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Determination of Heavy Metal Fallout on the Surrounding Flora and Aquifer: Case Study of A Scrap Metal Smelting Factory in Odogunyan Area, Ikorodu, Lagos- State, Nigeria

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Abstract

This study was carried out to assess the extent of contamination (of heavy metal leachates from a scrap metal dump) on selected flora and some sources of potable water found in the surroundings of a scrap metal smelting yard. Using the Complete Randomnised Design (CRD), plant samples were taken at varing distances from the scrap metal dumpsite. Three sources of water were also sampled in the vicinity of the scrap metal dumpsite. Using the Atomic Absorption Spectrophotometer (AAS), each of the water and plant samples were analyzed for Arsenic (As), Cadmium (Cd), Chromium (Cr), Lead (Pb) and Nickel (Ni). The study site is in the Odogunyan/Spintex area of Ikorodu, Lagos-Nigeria; and the study was conducted between July – October, 2012. The mean concentration of As, Cd, Cr, Pb and Ni in the water samples ranged from 0.0002 to 0.5150mg/L, 0.00043 to 0.6342mg/L, 0.0195 to 0.5078mg/L, 0.0080 to 5.9958mg/L and 0.0005 to 6.7976mg/L respectively. Mean concentration of As, Cd, Cr, Pb and Ni in the plant samples ranged from 0.9526 to 1.3122mg/kg, 0.7139 to 1.0199mg/kg, 0.8860 to 1.1901mg/kg, 9.8441 to 15.0046mg/kg and 11.1075 to 14.8510mg/kg respectively. Results obtained from this study showed higher concentration of the heavy metals in the water from the well and lower concentration in the borehole. In the plant there was a higher concentration of the heavy metals at distances nearer to the scrap metal dumpsite, and lower concentration as distances increased away from the scrap metal dumpsite. Compared to the WHO standard for heavy metal concentration, results from some wells in this study showed values that were more than 51, 2000, 10, 599 and 399 times above the maximum permissible levels for Ar, Cd, Cr, Pb and Ni respectively in potable water source.

Keywords: Scrap metal, heavy metals, soil pollution, water pollution.

Introduction

Pollution of the biosphere by toxic metals has accelerated severely since the beginning of the industrial revolution[1]. The primary sources of metal pollution include the burning of fossil fuels, mining and smelting of metalliferrous ores, other industrial activities, municipal wastes, fertilizers, pesticides and waste water irrigation[1]. In addition, the contamination of groundwater and soil by heavy metals leads to major environmental and human health problems[1].

Plant metabolism is also affected negatively by the heavy metal contamination[1]. Although some of the heavy metals act as micronutrient at lower concentrations, but at higher concentrations, are harmful for the normal functioning of plants and animals[2].

Unlike almost all organic pollutants, such as organochlorines, heavy metals occur as natural constituents of the earth crust, and are persistent environmental contaminants. In rocks, they exist as their ores in different chemical forms, from which they are recovered as minerals[3].

To a small extent, they enter the body system through food, air and water and bio-accumulate over a period of time[4]. The term "heavy metals" refers to any metallic element that has a relatively high density and is toxic or poisonous even at low concentration[3]. "Heavy metals" is a general collective term, which applies to the group of metals and metalloids with an atomic density greater than 4g/cm^3, or 5 times or more, greater than water[5-8]. However, being a heavy metal has little to do with density, but concerns chemical properties. Heavy metals include lead (Pb), cadmium (Cd), zinc (Zn), mercury (Hg), arsenic (As), silver (Ag), chromium (Cr), copper (Cu), iron (Fe) and the platinum group elements which comprises platinum, palladium, rhodium, ruthenium, osmium, and iridium[9].

Heavy metals can be emitted into the environment by both natural and anthropogenic sources specifically mining operations[5, 6]. The amount of most heavy metal released into the environment via anthropogenic activities are many times greater than depositions from natural background sources[10].

Combustion processes are the most important sources of heavy metals, particularly, power generation, smelting, incineration and the internal combustion engine[11]. In some cases, even long

after mining activities have ceased, the emitted metals continue to persist in the environment[12]. Reported that hard rock mines operate from 5-15 years until the minerals are depleted, but metal contamination that occurs as a consequence of hard rock mining persist for hundreds of years after the cessation of mining operations.

