).
6. Kabata – Pendias, A. and Pendias, H., Trace elements in soils and plants, 3rd edition. CRC, Press, Boca Raton. 315 (1984).
7. Miranda, M., Lopez-Alonso, M., Castillo, C., Hernandez, J and Benedito, J.L., Effects of moderate pollution on toxic and trace metal levels in calves from a polluted area of northern Spain. *Environmental International.* Elsevier, **31**: 343–348 (2005).
8. Mehra, A., Cordes, K.B., Chopra, S. and Fountain, D., Distribution and bioavailabilty of metals in soils in the vicinity of copper works in Staffordshire, U.K. *Journal of chemical Speciation and bioavailabilty.* **11**(2): 57-66 (1999).
9. Kim, K.-W., Myung, J.-H.,Ahn, J.S. and Chon, H.-T., Heavy metals contamination in dusts and stream sediments in the Taejon area, Korea. *Journal of Geochemical Exploration* **64**: 409-479. Elsevier (1998).
10. Traina J.S and Laperche V., Contaminant Bioavailability in soils, sediments and aquatic environments. *Proceeding of National Academy of Sciences*, USA **96**: 3365-3371 (1999).
11. Bellows, A.C., Brown, K. and Smit, J., Health Benefits of Urban Agriculture. Food SecurityuCoalition.Retieved from: http://www/issuelab.com/browse/browse_pub.php?pub_id112 (2003).
12. Thornton, I., Geochemistry Applied to Agriculture in Thornton (ed.) Applied Environmental Geochemistry., 231-263. Academic Press London (1983).