International Journal of
Science and Engineering Investigations vol. 6, issue 60, January 2017
ISSN: 2251-8843

The Heavy Metals (Ag, Fe, Co, Cr, Cu, Cd, Mn, Zn, Ni and Pb) in Beans (Phaseolus vulgaris) Grown in Lake-Chad Research Institute, Maiduguri, Borno State, Nigeria

Garba S. T.[1], Abba A. B.[2], Abdullahi S.[3], Abdullahi M.[4]
[1]Department of Chemistry, P. M. B. 1069 University of Maiduguri, Maiduguri, Nigeria
[2]202 Housing Estate, Number A02, Maiduguri, Borno State, Nigeria
[3]Government Girls' College, P. M. B. 1515 Maiduguri, Borno State, Nigeria
[4]Standard Organization of Nigeria, P. M. B. 1161, Borno State Office, Nigeria
([1]stelagarba@yahoo.com, [2]ammabakarema@gmail.com, [3]sadiyaabdullahi85@gmail.com, [4]mu39azuabdullahi@rocketmail.com)

Abstract- The concentration of the metals; Ag, Fe, Co, Cr, Cu, Cd, Mn, Zn, Ni and Pb were determined in different parts of beans (*Pharsalus vulgaris)* grown in Lake-Chad research Institute, Maiduguri, Borno State, Nigeria using atomic absorption spectroscopy (AAS). To achieve this, fresh sample of *Phaseolus vulgaris* were collected in the morning hours. Collection was done in phases or batches. The first phase was collected when the crops were at their tender age (4 - 6 weeks of germination), the second or final phase, was done when the crops were ready to be harvested. Samples collected were washed with tap water, carefully separated into roots, stem, and the leaves. Dried to a constant weight in an oven at 105^{O}C, ground and sieved using a < 2mm nylon sieve, treated using 6M HCl and analyzed. The result showed that, at the tender period of 4-6 weeks of germination, the levels ranged from 0.419 - 0.043 µg Ag/g, 0.784 - 0.263 µg Mn/g, 0.019 -0.003 µg Cd/g, 0.144 - 0.059 µg Cu/g, 0.146 - 0.073 µg Co/g, 0.046 - 0.009 µg Cr/g, 0.691 - 0.375 µg Zn/g, 0.069 - 0.034 µg Ni/g, 11.171 - 5.510 µg Fe/g and 0.174 - 0.147 µg Pb/g most of which (the levels) were statistically different at ($P < 0.05$). These levels were found to slightly decrease at the period of harvesting. At this period which include the seeds, the concentration ranges from 0.299 - 0.024 µg Ag/g, 0.542 - 0.255µg Mn/g, 0.015 - 0.004µg Cd/g, 0.473 - 0.022µg Cu/g, 0.143 - 0.014µg Co/g, 0.01 - 0.005µg Cr/g, 0.644 - 0.367µg Zn/g, 0.219 - 0.002µg Ni/g, 5.505 - 2.598µg Fe/g and from not detectable - 0.147µg Pb/g most of these level were found statistically different at ($P < 0.05$). The result of this study showed that the levels of the entire elements determined are generally below the permissible levels and are therefore safe consumption. However, the growing popularity of beans and its products in recent years on the basis of its nutritional properties and beneficial effects calls for additional data and a periodical quality control.

Keywords- *Soil, Crops, Pollution*

I. INTRODUCTION

Soil is a naturally occurring, unconsolidated mineral and organic material at the earth's surface that provides an environment for living organisms and a sink or reservoir to all sorts of pollutants. It is a dynamic habitat for an enormous variety of life-forms. It gives mechanical support to plants from which they extract nutrients [1]. Nearly all plant nutrients are taken up by plant from the soil water solution in the form of ions, either cations or as anions. Sixteen nutrients are essential for plant growth and reproduction. Based on their solubility under physiological conditions, 17 heavy metals may be available for living cells and of importance for organism and ecosystems [2]. The understanding of the behaviour of heavy metal in soil-plant system is therefore imperative for safety purposes.

Food legume crops represent an important component of agricultural food crops consumed in developing countries, especially in Sub-Saharan African countries, Nigeria in particular. They complement cereal crops as a source of protein and minerals. They also serve as rotation crops on the farmland with cereals, reducing soil pathogens and supplying nitrogen to the cereal crop. Food legume crops are considered vital crops for achieving food and nutritional security for both poor producers and consumers. They play an important role as a source of animal feed in small-holder livestock systems. Food legumes also have higher prices, compared to cereals, and are increasingly grown to supplement farmers' incomes [3]. The important and diverse role played by food legumes in the farming systems and in diets of poor people makes them ideal crops for achieving developmental goals of reducing poverty and hunger, improving human health and nutrition, and enhancing ecosystem resilience. According to Bojinova, et al. [4] and Sajwan, et al. [5] beans belonged to the group of crop that strongly accumulates heavy metals.