Some heavy metals like (Fe, Zn, Ca and Mg) have been reported to be of bio-importance to man and their daily medicinal and dietary allowances had been recommended[9]. Their tolerance limits in drinking and potable waters have also been reported. However, some others (like As, Cd, Pb, and methylated forms of Hg) have been reported to have no known bio-importance in human biochemistry and physiology and consumption even at very low concentrations can be toxic[13,14]. Even for those that have bio-importance, dietary intakes have to be maintained at regulatory limits, as excesses will result in poisoning or toxicity, which is evident by certain reported medical symptoms that are clinically diagnosable[9,14].

Occurrence of oxidative stress in plants could be the indirect consequence of heavy metal toxicity[15,16]. Molecular oxygen can accumulate in the leaves of plants under heavy metal stress, which can result into oxidation of cellular components. Exposure of plants to heavy metals causes reduction in photosynthesis, water uptake, and nutrient uptake[17]. Plants grown in soil containing high levels of cadmium show visible symptoms of injury reflected in terms of chlorosis, growth inhibition, browning of root tips, and finally death[18,19].

Objective: The aim of this study is to investigate the extent of heavy metals contamination (burden), and consequently highlight the risk of heavy metal movement along the food chain, using some important indices in the environment. The following were the specific objectives of this study: i. To determine the heavy metal burden in some portable water sources around the study site. ii. To determine the heavy metal burden in *Eleusine indica* (goose-grass, bullgrass), a common plant that is freely grazed upon by the ruminants in the locality.

Material and Methods

Description of Experimental Site: This study was carried out around scrap metal dumpsites operated by scrap metal smelting companies located at Odogunyan area of Ikorodu in Lagos State. The experimental site further has some residential houses within and around the vicinity of these companies. These dumpsites are located along a major road (Spintex road - ±25, N(06^o 39.983'), E(003^o 31.224') from where the scrap metals are transported down to the metal smelting company. Prior to the smelting operations, the scrap metals are stored in heaps on top of each other, without any form of cover over them, and on bare (unconcretized) ground. This stacking arrangement leaves those scrap metals at the bottom to remain long enough to release some leacheates into the surrounding soil when rain falls on them.

Collection of Samples: The samples (water and weed) were collected once every week for four weeks towards the end of the rainy season around November, 2012.

Collection of Weed Samples: The weed samples *Eleusine indica* (goose-grass, bullgrass) were taken at distance intervals of 0, 5, 20, and 1000 metres away from the scrap metal dumpsite.

The weed was selected owing to its abundance in the experimental site as it was found to be the dominant plant species. These plants are taken from each sampling points considered in this study. Coordinates for each of the points were as follows: For 0m distance, location ± 25, N(06^o 39.983'), E(003^o 31.224') (at the base of scrap metal heap), For 5m distance, location ± 24, N(06^o 39.981') E(003^o 31.222'), For 20m distance, location ± 24, N(06^o 39.973'), E(003^o 31.220'), For 1000m distance, location ± 28, N(06^o 39.855'), E(003^o 31.195'),

All the three weed samples collected per distance point were uprooted from the soil and the soil attached to the root was shaken off completely. The three weed samples at each distance were bulked together to form a composite sample and the composite samples were then packed into glasswares, labelled and taken to the laboratory for analysis within the 1st three hours after collection. The weed samples were analyzed for heavy metal contents (lead, cadmium, chromium, arsenic and nickel).

Collection of Water Samples: Water samples were collected from the neighbouring residential houses in glass bottles of 0.75litres capacity from three different sources, denoted A, B and C. The water sources sampled are given below: i. Source A - Well water, ii. Source B - Well water, iii. Source C - Borehole.

The coordinates for each of the different sources were noted as follows: i. Source A – well water – location ±29, N(06^o 39.918'), E(003^o 31.182'), ii. Source B – well water – location ±26, N(06^o 40.024'), E(003^o 31.313'), iii. Source C– borehole – location ±37, N(06^o 40.052'), E(003^o 31.271').

The water samples were collected into two glass bottles 0.75 litres capacity at each of the sources A, B, C. A total of nine glass bottles of water sample were labelled appropriately and taken to the laboratory for analysis of some of the heavy metal content (within 3 hours after collection) thus: lead, cadmium, chromium, arsenic and nickel.

