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HEAVY METALS IN AGRICULTURAL SOILS IN NIGERIA: A REVIEW

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Abstract

This review paper presents the health risks of heavy metals such as: lead (Pb), chromium (Cr), zinc (Zn), cadmium (Cd), copper (Cu), mercury (Hg), nickel (Ni) and arsenic (As) etc contamination in soils. The review reveals the major sources of these metals which are urban and industrial effluents, deterioration of sewage pipe, treatment water works, sewage sludge, fertilizers and pesticides. It also reveals the adopted standard for drinking water (maximum tolerable limit) by FAO, JECFA and WHO which are as follows: 0.05mg/L, 0.05mg/L, 1.5mg/L, 0.001mg/L, 0.02mg/L, 15mg/L, 0.3mg/L, 0.5mg/L, 0.01mg/L, 0.05mg/L and 0.05mg/L for Pb, Cr, Cu, Hg, Ni, Zn, Fe, Mn, Se, As and Cd respectively. The accumulation of heavy metals in agricultural soils is of increasing concern because of food safety issues, potential health risks such as neurological disorder, cancer, kidney damage, fragile bone etc and their detrimental effects on soil ecosystem. However, the regular monitoring of levels of these metals from dump sites, effluents and sewages in soil and drinking water is essential to prevent excessive buildup of these metals thereby increasing toxicity and elevating the public health risk.

Keywords: Environment, Heavy metals, Health risk, Soils, Toxicity.

1. Introduction

Many heavy metals are environmentally stable and non-biodegradable, toxic to the living beings and tend to accumulate in plants and animals, causing chronic adverse effects on human health (Vijaya *et al*., 2010). Heavy metals are introduced to the soil environment through a variety of sources such as combustion, extraction processes, agricultural runoff, transportation of dissolved metals etc (Akhilesh *et al.*, 2009). They are priority toxic pollutants that severely limit the beneficial use of water for domestic and industrial application (Vijaya *et al*., 2010). They further stated that frequent use of heavy metal-contaminated water in agricultural field's leads to soil pollution and gradually enriching the soil. Different studies have revealed that the presence of toxic heavy metals like iron (Fe), lead (Pb), mercury (Hg) reduce soil fertility and agricultural output. Anthropogenic activities, such as mining and industrial processing, were reported as the main sources of heavy metal contamination in the environment (Xilong *et al*., 2005). They also stated that under certain conditions, these metals may accumulate to a toxic concentration level which can lead to ecological damages. In suburban areas, the use of industrial and municipal wastewater is a common practice in many parts of the world (Rajesh *et al*., 2007). There are different sources of toxic element in urban soils (Thomas *et al.*, 2015), their loads in and around human settlements are a global problem. They enter the soils by different pathways, including: 1) aerial deposition (industries, vehicles and volcanoes), 2) paints, 3) pesticide and fertilizer application, 4) waste utilization, 5) disposal of degraded sediments, and 6) river and irrigation waters (Aguilar *et al.*, 2013). They pass through the air and food into the human organism, where they are usually not degraded, and hence they accumulate and may cause cancer, neuropathy and other diseases (Thomas *et al.*, 2015).

The accumulation of heavy metals in agricultural soils is of increasing concern because of food safety issues, potential health risks, and its detrimental effects on soil ecosystem (Cui *et al.*, 2004). Hg, Pb, Cd and Cr are of great concern due to their toxicity to human health and other organism, whereas Zn and Cu are essential elements for plants and human (Na *et al.*, 2007). Heavy metals can accumulate in the soil at toxic levels due to the long-term application of wastewater (Rajesh *et al.*, 2007). Heavy metals are extremely persistent in the environment which is non-biodegradable and non-thermodegradable, thus they readily accumulate to toxic levels (Rajesh *et al.*, 2007). Vegetable plants take up Hg, Pb, Cd, Zn, and Cu and accumulate them in their edible and inedible parts with various concentrations. One important dietary uptake pathway could be through crops irrigated with contaminated waste, when the capacity of the soil to retain heavy metals is reduced due to repeated use of wastewater, soil can release heavy metals into the ground water or soil solution available for plant uptake (Rajesh *et al*., 2007). Rajesh *et al.* (2007) identified important sources of heavy metals in wastewater as urban and industrial effluents, deterioration of sewage pipe and treatment works, and the wear of household plumbing fixtures while Mapanda *et al.,* (2005) identified other sources of contamination of agricultural soil as sewage sludge, fertilizers, and pesticides. Rajesh *et al*., (2006) further stated that the concentrations heavy metals in soil, crops and water are compared with established safe limits as this provides a basis for guiding further activities aimed at preventing excessive exposure of toxic substances (heavy metals) to human beings through monitoring and control of irrigation water and/or amelioration of uptake by crops.