The source of heavy metal in plants is their growth media (air, soil, nutrients) from which heavy metals are taken up by roots or foliage. Among these metals, Fe, Mo and Mn are important as micronutrients. Zn, Ni, Cu, V, Co, W, and Cr are toxic elements with high or low importance as trace elements. Arsenic (As), Hg, Ag, Sb, Cd, Pb, and U have no known function as nutrients and seem to be more or less toxic to plants and micro-organisms [6, 7]. When agricultural soils are polluted, these metals are taken up by plants and consequently accumulate in their tissues [8]. Animals that graze on such contaminated plants and drink from polluted waters, as well as marine lives that breed in heavy metal polluted waters also accumulate such metals in their tissues, and milk, if lactating [9, 10]. Humans are in turn exposed to heavy metals by consuming contaminated plants and animals, and this has been known to result in various biochemical disorders. The toxic effect of heavy metals varies. Individual metals exhibit specific signs of their toxicity. The following have been reported as general signs associated with cadmium, lead, arsenic, zinc, copper and nickel poisoning: Gastrointestinal (GI) disorders, diarrhea, stomatitis, tremor, hemoglobinuria causing a rust–red colour to stool, ataxia, paralysis, vomiting and convulsion, depression, and pneumonia when volatile vapours and fumes are inhaled [11]. The nature of effects could be toxic (acute, chronic or sub-chronic), neurotoxic, carcinogenic, mutagenic and/or teratogenic depending on the metal in question as well as how it is being handled.

Lead, for example, is the most significant toxin of the heavy metals, and the inorganic forms are absorbed through ingestion by food and water, and inhalation [12]. A notably serious effect of lead toxicity is its teratogenic effect. High levels of the metal inhibit the synthesis of haemoglobin, dysfunctions in the kidneys, joints and reproductive systems, acute and chronic damage to the central nervous system [13]. Several cases of human disease, disorders, malfunction and malformation of organs due to metal toxicity have been reported [14, 15]. It has become imperative therefore to know whether vegetables, fruits and food crops cultivated and supplied, sold or consumed are safe for human consumption especially now that the environmental quality of food production are of major concern [16].

This study therefore is aimed at evaluating the levels of the heavy metals; Ag, Fe, Co, Cr, Cu, Cd, Mn, Zn, Ni and Pb) in the beams (Phaseolus vulgaris) grown in Lake-Chad research Institute, Maiduguri, Borno State, Nigeria.

II. MATERIAL AND METHODS

A. Sampling Area

Sample of beans (*Phaseolus vulgaris*) were collected at Lake Chad institution Farm Centre in Maiduguri Metropolis, Borno state, Nigeria.

B. Sample Collection

Samples of fresh *Phaseolus vulgaris* crops were collected in the morning hours. Collection was done by careful uprooting of the plant from the soil. This was done in phases or batches. The first phase was collected when the crops were at their tender age (4 - 6 weeks of germination), the second or final phase, was done when the crops were ready to be harvested. The samples collected were washed with water in the laboratory, carefully separated into roots, stem, and the leaves. Soil samples were equally collected from the farm land, beneath the roots of the plants. Samples were collected using hand trowel, at the depth of 0 - 15 cm form the surface as in [17], put in a clean polyethylene bags and transported to the laboratory for subsequent analysis. Collection was done in the month of July to October 2015.

C. Sample Preparation and Analysis

The separated parts of the sample collected and separated were dried to a constant weight in an oven at $105^{O}C$, ground and sieved using a < 2mm nylon sieve. This was then digested by weighing 0.5g into an acid washed porcelain crucible placed in a muffle furnace and heated for about 4 hours at $500^{o}C$. When cooled 10ml of 6M HCl was added and heated again for about fifteen minutes (15 min). Dropwise addition of the acid was made gently with continuous stirring and heating to dryness. Ten mil(s) (10ml) of distilled water was added and heated on steam bath for complete dissolution. The mixture was then allowed to cool and filtered through a Whatman No. 541 filter paper into a 50ml volumetric flask. This was then made up to the mark with additional distilled water, as in [17]. A blank was equally prepared following the same procedure but without the sample. Atomic Absorption Spectroscopy (AAS) model AA240FS Company Variance was used to determine the level of the metals; Ag, Fe, Co, Cr, Cu, Cd, Mn, Zn, Ni and Pb.

For the soil sample, 1.0g was digested by adding a mixture of 15ml concentrated HNO_3, H_2SO_4, and $HClO_4$ acids in the ratio of (5: 1: 1) in a 100ml volumetric flask. This was heated at $80^{0}C$ until colourless solution was obtained. The digest was then filtered through a Whatman filter paper No. 42 and diluted to 50ml with distilled water [18]. Analysis of the digested samples was carried out using same Atomic Absorption Spectroscopy (AAS).

III. RESULT

A. Physiochemical Properties of the soil sample.

Figure 1: below shows the physiochemical properties of the soil sample. The result shows that, the pH of the soil was found to be 5.58; this was the average pH within the range of the sampling sites. The effect of pH on a soil is to remove from the soil or to make available certain ions. Soils with high acidity tend to have toxic amounts of aluminium and manganese. Plants which need calcium need moderate alkalinity, but most minerals are more soluble in acid soils. Soil organisms are hindered by high acidity, and most agricultural crops do best with mineral soils of pH 6.5 and organic soils of pH 5.5 [19]. High pH results in low micro-nutrient mobility, EC was 30.40 $mscm^{-1}$; CEC 14.99meq/100g, the cation exchange capacity commensurate with the pH of the soil. As the pH of the soil increases the cation exchange capacity of the soil also increases. Thus an acidic soil may have low CEC which indicates low fertility of the soil [20]. OC 1.46%, N 0.62%.