Preparation of Plant Sample for Heavy Metal Analysis: Tender plant (weed) samples were uprooted and were thoroughly shaken to remove the sand. Thereafter, the samples were washed under running water so as to further remove any unwanted materials such a sand, stones and debris. A Stainless steel knife was used in cutting each of the plant sample into tiny bits. Then the plant samples were oven dried to a constant

weight in an oven that was maintained at 105^{o}C and thereafter pulverized into finer texture using a laboratory mortar and pestle and kept at less than 4^{o}C in a 500ml beaker before the analysis commenced.

Plant Sample Digestion Procedure: As described by standard methods[20], exactly 5.0 g of the pulverized plant sample (*Eleusine indica*) was weighed into a pre-cleaned 250ml borosilicate beaker for digestion. Another 30ml of concentrated hydrochloric acid (HCl) and nitric acid (HNO_3) in the ratio 3:1 was added into the weighed sample in the beaker. The sample together with the digesting solution was placed on the hot plate for digestion for about 20mins in the fume cupboard. The beaker and its contents after the digestion were allowed to cool. Another 20ml of the digesting solution (hydrochloric acid and nitric acid 3:1) was added and digested further in the fume cupboard until the brown fumes disappear leaving the white fumes, then the mixture was allowed to cool to the room temperature. The mixture was filtered using a glass funnel and Whatman's filter paper no 4 into a 250ml volumetric flask. The filtrate was made up to mark with de-ionised water and read on the Atomic Absorption Spectrophotometer (AAS).

Digestion Procedure for water sample: Using standard methods[20] 100ml of the homogenized water sample was measured into a pre-cleaned 250ml borosilicate beaker for digestion.

Thereafter, 30ml of the mixture of concentrated hydrochloric acid (HCl) and nitric acid (HNO_3) in the ratio 3:1 was added into the already measured sample in the beaker. The sample together with the digesting solution was placed on the hot plate for digestion inside the fume cupboard. The beaker and its contents after the digestion were allowed to cool. Another 20ml of the digesting solution (concentrated hydrochloric acid and nitric acid 3:1) was added and this mixture was digested further in the fume cupboard. After the digestion was complete, the mixture was allowed to cool to the room temperature. Then the mixture was filtered into a 250ml volumetric flask using a glass funnel and a Whatman's filter paper. The filtrate was made up to the mark with de-ionized water. The same procedure was followed for the digestion of all the other water samples. All the digested samples were sub-sampled into pre-cleaned borosilicate glass containers for AAS analysis to determine the different heavy metals considered in this study.

Preparation of Standards: Standards of arsenic, lead, cadmium, chromium and nickel solutions of 0.2, 0.4, 0.6, 0.8 and 1.0mg/L were made from each of the heavy metals solution of 1000mg/L stock solutions of the analytes.

These set of standard solutions and the filtrate of the digested samples were analyzed using AAS. The detection limit of the metals in the sample was 0.001mg/L. The make and model of the AAS used is the UNICAM 929 London, Atomic powered by the SOLAAR software.

Arsenic, lead, cadmium, chromium and nickel cathode lamps were used for the analysis of the respective heavy metal ions in the standards and the filtrate of the respective samples. Gas mixtures were used in the generation of the flame for the AAS. 3.5

Collection and Analysis of data: Data obtained for plant and water sample analysis were the mean for 3 samples for each of the four distances (0m, 5m, 20m and 1000m) and the three water sources respectively. The completely randomized design was adopted as the experimental design. Data collected were subjected to Analysis of Variance (ANOVA). Mean separation was by the Least Significant Difference (LSD) at 5% level of significance.

Results and Discussion

The results of the different heavy metals tested for in the portable water samples and weed (*Eleusine indica*) samples were as follow:

Arsenic (As): The results from table-1a show that there was significant difference (P = 0.05) in the mean concentration of Arsenic in the three sources of the water samples. It should be noted however that the value of Arsenic at source A exceeds the WHO limit of 0.01mg/L while those of sources B and C falls well below the WHO limit.

Results from table-1b shows the mean concentration of Arsenic in the weed samples at the different distances. However, there was significant difference (P = 0.05) in the mean concentration of Arsenic in the weed samples from one sample point to the other.

