IJAAR PUBLISHING®
DOI: 10.46654

International Journal of Advanced Academic Research | ISSN: **2488-9849**
Vol. 7, Issue 7 (July, 2021) | www.ijaar.org
Journal DOI: **10.46654/ij.24889849**
Article DOI: **10.46654/ij.24889849.e7710**

ASSESSMENT OF HEAVY METAL CONCENTRATION IN SOIL FROM FARMLAND AT UHUAKI UMUAWUKA EMII, OWERRI NORTH LGA, IMO STATE

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ABSTRACT

The study was conducted to assess the concentration of heavy metals in soil samples from Uhuaki Umuawuka Emii, Owerri North LGA, Imo State. 11 soil samples were analysed for their heavy metal concentration using Atomic Absorption Spectrophotometer (AAS) model FS240AA. Concentration of Titanium ranged from 0.18-0.26 with mean of 0.223, Chromium ranged from 0.01 to 0.15 with mean of 0.0042 µg/g. Manganese ranged from 0.06 to 0.07 with mean of 0.065 µg/g. Iron ranged from 0.0 to 2.75 with mean of 2.38 µg/g. Nickel ranged from 0.0 to 0.6 with mean of 0.029 µg/g. Copper ranged from 0.01 to 0.02 with mean of 0.016 µg/g. Zinc ranged from 0.04 to 0.05 with mean of 0.045 µg/g. Vanadium ranged from 0 to 0.01 with mean of 0.0042 µg/g. The mean concentrations of the heavy metals in soil samples ranged from 0.0005 to 2.385 µg/g, in the order Fe > Ti > Cr > Mn > Zn > Ni > Cu > Ga > V > Co > Ge > As with Ga, V,Co, Ge and As recording almost zero concentrations. The study shows that concentrations of heavy metals in the soil samples were very low when compared with the regulated standard. This may be attributed to low level of industrial activities in the area. However, Iron recorded the highest concentration. From the present study the following conclusions could be made: The concentrations of the heavy metals in soils from Emii area showed low levels of pollution, the highest concentration recorded was from iron, all levels of concentration falls within the permissible limits. However, sensitization of the populace in the area is needed about the health implications of heavy metal especially with the gradual urbanization of most outskirt towns.

Keywords: Heavy metals, soil, pollution, Emii, Owerri North

INTRODUCTION

Heavy metals are kept under environmental pollutant category due to their toxic effects on plants, man and animals. These heavy metals are not metabolized to other intermediate compounds and do not easily decompose in the environment.

Heavy metals such as cadmium, nickel, arsenic and lead pose a number of hazards to humans, animals and plants (Barron, 1990). As trace elements, some heavy metals (e.g copper, selenium and zinc) are essential to maintain the metabolic pathway of the human body; however, at higher concentration, they can lead to poisoning (Bagul *et al*., 2015).

Many different definitions of heavy metals have been proposed, some are based on density, some on atomic number or atomic weight, and some on chemical properties or toxicity (Agency for toxic substances and disease registry (ATSDR), 2005). Heavy metals are also chemical elements with a specific gravity that is at least 5 times the specific gravity of water. Specific gravity itself is a measure of density of a given amount of a solid substance when compared with an equal volume of water (ATSDR, 2005).

Heavy metals are among the contaminants in the environment. Besides the natural activities, almost all human activities also have potential contribution to producing heavy metals as side effects. Migration of these contaminants to non-contaminated areas as dust or leachates through the soil and spreading of heavy metals containing sewage sludge are a few examples of events contributing towards contamination of the ecosystem (Gaur & Adholeya, 2004).

Heavy metals are important environmental pollutants, particularly in areas with high anthropogenic pressure. Their presence in the atmosphere, soil and water, even in traces, can cause serious problems to all organisms. Heavy metal accumulation in soils is of concern in agricultural production due to the adverse effects on food quality (safety and marketability), crop growth (due to phytotoxicity) (Ma *et al.*, 1994; Masky and Calvert, 1990; Fergusson, 1990) and environmental health (soil flora / fauna and terrestrial animals).