Most living things in soils, including plants, insects, bacteria, and fungi, depends on organic matter for nutrients and/or energy. Organic matter holds soils open, allowing the infiltration of air and water, and may hold as much as twice its weight in water. As a source of humus, organic matter acts as a buffer, like clay, against changes in pH and soil moisture [21]. Organic materials in soil increase the CEC through an increase in available negative charges. As such, organic matter build-up in soil usually positively impacts soil fertility. However, organic matter is heavily impacted by soil acidity as acidity causes many organic compounds to release ions to the soil solution [20]. The soil was found to be sandy loam as shown in figure 1.

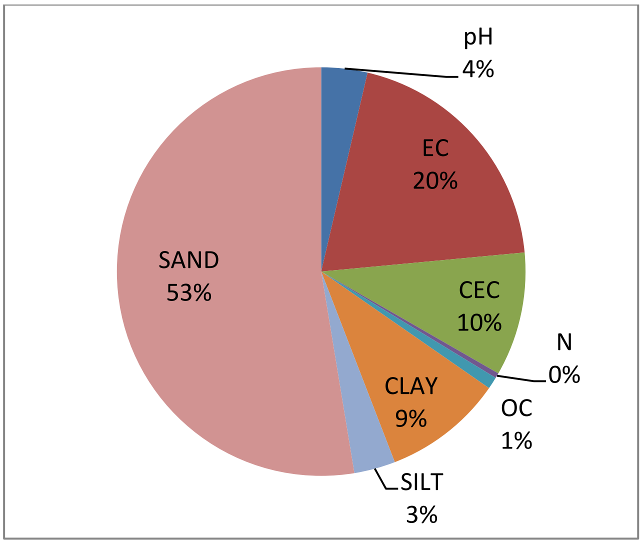

Figure 1. The physiocochemical Properties of the soil Sample

The concentration of heavy metals in brown beans at different stages of germination is as presented in tables 1 and 2. Table 1 below shows the concentration of heavy metals in the root, stem and leaves of the brown beans at the first stages of sampling (after four to six weeks of germination) as well as the soil. Heavy metals are defined as metals and metalloids having densities greater than > 5 g cm^{-3}. Heavy metals may be found in soils naturally [22] or can be added to soils through anthropogenic activities (Figure 1). Natural sources of heavy metals such as volcanoes emissions transport of continental dusts, and weathering of metal-enriched rocks due to long exposure to air, greatly adds higher amounts of heavy metals to soils [23]. The anthropogenic activities may include; mining and smelting, excessive application of fertilizers to boost crop production, automobile and atmospheric deposition, extensive usage of toxic pesticides and as well as application of sewage sludge can result in soil pollution [24, 25]. It shows that, the stem has the highest level of Fe (11.171±0.044ppm), followed by the root (6.651±0.022ppm) whereas the leaves had the lowest level of 5.510 ±0.094ppm. Second to iron in the stem, is zinc (Zn) with 0.691 ±0.026pm, the leaves had 0.644 ±0.009ppm and the root has the lowest concentration of 0.376 ±0.009ppm Zn at this stage of germination. Other metals such as Cu, the level ranges from 0.059 ±0.010ppm in the root to 0.144 ±0.039ppm in the leaves. The level of Ni ranges from 0.069 ± 0.005ppm in the roots, and decreases to 0.016 ± 0.007ppm in the leaves. Manganese ranges from 0.263 ± 0.005ppm in the root, and increases to 0.784±0.011ppm in the leaves. The levels 0.019 ±0.007ppm observed in the root for Cd was found to decreased to 0.003±0.006ppm Cd in the leaves. The values 0.146±0.012; 0.073 ±0.006 and 0.089±0.102ppm observed in the root, stem and the leaves respectively for Co. Lead has 0.174 ±0.005ppm in the root, 0.147 ±0.005ppm in the stem whereas 0.160 ±0.004ppm was observed in the leaves. The level of Cr was found to fluctuate. The value 0.046±0.05ppm was found in the root, these decreases to 0.009±0.006ppm in the stem and increases to 0.010 ±0.007ppm in the leaves (Table 1).

TABLE I. THE MEAN CONCENTRATION (μG/G ±SD) OF THE METALS DETERMINED IN THE SOIL, ROOT, STEM AD LEAVES OF *PHASEOLUS VULGARIS* AFTER 4-6 WEEKS OF GERMNATION

	Elements			
Sample	Soil	Root	Stem	Leaves
Ag	0.628±0.014	0.367a±0.005	0.419±0.004	0.043a±0.005
Mn	5.530±0.007	0.263±0.005	0.484±0.008	0.784±0.011
Cd	0.209a±0.037	0.019b±0.007	0.015a±0.008	0.003a±0.006
Cu	0.463±0.017	0.059bc±0.010	0.085b±0.007	0.144b±0.039
Co	0.207± 0.017	0.146c±0.012	0.073b±0.006	0.089ab±0.102
Cr	0.295a±0.017	0.046b±0.035	0.009a±0.006	0.011a±0.008
Zn	0.513±0.006	0.376a±0.009	0.691±0.026	0.644±0.009
Ni	0.334±0.023	0.069b±0.005	0.034a±0.006	0.016a±0.007
Fe	49.327±0.018	6.651±0.022	11.171±0.044	5.510±0.094
Pb	1.816± 0.011	0.174±0.005	0.147±0.005	0.160a±0.004