Essentiality and toxicity of heavy metals for different organisms.

Heavy metals can be divided according to their need for different organisms. Table 1 presents the metals classified as essential and non-essential. Risks of heavy metal contamination in of Soil-Pant System through the application of Cu, Fe, Mn, molybdenum (Mo) and Zn are essential to plants, animals and humans (Alysson and Fabio, 2014). Cobalt (Co) and Selenium (Se) are essential only to animals and humans, while Cr and Ni are essential to humans and plants, respectively. The researchers also stated that arsenic (As), Cd, Pb and Hg are not essential to any of these organisms. On the other hand, As, Cd, Pb and Hg are not essential to humans but in excess can also cause toxicity (Alysson and Fabio, 2014). People exposed to Pb or Hg develop neurological disorders, while exposure to Cd is associated with kidney damage and fragile bones, and various forms of cancer can occur due to the ingestion of food or water contaminated with As (Cambell, 2006). A summary of the toxicity of heavy metals commonly associated with environmental contamination is given in Tables 1, 2 and 3 respectively.

Table 1. Essentiality of heavy metals for different organisms

Heavy metal	Organism†	Essentiality‡	Toxicity§
Zinc (Zn)	Plants	Yes	Chlorosis (Fe-deficiency-induced), stunted plant growth and reduced yield.
	Animals		Diarrhea, anorexia, jaundice, kidney and abomasums damage, arthritis and weight loss.
	Humans	Yes	Diarrhea, nausea, vomiting, epigastric pain, lethargy, anemia, neutropenia, impaired immune function and decreased HDL cholesterol.

Iron (Fe)	Plants	Yes	Leaf bronzing, roots with black coating and reduced plant growth. Common in flooded rice.
	Animals	Yes	Anorexia, diarrhea, metabolic acidosis, reducedbody growth rate and death.
	Humans	Yes	Vomiting, diarrhea, metabolic acidosis and increased risk of atherosclerosis and Alzheimer's disease.
Manganese (Mn)	Plants	Yes	General chlorosis, necrotic leaf spots and stunted plant growth.
	Animals	Yes	Anemia, gastrointestinal lesions and growth retardation.
	Humans	Yes	Psychiatric disturbance and neurodegenerative disorder, including Parkinson's disease.

Table 2. Non Essential heavy metals for different organisms

Heavy metal	Organism†	Essentiality‡	Toxicity§
Lead (Pb)	Plants	No	Chlorosis, root system darkening, stunted plant growth and increased oxidative stress.
	Animals	No	Appetite loss, diarrhea, anemia and body weight loss.
	Humans	No	Neurological problems (from headache topsychosis) and kidney damage.
Mercutry (Hg)	Plants	No	Hypertrophic root, retarded plant growth and increased oxidative stress.
	Animals	No	Vomiting, bloody diarrhea and necrosis of the alimentary mucosa.
	Humans	No	Neurological disturbances, kidney damage and decreased fertility.
Arsenic (Ar)	Plants	No	Increased oxidative stress and reduced plant growth.
	Animal	No	Blindness and reduced weight gain.
	Human	No	Increased cancer risk.