Mobilization of heavy metals into the biosphere through human activities has become an important process in the geochemical cycling of these metals. This is acutely evident in urban areas where various stationary and mobile sources release large quantities of heavy metals into the atmosphere and soil, exceeding the natural emission rates (Nriagu, 1989; Bilos *et al.*, 2001).

Increased human activities, such as industrialization, coupled with over- population and increased ambient temperature amongst other factors, have become major environmental issues in recent years. Soil prospecting and other industrial activities result in pollution through gas flares, content oil spills, and industrial effluents. These affect both aquatic and terrestrial ecosystems and can result in destruction of forest and farmlands (Dambo, 2000).

Rapid industrialization, intensive agriculture and other anthropogenic activities have led to land degradation, environmental pollution and decline in crop productivity and sustainability. These have been of great concern to man and other animals.

These wastes, although useful as sources of nutrients, are also sources of carcinogens and toxic metals. Relevant industrial activities include those of steel, glass, and paint manufacturing industries. Discharges from these industries pollute the air, water and soils,

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endangering the environment as they ultimately find their way into the food chain, albeit in small doses. These accumulate over time and across trophic levels to pose serious health hazards to man (Pickering & Owen, 2000).

The contamination of soil by heavy metal can cause adverse effects on human health, animals and soil productivity *(Smith et al., 1996)*. Metals cause physiological disorders in soils as absorption through root system consequently retards plant growth and deprives it of vigour (Moustakas et al., 1994). Depending on the tendency of the contaminants they end up either in water held in the soil or leached to the underground water. Contaminants like Cd, Cu, Ni, Pb and Zn can alter the soil chemistry and have an impact on the organisms and plants depending on the soil for nutrition (Shaylor et al., 2009).

The study area is one of the rapidly outskirt towns around Owerri Municipal, hence the need for this study as soil is a crucial component of urban environments and its management is the key to its quality.

THE STUDY AREA

The study area fall within the Cartesian coordinates of latitude: 5^{0}20’ N” and 5^{0}33’N and longitude: 6^{0}53’E and E7^{0}08’E (Fig 1). The geology of the area is predominantly composed of coastal plain sand.

The climate falls within the tropical rain forest zone. The first phase of rainy season starts from April to July while the second lasts from September to October. The dry season is divided into the cold dry season (harmattan) and the hot dry season.

The mean annual atmospheric temperature within the study area is about 28^{0}c maximally. It is usually at its peak from February-April toward the end of dry season but hardly exceeds 3^{0}c. The mean annual pressure ranges from 1010 millibars to 1012.9 millibars. Average daily pressure value at mean sea level (MSL) is about 109mb- 10mb during the dry season.