Elements with same letters within a column are not significantly different at $P < 0.05$ according to LSD test. Data are presented in mean ± SD (n = 4). SD = Standard Deviation

Table 2 below shows the concentration of the metals determined in the roots, stem, leaves and the seed of brown beans (*Phaseolus vulgaris*) at the final sampling stage (harvesting period). The result shows that, iron (Fe) was observed in all the samples analyzed with the roots having the highest concentration of 5.505±0.087ppm followed by the leaves (3.682±0.323ppm), the stem had the lowest level of 2.598±0.355ppm. Highest level of Mn (0.542±0.046ppm) was observed in the leaves followed by the stem (0.426±0.069ppm), the roots had (0.255±0.008ppm) whereas the seed had 0.255±0.040ppm Mn. The root seem to have the same concentration (0.255ppm) with the seeds though they were found significantly different at $p<0.05$ according to LSD test. The level of Ag in the root was 0.249±0.02ppm, these increases slightly in the stem to 0.299±0.055ppm; it decreases to 0.031±0.012ppm in the leaves and 0.02±0.007ppm in the seeds. Cadmium, Ni and Pb were found below detection limits in the seeds but has the levels; 0.012±0.00, 0.219±0.169 and 0.147±0.005ppm respectively in the roots (Table 2). With the exception of Mn, most of the metals were found to decrease in concentration from the roots to the seeds. The level of Zn in the seed (0.375±0.011ppm) was found to be higher than what was observed in the leaves (0.367±0.014ppm).

www.IJSEI.com ISSN: 2251-8843 Paper ID: 66017-03

TABLE II. THE MEAN CONCENTRATION (μG/G ±SD) OF THE METALS DETERMINED IN THE ROOT, STEM, LEAVES AND THE SEEDS OF *PHASEOLUS VULGARIS* AT HARVESTING PERIOD

	Elements			
Sample	Root	Stem	Leaves	Seeds
Ag	0.249a±0.024	0.299a±0.055	0.031a±0.012	0.024a±0.007
Mn	0.255a±0.008	0.426a±0.069	0.542±0.046	0.255b±0.040
Cd	0.012b±0.009	0.011b±0.009	0.004a±0.007	0.001b±0.010
Cu	0.473b±0.013	0.078ab±0.011	0.117a±0.015	0.022a±0.009
Co	0.143c±0.010	0.062ab±0.011	0.046a±0.070	0.014a±0.007
Cr	0.010b±0.008	0.006b±0.007	0.010a±0.007	0.005a±0.008
Zn	0.644±0.009	0.391a±0.039	0.367±0.014	0.375b±0.011
Ni	0.219ac±0.169	0.034b±0.006	0.014a±0.007	0.002±0.012
Fe	5.505±0.087	2.814±0.520	3.682±0.323	2.598±0.355
Pb	0.147c± 0.005	0.016b±0.004	0.020a±0.007	ND

Elements with same letters in a column are not significantly different at P <0.05 according to LSD. Data are presented in mean ± SD (n = 4). SD = Standard Deviation

IV. DISCUSSION

Legumes are rich and inexpensive source of proteins, carbohydrates, dietary fibres to millions of peoples worldwide. Most legumes that are used for foods are multipurpose plants, serving for animal forage as well as soil improvement due to their ability to fix atmospheric nitrogen. In addition to being an important source of protein, legumes have been reported to be a good source of minerals (K, P, Ca, Mg) and trace elements [26, 27]. Heavy metals are potential environmental contaminants with the capability of causing human health problems if present to certain level in the food. Several cases of human disease, disorders, malfunction and malformation of organs due to metal toxicity have been reported [14]. Metals, such as iron, zinc and manganese are essential metals, since they play an important role in biological systems. Copper and Zinc are essential micronutrients but can be toxic when taken in excess. Lead and cadmium are non-essential metals as they are toxic, even when at low concentrations [28]. These metals are taken up from soils and bioaccumulated in crops, causing damage to plants when present at high levels and under certain conditions becoming toxic to human and animals that fed on these metal enriched plants [29].

The result of this study shows that, Fe has the highest concentration of all the metals determined in the roots, stem and leaves of the bean (Table 1) at the early period of germination (4-6 weeks of germination). The concentration was however found to decrease when grown to maturity (harvesting period). At this stage, the plant was found to accumulate the metal in the order root > leaves > stem > seed. The results were however much lower than what was recorded in [30] who observed (7.9–24.8 l μg/g) of Fe in different samples of vegetables in Pakistan. The concentration of Fe observed in the leaves of this study (Table 1 and 2) were also found very much lower than what was observed in the leaves of beans from the east (115.4±2.85μg/g), middle (99.9±1.92 μg/g), south (137.1±7.50 μg/g) and northern (64.0 ±2.85 μg/g) district markets of Saudi Arabia [31]. The levels of the essential elements (Fe, Zn, Mn, Cu and Co) determined in this study were higher than those of toxic elements or the non-essential elements (Cd, Pb and sometimes Ni) as indicated in tables 1 and 2. The concentration of these essential metals however was found lower than what was observed in [32].