Cadmium (Cd): The results in table-1a show that there was significant difference (P=0.05) in the mean concentration of cadmium in the water samples from the three sources. However, it should be noted that the level of cadmium in all the three sources of water samples exceeded the maximum permissible level of cadmium recommended by WHO. Source A however has the highest mean concentration of cadmium of the three sources of water samples.

Results from table -1b show the mean concentration of Cadmium in the weed samples taken at distances 0m, 5m, 20m and 1000m. There was a significant difference (P = 0.05) in the mean concentration of Cadmium in the weed samples.

Chromium (Cr): The mean concentration of chromium (Cr) in the water samples and weed samples are as summarized in tables-1a and 1b respectively. There was a significant difference (P = 0.05) in the mean concentration of chromium in the water samples from source A compared to the remaining two sampling points. It should be noted however that the value of chromium at source A exceeded the WHO acceptable limit of 0.05mg/L while the values at sources B and C fell below the WHO acceptable limit.

Table-1a
Mean concentration of Heavy metal (mg/l) in water samples from the study sites

SOURCES mg/L	As	Cd	Cr	Pb	Ni
Source A (well)	0.5150^{c}	0.6342^{c}	0.5078^{c}	5.9958^{c}	6.7976^{c}
Source B (well)	0.0005^{b}	0.0007^{b}	0.0266^{b}	0.0214^{b}	0.0009^{b}
Source C (borehole)	0.0002^{a}	0.00043^{a}	0.0195^{a}	0.0080^{a}	0.0005^{a}
WHO max. acceptable conc. for potable water (mg/l)	0.01	0.0003	0.05	**0.01**	**0.02**

*Mean values for the same heavy metal carrying different superscripts along the same column are significantly different at P = 0.05.

Table-1b
Mean concentration of heavy metals (mg/kg) in *E. indica* samples from study sites

Distance from the base of scrap metal heap (metres)	As	Cd	Cr	Pb	Ni
0	1.2008^{bc}	0.9857^{c}	0.9032^{ab}	13.7480^{c}	11.1075^{a}
5	0.9598^{ab}	0.7139^{a}	1.1901^{c}	11.0267^{b}	13.8211^{bc}
20	1.3122^{c}	1.0199^{c}	1.0680^{bc}	15.0046^{d}	14.8510^{c}
1000	0.9526^{a}	0.8139^{b}	0.8860^{a}	9.8441^{a}	12.3676^{ab}

*Mean values for the same heavy metal carrying different superscripts along the same column are significantly different at P = 0.05.

Figure-1
Picture showing the dumped scrap metals at the experimental site

Figure-2
Close up picture showing the dumped scrap metals at the experimental site

The results in table-1b shows that the highest mean concentration of 1.1901 mg/kg of chromium in weed samples was obtained from the weed samples at 5m from the base of the scrap heap, while the lowest value came from weeds 1000m from the base of the scrap heap. There was a varied significant difference (P = 0.05) in the mean concentration of Chromium in this weed sample at the different distances.

Lead (Pb): The mean concentration of lead (Pb) in the water samples shows (table-1a) that there was significant difference (P = 0.05) in the mean concentration of Lead in the water samples from one source to the other. The mean value of Lead in sources A and B were however higher than the WHO permissible concentration of 0.01mg/L, while source C had mean values below the WHO permissible level.

The mean concentration of lead (Pb) in the weed samples as shown in table-1b reveals that there was a significant difference (P = 0.05) in the mean concentration of lead between all the distances (0m, 5m, 20m and 1000m), with the 20m distance having the highest concentration of 15.0046 mg/kg while the 1000m distance recorded the lowest mean level of 9.8441 mg/kg.

Nickel (Ni): A summary of the mean concentrations of nickel in both the water samples and weed samples are as shown in tables-1a and 1b respectively. There was a significant difference (P = 0.05) in the mean concentration of nickel among all the sampled water sources. However, the mean value of nickel at source A exceeded the WHO limit of 0.02mg/L while those of sources B and C fell below the WHO limit.

As with the previous observations in the weed samples, the value of nickel (14.8510 mg/kg) was highest at the 20m distance (table-1b).