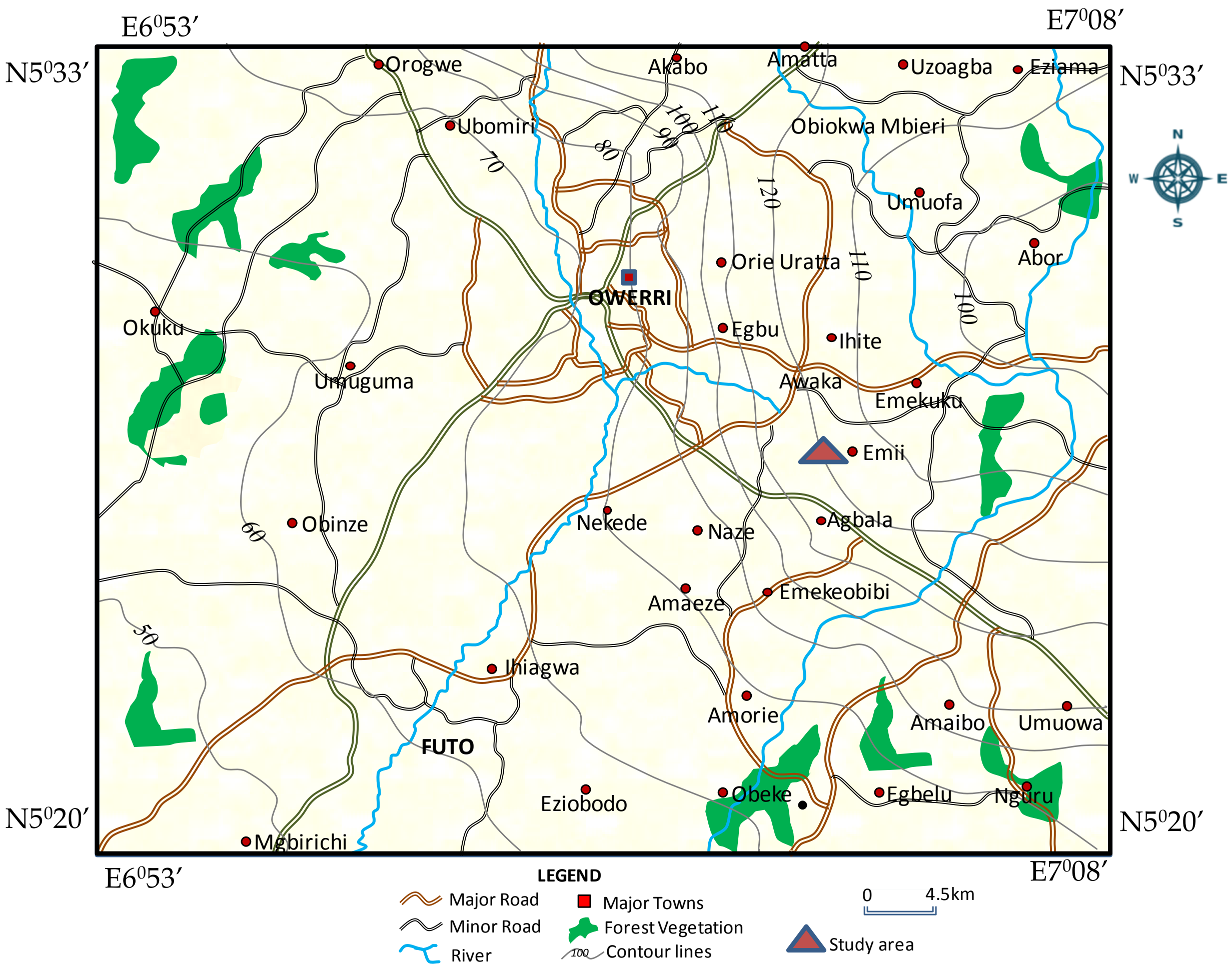

Fig 1. Location map of the study area

HEAVY METALS: AN OVERVIEW

Heavy metals are conventionally defined as elements with metallic properties and an atomic number greater than 20. The most common heavy metal contaminants are Cadmium (Cd), Chromium (Cr), Copper (Cu), Mercury (Hg), Lead (Pb) and Zinc (Zn). Metals are natural components in soil. Some of these metals are micronutrients necessary for plant growth. They include Zn, Cu, Mn, Ni and Co, while others (such as Cd, Pb, and Hg) have unknown biological function (Gaur and Adholeya, 2004).

Metal pollution has harmful effect on biological systems, and metals do not undergo biodegradation. Toxic heavy metals such as Pb, Co, Cd can be differentiated from other pollutants, since they cannot be biodegraded and can be accumulated in living organisms, thus causing various diseases and disorders even in relatively lower concentrations (Pehlivan *et al.*, 2009). Heavy metals, with soil residence times of thousands of years, pose numerous health dangers to higher organisms. They are also known to have effect on plant growth ground cover and have a negative impact on soil micro flora (Roy *et al.*, 2005).