Cadmium (Cd) and Zinc (Zn) are trace elements that are readily translocated from roots to the plant tops and can be effectively absorbed into foliage, move around the plant, be accumulated in leaves and seeds and eventually into the food chain through the casparian strip in the roots, xylem cells which is driven by evapotranspiration process [33, 34]. Cadmium is a non-essential, highly toxic heavy metal; it does not play any role in biological process in living organisms. Thus even at low concentration Cd could be harmful to living organisms [35]. Cd poisoning in man could lead to anemia, renal damage, bone disorder and cancer of the lungs [36]. In this study, the level of Cd was observed in a decreasing order from the root to the leaves; root< stem<leaves at the rudimentary age of growth (4-6 weeks of germination) as indicated in table 1. The levels of the element observed in the leaves of this study were found to be far below what was observed in a study from the east (1.04±0.06μg/g), middle (2.31±10.06 μg/g), south (1.47±0.10 μg/g) and northern (1.65±0.05 μg/g) district markets of Saudi Arabia [31]. This trend was equally observed at the harvesting period with the seeds having the lowest concentration 0.002±0.010ppm (Table 2). The concentration of Cd observed in the seeds of brown beans in this study were found lower than what was observed in seeds of brown beans in a study conducted from Kalak 0.09 ±0.04ppm (Khabat) location [37]. It is also lower than what was observed in common beans (0.178 ± 0.04ppm) as in [38]. Cadmium compounds are used as color pigment and in re-chargeable nickel-cadmium batteries. It is also present as a pollutant in phosphate fertilizers and has a long half-life period of 10–30 years in bones and kidneys. It has been reported that cadmium is present in most foodstuffs, but the levels vary greatly. Excessive exposure to this element has been reported to cause kidney damage and/or skeletal damage [39].

Zinc (Zn) was found next to Fe where the stem had the highest concentration, followed by the leaves and the root after 4-6 weeks of germination (Table 1). Zinc is an essential element to all organisms and has an important role in metabolism, growth, development and general well-being. It is an essential cofactor for large number of enzymes in the body. Zinc deficiency therefore may leads to coronary heart diseases and various metabolic disorders [40]. It has been reported that, except for tolerant plant genotypes which don't exclude Zn from their shoots, Zn is accumulated in the leaves [41]. In this study, the level of Zn was found to decrease in the stem and leaves but gradually accumulates in the seed as the plant grows to maturity (Table 1 and 2). This could be attributed to excessive rate of transpiration by the leaves as well as the stem. Report has it that, young developing tissues have higher Zn concentration than mature tissues except for seeds. It can also be stored in stems and be mobilized later to growing tissues. Mature seeds contain Zn localized in the embryo [41]. The levels of Zn observed in the different parts of the plant (root, stem, leaves and the seeds) of this study (Table 1 and 2) were found below what was observed in [31, 32, 38]. Zinc (Zn) and Copper (Cu) have numerous functions in animals and human and they are essential elements for the growth of plant. Copper serves as an antioxidant and helps the body to remove free radicals and prevent cell structure damage and Zn function as a cofactor for many enzymes of the body. The mean concentrations of Cu observed in this study (Table 1 and 2) were however lower than what was observed in [31, 38, 42]. These variations in concentrations may be attributed to environmental differences in terms of weather or climate, type of soils, fertilizer application and the level of anthropogenic activities taking place at the sites.

Chromium (Cr) is a polyvalent element, found naturally in the air, soil, water and lithosphere [43]. It exists in the environment in three stable oxidation states, Cr(0), Cr(III) and Cr(VI) which have different toxicities and transport characteristics [44]. Trivalent chromium Cr (III) and hexavalent chromium Cr (VI) are stable. Cr (VI) is carcinogenic and a potential soil, surface water and ground water contaminant, while its reduced trivalent form is much less toxic, insoluble and a vital nutrient for humans [45]. Accidental or intentional ingestion or exposure to high level of Cr(VI) compounds exerts toxic effects on biological systems [46]. Chromium accumulates mainly in roots and shoots; however roots accumulate the major part, being usually only a small part translocated to the shoots [47, 48]. Report has it that, accumulation of Cr in the different parts of plant was in the following order; roots > stem > leaves > seed [49]. The levels of Cr observed in leaves of this study (Table 1 and 2) were found at a very low concentration compare to the findings of some studies done elsewhere [31, 38, 42]. The concentration of this metal as observed in this study can be arranged in the following order root > stem < leaves > seeds. It has been reported that, bean seeds accumulates about 0.1% Cr, while roots accumulated 98% [50].

Nickel (Ni) is a microelement necessary for ordinary functioning of plants, animals and humans. However, in higher concentrations it has toxic effects. The increased quantities of this element may be a result of natural processes or anthropological factors such as, industrial processes, extraction and processing of ores, traffic etc. These anthropogenic releases can be expected to increase soil levels of trace elements such as,Ni^{2+}, resulting in a concomitant increase in the concentration of Ni^{2+} in plants and possibly in the food chain. Although Ni is considered a nonessential element in the nutrition of both plants and animals, it is present in substantial quantity in all living organisms [51]. Nickel is readily transported from roots to aboveground plant tissues. However at higher concentrations it can be toxic. Plants have been shown to accumulate Ni^{2+} " in both vegetative tissues [52] and seeds [53], and therefore represent a source of Ni^{2+} to primary and secondary consumers and ultimately man. In this study, the level of Ni^{2+} before maturity was found to decreased in the order, root > stem > leaves (Table 1). The levels were however lower than what was observed in [54]. At maturity, the trend in the levels in the parts of beans is same only that a slight decrease in the concentration was observed (Table 2).