Plants often are contaminated with heavy metals as one of the consequences of heavy metal pollution in soil, water and air[21, 22]. In their work, Rakib M.A. et al[23] reported a direct correlation between heavy metal pollution and antropogenic activities According to Singh A. and Agrawal M.[24], heavy metal contamination of the environment leads to a variety of harmful effects on soil and plant characteristics. Soils are known to be reservoirs for heavy metals released from Industrial activities and sundry other human induced processes[25]. Effects of heavy metal pollution on soil may include the alteration of soil pH, whereas in plants, it could lead to a reduction in the rate of photosynthesis, and consequently, the growth and yield in these plants[24]. In addition, the contamination of soil and groundwater by heavy metals is also known to cause major environmental and human health problems[1].

The results obtained from this study shows that the concentration of heavy metals studied were higher than the permissible limits given by WHO[26], especially in the well sample. The results for the water samples showed that for all the heavy metals studied, source A (well) had the highest concentration in all cases. These values (in all cases) exceeded the maximum acceptable concentration given by WHO[26], (for portable water) by more than 51, 2000, 10, 599 and 399 times for As, Cd, Cr, Pb and Ni respectively. This can be attributed to the possible contamination of the well water by leachates from the scrap metal heaps in the studied dumpsite. The result also

shows that source C (a borehole) had the lowest concentrations of the heavy metals considered in this study which fell below the permissible concentration given by WHO for all the heavy metals tested[27].

The most probable major cause of this alarming increased contamination being through anthropogenic sources such as storage/dumping of the scrap metals in heaps on the ground surface for a long period of time prior to smelting and recycling operations. Wastes generated from scrap metal smelting activities in the vicinity of the study site are suspected to have caused these increases in heavy metals contamination of the portable water around the study site, especially for site A. Dumping of these scrap metals in open (uncovered) and unconcritized grounds exposes the scrap metals to the direct impact of air and rain thereby generating leachates which seeps out, and in sloppy areas are carried through surface run-off downstream into the nearby exposed water sources.

Through rivers and streams, the heavy metals are transported as either dissolved species in water or as an integral part of suspended sediments, (dissolved species in water have the greatest potential of causing the most deleterious effects)[7]. They may then be stored in river bed sediments or seep into the underground water sources thereby moving along water pathways and contaminating water from underground sources, particularly wells; and the extent of contamination will depend on the nearness of the well to the scrap metal dumpsite[7]. Wells located near metal sites have been reported to contain heavy metals at levels that exceed drinking water criteria/standards[7,12].

Since boreholes are deeper than wells, findings by Garbarino J.R. et al.[7] sufficiently gives the reason for the low concentration in source C (a borehole) of all the heavy metals considered in this study.

The symptoms of acute Lead poisoning due to ingestion according to WHO[26] are headache, irritability, abdominal pain and various symptoms related to the nervous system; Lead encephalopathy is characterized by sleeplessness and restlessness and in severe cases of Lead encephalopathy, the affected person may suffer from acute psychosis, confusion and reduced consciousness[26]. Children may be affected by behavioural disturbances, learning and concentration difficulties[26]. Lead exposure in children may also lead to diminished intellectual capacity[26].

Acute exposure to Lead is known to cause proximal renal tubular damage and long-term Lead exposure may lead to anaemia[26] and may also give rise to kidney damage. According to a study of Egyptian Policemen, urinary excretion of N-Acetyl-β-D-glucosaminidase (NAG) was positively correlated with duration of exposure to Lead from automobile exhaust, blood lead and nail lead[27]. Another report recognized and documented the occupational exposure and proximity mechanism as an important route for contamination by toxic chemicals[28,29].

Lead accumulates in the body over time and remains in the blood for a month, in organs for several months, and in bones for years[30]. Inorganic Lead is classified as a reasonably anticipated human carcinogen by NTP and as a probable human carcinogen by IARC[31,32].

It was reported that skin exposure to nickel dust can cause allergic contact dermatitis, often at the point on the skin where the contact occurred[33].

Some occupational studies of employees exposed to Nickel compounds have found increased risk of lung and nasal cancer among employees[33]. Most Nickel compounds are classified as known human carcinogens by IARC and NTP[32, 31]. Persons who inhale large amounts of nickel may suffer from inflammation of the respiratory tract, chronic bronchitis or reduced lung function[33].