Lead (Pb)

Lead (Pb), with atomic number 82, atomic weight 207.19 and a specific gravity of 11.34, is a bluish or silvery grey metal, with melting point of 37.5^{0}C and a boiling point at atmospheric

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pressure of 1740^{0}C. It has four naturally occurring isotopes with atomic weights 208, 206, 207 and 204 (in decreasing order of abundance). Despite the fact that lead has four electrons on its valence shell, its typical oxidation state is +2 rather than +4, since only two of the four electrons ionize easily. Apart from nitrate, chlorate, and chloride, most of the inorganic salts of lead 2+ have poor solubility in water (WHO, 2001).

Lead (Pb) exists in many forms in the natural sources throughout the world and is now one of the most widely and evenly distributed trace metals. Soil and plants can be contaminated by lead from car exhaust, dust and gases from various industrial sources.

Lead (II) was found to be acutely toxic to human beings when present in high amounts. Since Pb^{2+} is not biodegradable, once soil has become contaminated, it remains a long-term source of lead (II) exposure. Metal pollution has a harmful effect on biological systems and metals do not undergo biodegradation (Pehlivan, *et al.*, 2009). Soil can be contaminated with lead from several sources such as industrial sites, leaded fuels, old lead plumbing pipes, or even old orchard sites in production where lead arsenate is used. Lead accumulates in the upper 8cm of the soil and is highly immobile.

Cadmium (Cd)

Cadmium is a divalent metal with atomic number 48, chemically similar to zinc and mercury. Although it is widely distributed in the lithosphere, cadmium is usually found at quite low concentrations in crystal rocks. Sometimes its concentrations, as high as 100ppm, are found in phosphatic rocks (due to presence of fossilized fish teeth). Cadmium may also be leached from sulphide ores of zinc, copper and lead (Idodo-Umeh & Ogbeibu, 2010). Cadmium is produced as an inevitable bye product of zinc refining, since these metals occur naturally within the raw ore. In general to non-smokers, the major exposure pathway is through food, via the addition of cadmium to agricultural soil from various sources (atmospheric deposition and fertilizer application) and uptake by food and fodder crops. Additional exposure to humans arises through cadmium in ambient air and drinking water (Idodo-Umeh & Ogbeibu 2010).

The toxic effects of cadmium are presumably associated with metals affinity for organic ligands containing sulphur, nitrogen or other electronegative functional groups. The most serious effects of cadmium poisoning usually involve damage to the kidney, particularly the renal tube. These symptoms are associated with proteinurea, glucosuria and high alkaline phosphate in the blood. Cadmium poisoning is also associated with bone softening, fatal lung damage, high rise of blood pressure and other heart diseases (Idodo-Umeh & Ogbeibu, 2010).

Chromium (Cr)

Chromium with atomic number 24 has its major ore as chromite, $FeOCr_2O_3$, from which ferrochrome alloys and chromium metals are obtained. Chromium (vi) is toxic but its lifetime in the aqueous environment is limited as it is reduced to chromium (iii) by organic materials. Chromium (vi) is used for the estimation of total organic carbon in environmental studies of materials such as soil and water (Sautra, 2008). Chromium is used in metal alloys and pigments for paints, cement, paper, rubber and other materials (Sautra, 2008). At sub-lethal level, chromium has a number of metabolic effects. When the level of sugar in the blood is critical to the functioning of body tissues, especially the brain, chromium plays a role in lowering the blood sugar level in the body by increasing the effectiveness of insulin. Also, it results in necrosis, nephritis and death in man and lower dose will cause irritation of the gastro intestinal mucosa. Hexavalent chromium in high doses has been implicated as the cause of digestive tract cancer in man. Also, chromium can produce cutaneous and nasal mucous membrane ulcers and dermatitis (from skin contact) (Sautra, 2008). High concentrations of chromium, however, cause much more deleterious effect, such as genetic damage and carcinogenesis (Sautra, 2008).