Lead (Pb) forms various complexes with soil components and only a small fraction of the lead present as these complexes in the soil solution are phytoavailable. Once lead has been absorbed by the root system, it may accumulate there or may be translocated to aerial plant parts. Studies had it that, most plant species, absorbed lead (approximately 95% or more) and get accumulated in the roots, only a small fraction is translocated to aerial plant parts because there are natural plant barriers in the root endodermis, as has been reported in *Vicia faba*, *Pisum sativum*, and *Phaseolus vulgaris* [55, 56, 57], *V. unguiculata* [58]. Despite its lack of essential function in plants, lead is absorbed by them mainly through the roots from soil solution and thereby may enter the food chain. In this study, the levels of lead in the various parts of the plant (Table 1 and 2) were found far below what was observed in studies done elsewhere [31, 38].

Cobalt (Co) is a biologically essential microelement with a broad range of physiological and biochemical functions. Co is usually contributed with vitamin B12 and its deficiency effect on the vitamin B12 consistency in the body. Cobalt deficiency is rare in human but cattle are seen effected with symptoms like anemia. The daily recommended range of Cobalt in human diet is 0.005 mg/day [59, 60, 61]. For symbiotic association, Cobalt is needed for N_2 fixation in legumes and root nodules of non-legumes. The level of the element in this study was observed to decrease with the growth of the plant. It is found to decreased in the order; root > stem > leaves > seeds (Table 1 and 2). Reports has it that According to a study carried on cobalt in different foods, Cobalt variation in plant based food such as seed, vegetables and fruits is 0.006-0.009 mg/kg [62].

V. CONCLUSION

Heavy metal contamination of vegetables cannot be underestimated as these foodstuffs are important components of human diet. Plant based food items are rich sources of vitamins, minerals, and fibers coupled with beneficial antioxidative effects. Prolonged consumption of foodstuffs contaminated with heavy metals may lead to chronic accumulation in different organs such as kidney and liver causing disruption of numerous biochemical processes, leading to cardiovascular, nervous and bone diseases. In this study, the level of the heavy metals determined can be arranged in the following order; root > stem > leaves > seeds. The levels of the metals determined in this study were all within the permissible limits or may be said to be safe for both animal and human consumption.

REFERENCE

[1] O.A. Al-Khashman, Heavy metals distribution in dust, street dust and soil from the workplace in karak industrial estate, Jordan. Atmos. Environ., 38, pp. 6803-681, 2004.

[2] R.C. Weast, Handbook of chemistry and physics, 64th edn. Boca Raton, CRC Press, pp. 67-114, 1984.

[3] D. C. Gowda, P. Gupta, and E. A. Davidson, (1997). Glycosylphosphatidylinositol anchors represent the major carbohydrate modification in proteins of intraerythrocyttic stage plasmodium falciparum, J. Biol, Chem. 272, pp, 6428-6439, 1997.

[4] P. Bojinova, B. Georgiev, V. Krasteva, H. Chuldjian, and L. Stainislavova, Investigation about the heavy metal pollution in soils and agricultural crops in region of nonferrous metal works, D. Bagoev, Soil Science, Agrochemistry and Ecology, 4-6, p 32, 1994.

[5] K. Sajwan, W. Ornes, T. Youngblood, and A. Alva, Uptake of soil applied cadmium, nickel and selenium by bush beans, Water, Air and soil pollution, 91, p. 209, 1996.

[6] C. W. Breckle, Growth under heavy metals. In: Waisel Y, Eshel A, Kafkafi U, eds. Plant roots: the hidden half. New York, NY: Marcel Dekker, pp. 351–373, 1991.

[7] D. H.Nies, Microbial heavy-metal resistance. Appl. Microbiol. Biotechnol. 51, pp. 730–750, 1999.

[8] P. Trueby, (2003). impact of heavy metals on forest trees from mining areas. in: international conference on mining and the environment iii, Sudbury, Ontario, Canada. 2003. (www.xcd.com/sudbury03/prof156.html).

[9] F. Habashi, Environmental issues in the metallurgical industry –progress and problems, environmental issues and waste management in energy and mineral production. Balkama, Rotherdam, 1992, pp. 1143 -1153.

[10] D. peplow environmental impacts of mining in eastern washington, Center for water and watershed studies fact sheet, University of Washington, Seattle, 1999.

[11] D. McCluggage, Heavy Metal Poisoning, NCS Magazine, Published by The Bird Hospital, CO, U.S.A. 1991, (www.cockatiels.org/articles/Diseases/metals.html).

[12] D. J. Ferner, Toxicity, heavy metals. eMed. J. 2(5), PP. 1, 2001.

[13] Lenntech Water Treatment and Air Purification (2004). Water Treatment, Published by Lenntech, Rotterdamseweg, Netherlands (www.excelwater.com/thp/filters/Water Purification.htm).

[14] Järup, L. (2003). "Hazards of heavy metal contamination," *British Medical Bulletin*, vol. 68, pp. 167–182.

[15] G. Pandey and S. Madhuri, Heavy Metals Causing Toxicity in Animals and Fishes. Res. J. Animal, Veterinary and Fishery Sci. Vol. 2(2), pp. 17-23, 2014.