Table 3. Mixed Essential heavy metals for different organisms

Heavy metal	Organism†	Essentiality‡	Toxicity§
Chromium (Cr)	Plants	No	Increased oxidative stress and reduced plant growth. Cr(VI) is more toxic than Cr(III).
	Animals	No	No effect recognize as of the time of this research
	Humans	Yes	Allergy and increased cancer risk. Cr(VI) is more toxicthan Cr(III) or Cr(V).
Nickel (Ni)	Plants	Yes	Increased oxidative stress, retarded germination, stunted root growth, chlorosis, inhibited plant growth and reduced yield.
	Animals	No	No effect recognize as of the time of this research
	Humans	No	Skin allergies, lung fibrosis, kidney and cardiovascular system damage and stimulation of neoplastic transformation.
Manganese (Mn)	Animals	Yes	Anemia, gastrointestinal lesions and growth retardation.
	Humans	Yes	Psychiatric disturbance and neurodegenerative disorder, including Parkinson's disease.
Selenium (Se)	Plants	No	Chlorosis, wilted and dried leaves, reduced plant growth and plant premature death.
	Animals	Yes	Impaired vision, anemia, loss of hair, ataxia, stiffness of joints, paralysis, atrophy of heart and death.
	Humans	Yes	Hypochromic anemia, damaged nails and hair loss.

†In case of animals, they are livestock animals.

‡Yes: essentiality recognized. No: essentiality unrecognized.

§Most common manifestations, symptoms and consequences of heavy metal toxic effects.

Source: (Alysson and Fabio, *2014*)

The relative importance of heavy metals toxicity was addressed by the above researchers in terms of food chain contamination. Alysson and Fabio (2014) identified Cd as the metal with greatest potential to contaminate plants and subsequently to be transferred to animals and humans that eat these contaminated plants or part of them. This statement is based on the fact that (i) Cd poses animal and human health risks in plant tissue concentrations that are not generally phytotoxic and (ii) Cd concentrations in agricultural soils are increasing in many parts of world due to Cd inadvertent additions through the use of fertilizers, sewage sludge and soil amendments (Rodríguez-Serrano *et al.*, 2009). Due to the high risk of contaminating the food chain, the risk of Cd to cause toxicity is considered to be high as well. Despite increased concern with Cd, the toxicity risk of other heavy metals should not be neglected (Alysson and Fabio, 2014). The toxicity of heavy metals in living organisms is a phenomenon somewhat complex. Toxic effects of a metal depend on a number of factors that often include (i) rate, (ii) exposure time, (iii) tolerance of the organism and (iv) environmental conditions. In recent years, the effect of the interaction between heavy metals, animals and plants on the expression of toxicity has been considered very intensely. As a result of the interaction, a given metal may increase or decrease the negative effects of other metal in the organism (Alloway, 2013).

Despite the complexity, the toxicity of heavy metals in plants and in animals and humans that eat contaminated plants is primarily associated with previous environmental contamination. Soils may be contaminated with such hazardous elements by the use of sewage sludge. High concentrations of metals in the sludge increase the risks of contamination and therefore the toxicity. Thus, it is important to know the chemical composition of sewage sludge (Alysson and Fabio, 2014). Table 2 present the WHO (2004) safe limits as regards the minimum and maximum limits for drinking water and their adverse effect.

2. Common Heavy Metals Found in Nigerian Agricultural Soils

Lead: Exposure to lead can result in a wide range of biological effects depending on the level and duration of exposure. Various effects occur over a broad range of doses, with the developing young and infants being more sensitive than adults (NSC, 2009). Lead poisoning, which is so severe as to cause evident illness, is now very rare. Lead performs no known essential function in the human body; it can merely do harm after uptake from food, air, or water (Raymond and Felix, 2011).

Table 4: WHO Safe limits in PPM with Minimum and Maximum Acceptable limits for drinking Water and their adverse effects.

S/No.	Heavy Metals	Ground Water maximum	minimum	Effect on lifting
1	Lead	0.05	-	Toxic plumb solvency diseases, burning in mouth, several inflammations in gastro intestinal track, causes paralysis mental confusion, visual disturbance anemia etc.
2	Chromium	0.05	-	Carcinogenic acuity (cancer), can produce coetaneous and nasal mucous membrane ulcer and Dermatitis, Hexavalent Cr causes lung tumors
3	Copper	1.5	0.05	Astringent taste but essential elements for metabolism, deficiency results is anemia in infants, excess may results in liver damage.