Arsenic (As)

Arsenic with atomic number 33 is widely distributed through the earth's crust. Arsenic combines with oxygen, chlorine and sulphur to form inorganic compounds. Arsenic in plants and animals combine with carbon and hydrogen to form organic arsenic compound which is the toxic form of arsenic for man (Ndiokwere and Ezehe, 2000). Arsenic exists both in inorganic and organic forms and also in different valence states. Inorganic arsenic is significantly more toxic than organic arsenic compounds such as dimethyl arsenate and in turn the trivalent forms of arsenic, for example, arsenic trichloride is more toxic only after metabolic conversion to the trivalent form of arsenic. This pattern of toxicity is also seen for certain other metallic compounds in the body e.g. chromium compounds. Exposure to inorganic arsenic is primarily of concern because of its cancer-causing properties. Arsenic has been classified by the International Agency for Research into Cancer (IARC) as a human carcinogen on the basis of increased incidence of cancers at several sites where people are exposed to arsenic at work, in the environment or through their diet. However, arsenic is also more acutely toxic compared with other metallic compounds, and was used in earlier times as a rodenticide, while continual low level exposure to arsenic is associated with skin, vascular and nervous system disorders.

Arsenic (III) exerts its toxic action by attacking – SH groups of an enzyme, thereby inhibiting enzyme action. Long term exposure has been linked to a variety of illness including hypertension, diabetes, cardio vascular diseases, infertility, cancer of the skin, lungs, urinary bladder and kidney (Barron, 1990).

IRON (Fe)

Iron is a chemical element with the symbol Fe and atomic number 26. It exists in wide range of oxidation states. Iron and iron alloys (steel) are by far the most common metals and most common ferromagnetic materials in everyday use. Iron is the most common in the earth's crust (Sautra, 2008). Sources include mine, coal storage pile, drainage, steel manufacturing and rolling, inorganic chemicals, metal processing and plating, paint and ink manufacturing companies (Sautra, 2008). At sub-lethal level, iron has a number of metabolic effects which include bleeding gums, constipation, dizziness, emotional problems, fatigue, headache, joint pain, nausea, loss of weight. High concentration of iron however causes much more deleterious effects, such as rheumatoid arthritis, birth defects, heart damage, heart failure, hepatitis, high blood pressure, insomnia, liver diseases, mental problems and shortness of breath (Barron, 1990).

Barium (Ba)

Barium with atomic number 56 is a very abundant, naturally occurring metal and is used for a variety of industrial purposes. Barium compounds, such as barium-nickel alloys, are used for spark-plug electrodes and in vacuum tubes as a drying and oxygen-removing agent; barium sulfide is used in fluorescent lamps; barium sulfate is used in diagnostic medicine; barium nitrate and chlorate give fireworks a green color. Barium compounds are also used in drilling muds, paint, bricks, ceramics, glass, and rubber.

Barium is not known to cause cancer.

- Short term exposure can cause vomiting, abdominal cramps, diarrhea, difficulties in breathing, increased or decreased blood pressure, numbness around the face, and muscle weakness.
- Large amounts of barium intake can cause, high blood pressure, changes in heart rhythm or paralysis and possibly death.

METHODOLOGY

11 soil samples from Uhuaki Umuawuka Emii were analysed for their heavy metal concentration. Atomic Absorption Spectrophotometer (AAS) model FS240AA was used for analyzing the aforementioned heavy metals. The mode of operation of AAS is based on the sample being aspirated into the flame and atomized when the light beam in the AAS is directed through the flame into the monochromator, and onto the detector that measures the amount of light absorbed by the atomized element in the flame. Since metals have their own characteristic absorption wavelengths, a source lamp composed of that element is normally used, a method relatively free from spectral or radiational interferences. The amount of energy of the characteristic wavelength absorbed in the AAS is proportional to the concentration of the element in the sample

QUALITY ASSURANCE

Appropriate quality assurance procedures and precautions were carried out to ensure reliability of the results. Samples were generally carefully handled to avoid contamination. Glasswares were properly cleaned, and the reagents were of analytical grade. Double distilled deionised water was used throughout the study. Reagents blank determinations were used to correct the instrument readings.