[16] T. M. Chiroma, F. K. Hymore, R. O. Ebawele, Heavy Metal contamination of vegetables and soils irrigated with sewage water in Yola. NJERD, Vol., 2 No. 3.PP. 25-31., 2003

[17] M. Radojevic, and V. Bashkin, Practical environmental analysis. The Royal Societyof Chemistry London, 1999, pp. 287-361

[18] S. E. Allen, H. M. Grimshaw, and A. P. Rowland, Chemical analysis. In P. D. Moore & S. B. Chapman (Eds.), Methods in plant ecology London: Blackwell Scientific. 1986, pp. 285–344.

[19] R. L. Donahue, R. W. Miller, and J. C. Shickluna, An introduction to soils and plant growth. 4th ed. Prentice-Hall Inc., Englewood Cliffs, New Jersey. P. 626, 1977.

[20] R. C. Turner, and J. S. Clark, Lime potential in acid clay and soil suspensions. Trans. Comm. II & IV Int. Soc. Soil Science, pp. 208–215, 1966.

[21] J. Gilluly, *A. C.* Waters, *A. O.* Woodford, Principles *of* geology *(*4th ed.*)*, W. H. *Freeman, 1975 P. 216.* ISBN 978–0716702696

[22] M. Oves, M. S. Khan, A. Zaidi, and E. Ahmad, Soil contamination, nutritive value, and human health risk assessment of heavy metals: an overview. Toxicity of heavy metals to legumes and bioremediation pp. 1-27, 2012.

[23] W. H. Ernst, Sulfur metabolism in higher plants: potential for phytoremediation. Biodegradation 9, pp. 311-318, 1998.

[24] F. A. Nicholson, K. C. Jones, A. E. Johnston, Effect of phosphate fertilizers and atmospheric deposition on long-term changes in the cadmium content of soils and crops. Environ Sci Technol 28, pp. 2170-2175, 1994.

[25] N. Ahemad, and M. S. Khan, Toxicological assessment of selective pesticides towards plant growth promoting activities of phosphate solubilizing Pseudomonas aeruginosa. Acta Microbiol Immunol Hung, 58, pp. 169-187, 2011.

[26] C. Petchiammal, H. Waheeta, Antioxidant activity of proteins from fifteen varieties of legume seeds commonly consumed in India. *International Journal of Pharmacy and Pharmaceutical Sciences*, vol. 6, suppl. no 2, pp. 476-479, 2014.

[27] R. N. Tharanathan, S. Mahadevamma, Grain legumes a boon to human nutrition. *Trends in* Food Science and Technology, vol. 14, no.12, pp. 507-518, 2003. http://dx.doi.org/10.1016/j.tifs.2003.07.002

[28] H. Gençcelep, Y, Uzun, Y. Tun ÇtŰrk, and K. Demirel, Determination of mineral content of wild-grown edible mushrooms. Food Chemistry, vol. 133, pp. 1033-1036, 2009.

[29] I. H. EL-Sokkary, and A. I. Sharaf, Enrichment of soils and plants irrigated by wastewater by zinc and cadmium. *Egyptian Journal of Soil Science*, vol. 36, no. 1-4, p. 219, 1996. http://dx.doi.org/10.1016/j.jff.2013.12.030

[30] E. Zahir, I.I. Naqvi, and S. S. Mohi Uddin, Market Basket Survey of selected metals in fruits from Karachi city (Pakistan). Journal of Basic and Applied Sciences 5 (2), pp. 47–52, 2009.

[31] H. H. Ali, and K. M. Al-Qahtani, Assessment of some heavy metals in vegetables, cereals and fruits in Saudi Arabian markets, Egyptian Journal of Aquatic Research 38, pp. 31–37, 2012.

[32] T. Mária, V. Alena, B. Daniel, and S. I. Dalaram, The relationship of heavy metal contents in soils to their content in chosen legume seeds. Centre of excellence for white-green biotechnology, ITMS 26220120054, supported by the Research and Development Operational Programme Ochrona Środowiska i Zasobów Naturalnych nr 49, 2011.

[33] B. J. Alloway, Heavy metals in soils, 2nd ed. Blackie Academic and Professional, London, p. 368, 1995.

[34] G. Ambedkar. M. Muniyan, analysis of heavy metals in water, sediments and selected freshwater fish collected from gadilam river, Tamilnadu, India. Int. J. Toxicol. Appl. Pharmacol. 2(2), pp. 25-30, 2012.

[35] J. B. Edward, E. O. Idowu, J. A. Oso, O. R. Ibidapo, Determination of heavy metal concentration in fish samples, sediment and water from Odo-Ayo River in Ado-Ekiti, Ekiti-State, Nigeria. Int. J. Environ. Monit. Anal. 1(1), pp. 27-33, 2013.

[36] S. D. Ismael, H. N. Rasol, and S. D. Ali, The relationship of heavy metals contents in soils to their content in legume seeds used in famous traditional food in kurdistan region-Iraq, Potravinarstvo, vol. 10, no. 1, pp. 550-556, 2016. doi:10.5219/663

[37] A. K. Salama, and M. A. Radwan, Heavy metals (Cd, Pb) and trace elements (Cu, Zn) contents in some foodstuffs from the Egyptian market, Emir. J. Agric. Sci. 17 (1), pp. 34-42, 2005.

[38] J. Järup, and A. Akesson, "Current status of cadmium as an environmental health problem," Toxicology and Applied Pharmacology, vol. 238, no. 3, pp. 201–208, 2009.