The results obtained from the weed samples showed the presence of heavy metals in the weed samples. The concentration of Arsenic, Cadmium, Lead and nickel was highest at distance 20m, while the concentration of Chromium was highest at distance 5m. The lowest concentration in 3 out of the 5 heavy metals studied (namely Arsenic, Chromium and Lead) was seen at distance 1000m away from the study site while cadmium and Nickel had the lowest concentration at distance 5m and 0m respectively. In general, we can safely deduce that the farther away a place or a plant is from a heavy metal source, the lower the heavy metal burden, especially those that are transported as gaseous emissions[34,22,35].

An exception to this general rule may obtain where the principal mode of transportation of these heavy metals is water. Here, factors such as the type and nature of the subsurface geology, the nature and topography of the soil may possibly account for where deposits are highest or lowest and not necessarily the distance from the source[36].

When soils are contaminated (polluted) by heavy metals, these metals are taken up by plants and consequently accumulate in their tissues[37]. The exposure of plants to heavy metals causes reduction in photosynthesis, water uptake and nutrient uptake[17]. Recent studies has also shown that plants grown in soil containing high levels of cadmium show visible symptoms of injury reflected in terms of chlorosis, growth inhibition, browning of root tips, and finally death[18,19]. In a similar studies, the presence of heavy metal contamination of a soil was reported to have constituted a stress factor to the plants growing on this soil[38], especially because plants (and plant parts) are capable of adsorbing and absorbing heavy metals from their environment[39].

E. indica used in this study is of particular interest because this plant is directly grazed on by ruminants (that are raised under the free range system) around the study area. Animals that graze on such contaminated plants or weeds also accumulate such

metals in their tissues[7,12]. Humans are in turn exposed to heavy metals by consuming contaminated plants and animals[40] and this has been known to result in various biochemical disorders[9]. In summary, all living organisms within a given ecosystem are variously contaminated along their cycles of food chain. The contamination of the food chain by heavy metals is not directly affected by the plant's total uptake, but rather by the concentration of these heavy metals in those plant parts that are directly consumed[41].

Conclusion

In conclusion, it can be seen from the results from this study, that both the water and plant samples found around the vicinity of this scrap metal smelting Industry are contaminated with the heavy metals that were beyond the maximum permissible level (in some instances). This phenomenon naturally throws to the fore the urgent need for an immediate formulation and institution of a national policy by the Nigerian government on the promotion of the manufacturing of goods which at the end of their useful life can be recycled safely and efficiently. In addition, there is the need for the strict implementation and enforcement of our existing but lax environmental laws and regulations. In this instance therefore, there is the need for the provision of site management practices (for these factories) that are designed to minimize or out rightly eliminate the potential adverse environmental and health effects of scrap metal smelting and recycling. In this instance, it is imperative that these scrap metals be stored in buildings (warehouses) with well cemented floors and proper roofing.

References

1. Singh A. and Agrawal M., Effects of municipal waste water irrigation on availability of heavy metals and morpho-physiological characteristics of *Beta vulgaris L., J.environ. Biol*., **31**, 727-736 **(2010)**

2. Shah F.R., Ahmad N., Masood K.R. and Zahid D.M., The influence of cadmium and chromium on the biomass production of sishum (*Delbergia sishoo* Roxb.) Seedling, *Pak. J. Bot*., **40(4),** 341-1348 **(2008)**

3. Lenntech Water Treatment and Air Purification, Water Treatment, Published by Lenntech, Rotterdamseweg, Netherlands, Accessed 20/10/2012. Available: http:www.excelwater.com/thp/filters/Water –Purification. htm) **(2004)**

4. United Nations Environmental Protection/Global Program of Action, Why The Marine Environment Needs Protection From Heavy Metals, Heavy Metals 2004, UNEP/GPA Coordination office. Accessed 20/10/2012, Available: http://www.oceansatlas.org/untlas/uses/ uneptextsph/ wastesph/ 2602gpa **(2004)**

5. Hutton M. and Symon C., The Quantities of Cadmium, Lead, Mercury and Arsenic Entering the U.K. Environment from Human Activities, *Sci. Total Environ.,* **57**,129-150 **(1986)**