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RESULTS

Sample ID	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As
2mm_G1	0.1796	0.0021	0.1433	0.0626	2.409	0.00338	0.0503	0.01454	0.03936	0.00051	0.00017	0.00066
2mm_G2	0.2065	0.00295	0.0973	0.0598	2.379	0.0028	0.04262	0.0136	0.04052	0.00053	0.0003	0.00065
2mm_G3	0.241	0.00465	0.1028	0.068	2.754	0.0045	0.02883	0.01692	0.04975	0.00039	0.00018	0.00082
2mm_G4	0.2378	0.0023	0.00953	0.0679	2.666	0.0028	0.0273	0.01839	0.05204	0.00029	0.00017	0.00104
2mm_G5	0.2222	0.00578	0.1072	0.0654	2.747	0.00301	0.03448	0.01995	0.04972	0.00055	0.00016	0.00105
2mm_G6	0.1919	0.00305	0.0987	0.0623	2.527	0.00268	0.03754	0.01431	0.03682	0.0003	0.00028	0.00084
2mm_U1	0.2554	0.00529	0.0202	0.0706	2.454	0.0026	0.00532	0.01248	0.04074	0.00082	0.00016	0.00138
2mm_U2	0.252	0.0066	0.0085	0.0682	2.502	0.00242	0.00549	0.01518	0.0444	0.00069	0.00015	0.00115
2mm_U3	0.2345	0.00524	0.032	0.0603	2.336	0.00327	0.00495	0.0112	0.04152	0.00042	0.0003	0.00101
2mm_U4	0.2264	0.0046	0.0336	0.064	0.00232	0.0025	0.00532	0.01552	0.04433	0.00064	0.00037	0.00207
2mm_U5	0.2446	0.00452	0.0271	0.0668	2.585	0.00232	0.00556	0.0161	0.04606	0.0003	0.0002	0.00154
2mm_U6	0.246	0.00571	0.0163	0.071	2.596	0.0026	0.00594	0.01531	0.04816	0.00057	0.00018	0.00173
500_G1	0.1947	0.00441	0.1506	0.0605	2.543	0.00359	0.0606	0.01822	0.04426	0.00055	0.00029	0.00094
500_G2	0.1855	0.002	0.1165	0.0609	2.262	0.0028	0.0539	0.01369	0.03685	<0.00029	0.00012	0.00064
500_G3	0.2332	0.00261	0.0831	0.0676	2.576	0.0049	0.03043	0.02092	0.05454	0.00053	0.00022	0.00099
500_G4	0.2327	0.00295	0.1274	0.0691	2.604	0.0029	0.04276	0.01918	0.05152	0.00026	0.00042	0.00141
500_G5	0.2166	0.00656	0.1007	0.0702	2.58	0.00342	0.04229	0.01705	0.04877	0.00024	0.00035	0.00115
500_G6	0.2244	0.00408	0.1169	0.0648	2.42	0.0028	0.0471	0.01707	0.0435	0.00071	0.00015	<0.00067
MEAN	**0.2236**	**0.0042**	**0.0773**	**0.0656**	**2.3857**	**0.0031**	**0.0295**	**0.0161**	**0.0452**	**0.0005**	**0.0002**	**0.0011**

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The results of the mean concentration of heavy metals in soil samples are shown in Table 1.

Concentration of Titanium ranged from 0.18-0.26 with mean of 0.223, Chromium ranged from 0.01 to 0.15 with mean of 0.0042 µg/g. Manganese ranged from 0.06 to 0.07 with mean 0.065 µg/g. Iron ranged from 0.0 to 2.75 with mean of 2.38 µg/g. Nickel ranged from 0.0 to 0.6 with mean of 0.029 µg/g. Copper ranged from 0.01 to 0.02 with mean of 0.016 µg/g. Zinc ranged from 0.04 to 0.05 with mean of 0.045 µg/g. Vanadium ranged from 0 to 0.01 with mean of 0.0042 µg/g.