[39] A. Saraf, A. Samant. Evaluation of some minerals and trace elements in Achyranthes aspera Linn. Int. J. Pharma. Sci. 3(3), pp. 229-233, 2013.

[40] A. D. Robson, Development in plant and soil sciences. Zinc in soils and plants. Kluwer Academic Publishers, Dordrecht, 1993.

[41] O. A. Olayiwola, S. A. Shittu, and O. R. Adebayo, Evaluation of heavy metals in three common Nigerian Cowpea (*Vigna unguiculata*) paste end product (''Moinmoin'') using different packaging materials, International Journal of Environmental Sciences Volume 3, No 2, pp. 833-840, 2012.

[42] C. Vasilatos, I. Megremi, M. Economou-Eliopoulos, I. Mitsis, Hexavalent chromium and other toxic elements in natural waters in the Thiva - Tanagra - Malakasa Basin, Greece. Hellenic J. Geosciences, 43, pp. 57-66, 2008.

[43] N. Papassiopi, A. Kontoyianni, K. Vaxevanidou, A. Xenidis, Assessment of chromium biostabilization in contaminated soils using standard leaching and sequential extraction techniques. Sci. Total Environ. 407, pp. 925-936, 2009.

[44] H. J. Gibb, P. S. Lees, P. F. Pinsky, B. C. Rooney, Lung cancer among workers in chromium chemical production. Am. J. Ind. Med, 38(2), pp. 115-126, 2006.

[45] A. P. Das, and S. Mishra, Hexavalent chromium (VI): environment pollutant and health hazard. J. Environ. Res. Develop. 2(3), pp. 386-392, 2008.

[46] L. B. Paiva, J. G. de Oliveira, R. A. Azevedo, D. R. Ribeiro, M. G. da Silva, and A. P. Vitória, "Ecophysiological responses of water hyacinth exposed to Cr^{3+} and Cr^{6+} ," *Environmental and Experimental Botany*, vol. 65, no. 2-3, pp. 403–409, 2009.

[47] P. Sundaramoorthy, A. Chidambaram, K. S. Ganesh, P. Unnikannan, and L. Baskaran, "Chromium stress in paddy: (i) nutrient status of paddy under chromium stress; (ii) phytoremediation of chromium by aquatic

and terrestrial weeds," *Comptes Rendus Biologies*, vol. 333, no. 8, pp. 597–607, 2010.

[48] K. K.Tiwari, S. Dwivedi, N. K. Singh, U. N. Rai, and R. D. Tripathi, "Chromium (VI) induced phytotoxicity and oxidative stress in pea (*Pisum sativum* L.): biochemical changes and translocation of essential nutrients," Journal of Environmental Biology, vol. 30, no. 3, pp. 389–394, 2009.

[49] E. W. Huffman Jr. and H. W. Allaway, "Chromium in plants: distribution in tissues, organelles, and extracts and availability of bean leaf Cr to animals," Journal of Agricultural and Food Chemistry, vol. 21, no. 6, pp. 982–986, 1973.

[50] H. J. M. Bowen, Trace Elements in Biochemistry. Academic Press, New York, pp. 241, 1966.

[51] D. Mishra, and M. KAR, Nickel in plant growth and metabolism. Bot Rev 40, pp. 395-452, 1974.

[52] A. P. Vaselow, In: Diagonostic Criteria for plants and Soils; Chapman, E. D. (ed) University of Califofnia Riverside; pp. 302-309, 1966.

[53] C. Cabrera, F. Lloris, R. Gime´nez, M. Olalla, and M. Carmen Lo´pez,, Mineral content in legumes and nuts: contribution to the Spanish dietary intake, The Science of the Total Environment 308, pp. 1–14, 2003.

[54] A. Małecka, A. Piechalak, I. Morkunas, B. Tomaszewska, Accumulation of lead in root ells of *Pisum sativum*. Acta Physiol Plant 30(5), pp. 629–637, 2008.

[55] M. Shahid, E. Pinelli, B. Pourrut, J. Silvestre, and C. Dumat, Lead-induced genotoxicity to *Vicia faba* L. roots in relation with metal cell uptake and initial speciation. Ecotoxicol Environ Saf 74(1), pp. 78–84, 2011.

[56] P. M. Kopittke, C. J. Asher, R. A. Kopittke, and N. W. Menzies, Toxic effects of Pb^{2+} on growth of cowpea (*Vigna unguiculata*). Environ Pollut 150(2), pp. 280–287, 2007.

[57] Agency for Toxic Substances and Disease Rigistry, Toxicology Profile for Cobalt. Us Department of Health and Humans Service. 2004.

[58] S. Okamoto, and L. D. Eltis, The biological occurrence and trafficking of cobalt. Metallomics 3, pp. 963-970, 2011.

[59] K. Jayakumar, P. Vijayarengan, Z. Changxing, M. Gomathinayagam, C. A. Jaleel, Soil applied cobalt alters the nodulation, leg-haemoglobin content and antioxidant status of Glycine max (L.) Merr. Colloids Surf B Biointerfaces 67, pp. 272-275, 2008.

[60] J. C. Leblanc, P. Verger, T. Guerin, and J. L. Volatier, Etude de la'alimentation totale française. Mycotoxines, minéraux etélément traces. In: INRADGAL (Ed.), p. 68, 2009.