6. Battarbee R.W., Anderson N.J., Appleby P.G., Flower R.J., Fritz S.C., Haworth E.Y., Higgit S., Jones V.J., Kreiser A., Munro M.A.R., Natkanski J., Oldfield F., Patrick S.T., Richardson N.G., Rippey B., Stevenson A., C Lake, Acidification in The United Kingdom. ENSIS Publishing, London, Accessed 20/10/2012. Available: Http://www.geog.Ucl.ac.Uk/~spatrick/f_r_pubs.htm. **(1988)**

7. Garbarino J.R., Hayes H., Roth D., Antweider R., Brinton T.I. and Taylor H., Contaminants in the Mississippi River, U.S. Geological Survey Circular 1133, Virginia,U.S.A.Accessed20/10/2012, Available: (www.pubs,usgs.gov/circ/circ1133/) **(1995)**

8. Hawkes J.S., Heavy Metals, *J.chem.Edu.,* **74(11)**, 1374-1381 **(1997)**

9. Duruibe J.O., Ogwuegbu M.O.C. and Egwurugwu J.N., Heavy Metal Pollution and Biotoxic Effects in Humans, *Int. J. Phys. Sci.,* **2(5)**, 112-118 **(2007)**

10. Ozdilek H.G., Mathisen P.P. and Pellegrino D., Distribution of heavy metals in vegetation surrounding the Blackstone River U.S.A: Considerations regarding sediment contamination and long term metals transport in freshwater Riverine Ecosystems, *J. Environ. Biology,* **28(2)**, 493-502 **(2007)**

11. Duffus J.H., Heavy metals, A meaningless term? (IUPAC Technical Report), *Pure and Applied Chemistry*, **74,** 793-807 **(2002)**

12. Peplow D., Environmental Impacts of Mining in Eastern Washington, Center for Water and Watershed Studies Fact sheet, University of Washington, Seattle **(1999)**

13. Ferner D.J., Toxicity of heavy metals, *eMed. J.,* **2(5)**, 1-11 **(2001)**

14. Young R.A., Toxicity Profiles: Toxicity Summary for Cadmium Risk Assessment Information System, RAIS, University of Tennessee. Accessed 20/10/2012, Available: http//rais.ornl.gov/tox/profiles/ cadmium.shtml **(2005)**

15. Wojtaszek P., Oxidative Burst: An Early Plant Response to Pathogen Infection, *Biochem. J.,* **322**, 681-692 **(1997)**

16. Mithofer A., Schulze B. and Boland, W., Biotic and heavy metal stress response in plants: evidence for common signals, *FEBS letters,* **566,** 1-5 **(2004)**

17. Yadav S.K., Heavy metal toxicity in plants: An overview on the role of glutathione and phyto chelatins in heavy metal stress tolerance of plants, *South African J. Bot.,* **76**, 167-179 **(2009)**

18. Wojcik M. and Tukiendorf A., Phytochelatin synthesis and cadmium localization in wild type of *Arabidopsis thaliana, Plant Growth Regulator,* **44**, 71-80 **(2004)**

19. Mohanpuria P., Rana N.K. and Yadar S.K., Cadmium induced oxidative stress influence on glutathione metabolic genes of *Camellia sinensis* (L.) O. Kuntze, *Environ Toxicol,* **22,** 368-374 **(2007)**

20. American Public Health Association, APHA Standard Methods for the examination of water and wastewater, 17th edition, New York **(1990)**

21. Cheng S., Effects of heavy metals on plants and resistance mechanisms, *Environ Sci Pollut Res Int.* 10**(4)**, 254-264 **(2003)**

22. Sanyaolu, V.T., Sanyaolu, A. A. A. and Fadele, E., Spatial variation in Heavy Metal residue in *Corchorus olitorious* cultivated along a Major highway in Ikorodu- Lagos, *JASEM,* **15(2),** 283-287 **(2011)**

23. Rakib M.A., Ali M., Akter M.S. and Mohammed A.H., Bhuiyan, Assessment of Heavy Metal (Pb, Zn, Cr and Cu) Content in Roadside Dust of Dhaka Metropolitan City, Bangladesh, *Int. Res. J. Environment Sci.,* **3(1),** 1-5 **(2014)**