The mean concentrations of the heavy metals in soil samples ranged from 0.0005 to 2.385 µg/g, in the order Fe > Ti > Cr > Mn > Zn > Ni > Cu > Ga > V > Co > Ge > As with Ga, V,Co, Ge and As recording almost zero concentrations (Fig 2 and 3).

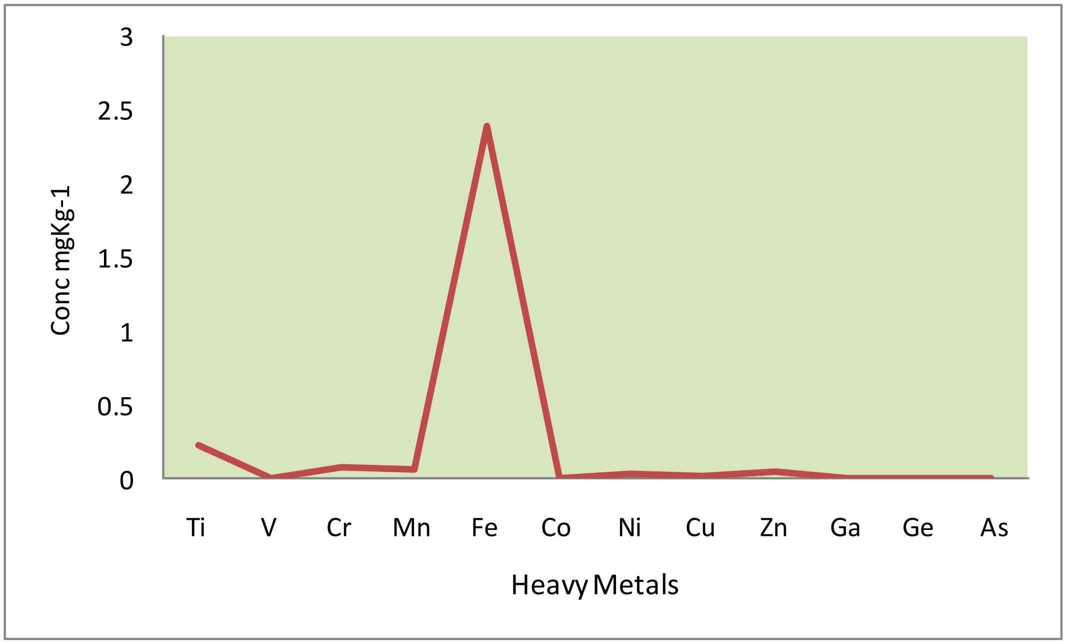

Fig 2. 2D line plot showing heavy metal concentrations in soils of the study area