4	Mercury	0.001	-	Causes minimata disease also causes blue baby disease in Infants the color of skin in baby is turn into blue. Paralysis.
5	Nickel	0.02	-	May be carcinogenic, can react with DNA. Resulting in DNA damage.
6	Zinc	15	5	Causes Astringent taste and opalescence in water, Essential elements in human metabolism.
7	Iron	0.3	0.1	Promote Iron Bacteria in water, bad Taste, In trace is nutritional.
8	Manganese	0.5	0.05	Produces bad taste, essential as cofactor in enzyme system and metabolism process.
9	Selenium	0.01	-	Toxic, leads to hair and finger loss, numbness in fingers or toes, causes circulatoryproblems.
10	Arsenic	0.05	-	Beyond this limit water become toxic, causes skin damage circulatory problem increase risk of skin cancer, (found in ground water in Rajnandgaon district in M.P. also seen very much skin problems in slums area that are mainly depends on ground water source for drinking purpose.)

*1 PPM = 1000 PPB, Source; (*Akhilesh *et al., 2009)*

Lead is particularly a dangerous chemical, as it can accumulate in individual organisms, but also in entire food chains. The most serious source of exposure to soil lead is through direct ingestion (eating) of contaminated soil or dust (Akhilesh *et al.,* 2009). In general, plants do not absorb or accumulate lead. However, in soils containing high concentration of lead, it is possible for some lead to be taken up. Studies have shown that lead does not readily accumulate in the fruiting parts of vegetable and fruit crops (e.g., corn, beans, squash, tomatoes, strawberries, and apples). Higher concentrations of Pb are more likely to be found in leafy vegetables (e.g., lettuce) and on the surface of root crops (e.g., carrots). Since plants do not take up large quantities of soil Lead, the Lead levels in soil considered safe for plants will be much higher than soil lead levels where eating of soil is a concern (pica) (Raymond and Felix, 2011). Generally, it has been considered safe to use garden produce grown in soils with total Lead levels less than 300 ppm (Taylor *et al*. 2010; Dasgupta *et al*. 2006). The risk of Lead poisoning through the food chain increases as the soil Lead level rises above this concentration. Raymond and Felix (2011) stated further that even at soil levels above 300 ppm, most of the risk is from Lead contaminated soil or dust deposits on the plants rather than from uptake of Lead by the plant. The Joint FAO/ World Health Organization Expert Committee on Food Additives (JECFA) established a Provisional Tolerable Weekly Intake (PTWI) for Lead as 0.025 mg/kg/bodyweight (bw) (JECFA, 2004). The WHO provisional guideline of 0.01 mg/L has been adopted as the standard for drinking water (WHO, 2004).

Chromium: Chromium is one of the less common elements and does not occur naturally in elemental form, but only in compounds. Chromium is mined as a primary ore product in the form of the mineral chromite ($FeCr_2O_4$). Major sources of Cr contamination include releases from electroplating processes and the disposal of Cr containing wastes (Shanker *et al*., 2005). Chromium (VI) is the form of Cr commonly found at contaminated sites. Chromium can also occur in the +III oxidation state, depending on pH and redox conditions. Chromium (VI) is the dominant form of Cr in shallow aquifers where aerobic conditions exist. Chromium (VI) can be reduced to Cr (III) by soil organic matter, $S^{2-}$and Fe^{2+} ions under anaerobic conditions often encountered in deeper groundwater (Raymond and Felix, 2011). Major Cr (VI) species include chromate (CrO_4^{2-}) and dichromate ($Cr_2O_7^{2-}$) which precipitate readily in the presence of metal cations (especially Ba^{2+}, Pb^{2+}, and Ag^{+}). Chromate and dichromate also adsorb on soil surfaces, especially iron and aluminum oxides. Chromium (III) is the dominant form of Cr at low pH (<4). Chromium (VI) is the more toxic form of chromium and is also more mobile. Chromium (III) mobility is decreased by adsorption to clays and oxide minerals below pH 5 and low solubility above pH 5 due to the formation of chromium hydroxides ($Cr(OH)_3$) (Sutle, 2010). Chromium mobility depends on sorption characteristics of the soil, including clay content, iron oxide content, and the amount of organic matter present. Chromium can be transported by surface runoff to surface waters in its soluble or precipitated form (Raymond and Felix, 2011). Soluble and un-adsorbed chromium complexes can leach from soil into groundwater. The leachability of Cr (VI) increases as soil pH increases. Most of Cr released into natural waters is particle associated, however, and is ultimately deposited into the sediment (Shanker *et al*., 2005). Chromium is associated with allergic dermatitis in humans (Requejo and Tena, 2005).