24. Singh A. and Agrawal M., Management of heavy metal contaminated soil by using organic and inorganic fertilizers: Effect on plant performance, *The IIOAB journal,* **2,** 22-30 **(2011)**

25. Abdullahi M.A., Mohammed S.S. and Iheakanwa A.I., Assessment of the Levels of Fe, Ni and Cu in Soil along the Bank of River Kaduna, Nigeria, *Res. J.Recent Sci.,* **2(12),** 38-42 **(2013)**

26. WHO Lead, Environmental Health Criteria, Vol. 165. World Health Organisation, International Programme on Chemical Safety (IPCS), Geneva, Switzerland **(1995)**

27. Mortada W.I., Sobh M.A., El-Defrawy M.M. and Farahat S.E., Study of lead exposure from automobile exhaust as a risk for nephrotoxicity among traffic policemen, *Am. J. Nephrol.,* **21,** 274-279 **(2001)**

28. Kuruva Syamala Devi, Arza V.V.S. Swamy, Ravuri Hema Krishna. Studies on the Solid Waste Collection by Rag Pickers at Greater Hyderabad Municipal Corporation, India, *Int. Res. J. Environment Sci*., **3(1),** 13-22 **(2014)**

29. Luay A. Al-Helaly and Tareq Y. Ahmed. Antioxidants and Some Biochemical Parameters in Workers Exposed to Petroleum Station Pollutants in Mosul City, Iraq, *Int. Res. J.*, **3(1),** 31-37 **(2014)**

30. New York State Department of Health, NYSDOH, Lead on the Job: A Guide for Workers, Accessed 20/10/2012, Available: http://www.health.state.ny.us/nysdoh/lead/worker.htm. **(2001**)

31. National Toxicology Program, NTP Eleventh Report on Carcinogens, **(2004)**

32. International Agency for Research on Cancer, IARC List of Agents Evaluated and their Classifications as Evaluated in IARC Monographs. Volumes 1-85. Accessed 10/11/2012. Available on http://monographs. iarc. fr/ENG/Classification/ index.php**(2006)**

33. Agency for Toxic Substances and Disease Registry (ATSDR), Toxicological Profile for Nickel **(2005)**

34. Atayese M.O., Eigbadon A.I., Oluwa K.A. and Adesodun J.K., Heavy metal Contamination of Amaranthus grown along major highways in Lagos, Nigeria, *African Crop Science Journal,* **16(4),** 225-235 **(2009)**

35. Sanyaolu V.T., Sanyaolu A.A.A. and Fadele E., Spatial variation in heavy metal concentration in an arable soil along a major highway in Ikorodu- Lagos, Nigeria, *Journal of Soil Science and Environmental Management,* **3(10),** 231-236 **(2012)**

36. WHO Guidelines for Drinking-Water Quality. World Health Organization, Geneva **(1993)**

37. Trueby P., Impact of Heavy Metals on Forest Trees Mining Areas, In: *International Conference on Mining and The Environment III*, Sudbury, Ontario, Canada. Accessed 20/11/2012. Available: http//: www.x cd.com/Sudbury03/Prof156.html) **(2003)**

38. Subha Priya Venkateswaran and Rajeshwari Sivaraj. Physiological and Pigment variations in *Talinum triangulare* (Jacq.) Willd. grown on Chromium polluted Soil treated with Chelants, *Int. Res. J. Environment Sci.,* **2(12),** 6-12 **(2013)**

39. Bhat Irshad Ul Haq1, Elias Nursafura and Khanam Zakia, Adsorption Studies of Cr (VI) and Fe (II) Aqua Solutions Using Rubber Tree Leaves as an Adsorbent, *Int. Res. J. Environment Sci.,* **2(12**), 52-56 **(2013)**

40. Ogwuegbu M.O.C. and Muhanga W., Investigation of Lead Concentration in the Blood of People in the Copperbelt Province of Zambia, *J. Environ*., **1,** 66-75 **(2005)**

41. Lee S., Allens E.H., Huang C.P., Sparks D.L., Sanders P.F. and Peijnenburg W.J., Predicting Soil-water Partition Coefficients for heavy metals, *Environ. Sci. Tech*., **30,** 3418-3424 **(1996)**