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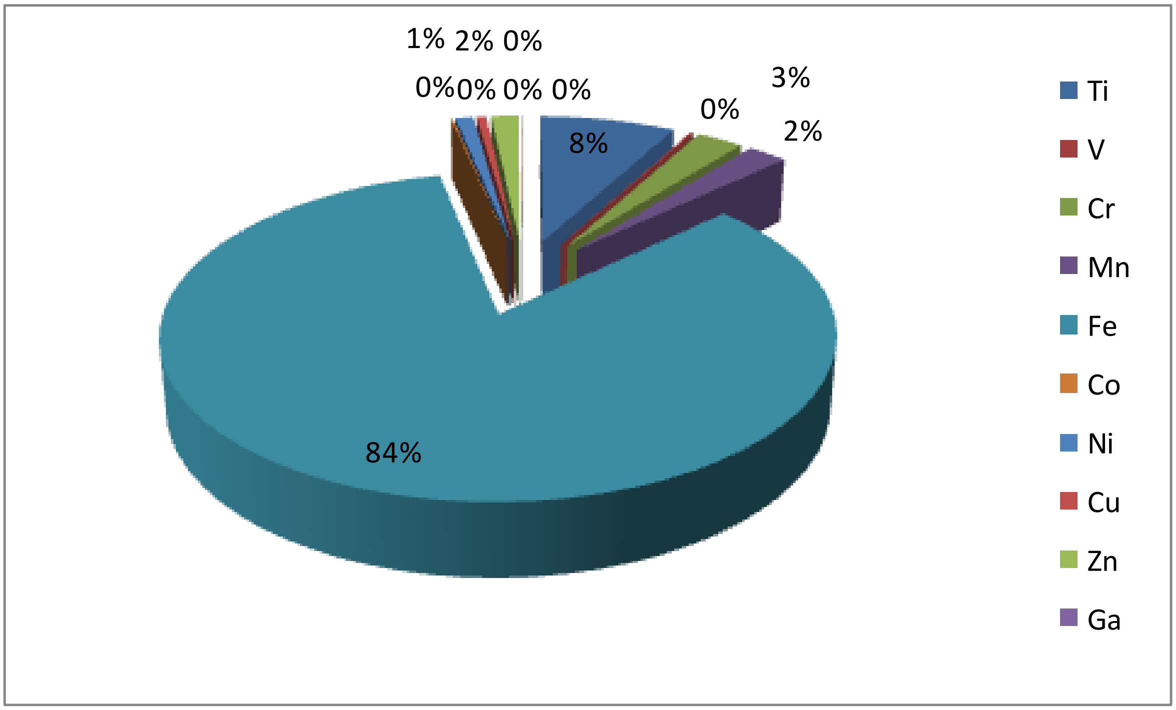

Fig 3. Chart showing percentage concentration of heavy metals in soils

Table 2. Table 2: Maximum Allowable Limits of Heavy Metal in Irrigation Water, Soils and Vegetables (µg/g) (After Ciroma et al, 2014)

Chemical Element	Maximum permissible level in irrigation water (µg/ml)	Maximum permissible level in soils (µg/g)	Maximum permissible level in vegetables (µg/g)
As	0.10	20	-
Cd	0.01	3	0.10
Co	0.05	50	50.00
Cr	0.55	100	-
Cu	0.017	100	73.00
Fe	0.50	50000	425.00
Mn	0.20	2000	500.00
Ni	1.40	50	67.00
Pb	0.065	100	0.30
Se	0.02	10	-
Zn	0.20	300	100

DISCUSSION

The mean concentrations of the heavy metals in soil samples ranged from 0.0005 to 2.385 µg/g, in the order Fe > Ti > Cr > Mn > Zn > Ni > Cu > Ga > V > Co > Ge > As with Ga, V,Co, Ge and As recording almost zero concentrations.

The study shows that concentrations of heavy metals in the soil samples were very low when compared with the regulated standard (Table 2). This may be attributed to low level of industrial activities in the area. However, Iron recorded the highest concentration. As may be expected, Iron and iron alloy (Steel) are by far the most common metals, and ferromagnetic materials in everyday use and sources include metal processing and plating, paints (car paints) and steel (Sautra, 2008).

Other heavy metals though occurring in trace amounts could have found their way through other related processes.

Cu may also be traceable to use of copper conductors and wires, tubes, solders and myriads of other maintenance items made of Cu. According to Alloway (1990) and Lenntech (2009), when Cu ends up in soils, it strongly attaches to organic matter and minerals. As a result, it does not travel far after release.

CONCLUSION

From the present study the following conclusions could be made:

a) The concentrations of the heavy metals in soils from Emii area showed low levels of pollution.
b) The highest concentration recorded was from iron
c) All levels of concentration falls within the permissible limits
d) However, sensitization of the populace in the area is needed about the health implications of heavy metal especially with the gradual urbanization of most outskirt towns.

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