Arsenic: Arsenic is a metalloid that occurs in a wide variety of minerals, mainly as As_2O_3, and can be recovered from processing of ores containing mostly Cu, Pb, Zn, Ag and Au (Castillo-Michel *et al*., 2007). It is also present in ashes from coal combustion. In aerobic environments, As (V) is dominant, usually in the form of arsenate (AsO_4^{3-}) in various protonation states. Arsenate and other anionic forms of arsenic behave as chelates and can precipitate when metal cations are present (Alysson and Fabio, 2014). Since arsenic is often present in anionic form, it does not form complexes with simple anions such as chlorine ion (Cl^-) and sulhpur (IV) oxides (SO_4^{2-}). Arsenic speciation also includes organometallic forms such as methyl arsinic acid ($(CH_3)AsO_2H_2$) and dimethylarsinic acid ($(CH_3)_2AsO_2H$).Many as compounds adsorb strongly to soils and are therefore transported only over short distances in groundwater and surface water (Requejo and Tena, 2005). Arsenic is associated with skin damage, increased risk of cancer, and problems with circulatory system (Scragg, 2006). The JECFA established a PTWI for inorganic arsenic as 0.015 mg/kg body weight (FAO/WHO, 2005, JECFA 2004). Following a thorough review and in order to maximize health risk reduction, the United State Environmental Protection Agency (USEPA) in 2001 decided to reduce the drinking water maximum contaminant limit (MCL) to 0.010 mg/L, which is now the same as the WHO guidelines (USEPA, 2005).

Zinc: Zinc is added during industrial activities, such as mining of coal, waste combustion and steel processing. Many food stuffs contain certain concentrations of Zn. Drinking water also contains certain amounts of Zn, which may be higher than when it was stored in metal tanks (Raymond and Felix, 2011). Industrial sources or toxic waste sites may cause the concentrations of Zn in drinking water to reach levels that can cause health problems. Zinc is a trace element that is essential for human health (Alysson and Fabio, 2014). Zinc shortages can cause birth defects (Wuana and Okieimen, 2011; Garba *et al*., 2010; Morgan *et al*., 2008). A consequence is that Zn polluted sludge is continually being deposited by rivers on their banks. Some researchers have identified that Zn may also increase the acidity of waters (Raymond and Felix, 2011). Water-soluble zinc that is located in soils can contaminate groundwater. Plants often have a Zn uptake that their system scan not handle, due to the accumulation of Zn in soils (Greany, 2005).

Cadmium (Cd): Cadmium with mercury (Hg) and Lead (Pb), Cd is one of the big three heavy metal poisons and is not known for any essential biological function (Raymond and Felix, 2011). In its compounds, Cd occurs as the divalent Cd (II) ion. Cadmium is directly below Zn on the Periodic Table and has a chemical similarity to that of Zn, an essential micronutrient for plants and animals. This may account in part for Cd's toxicity; because Zn being an essential trace element, its substitution by Cd may cause the malfunctioning of metabolic processes (Cambell, 2006). The most significant use of Cd is in Ni/Cd batteries, as rechargeable or secondary power sources exhibiting high output, long life, low maintenance, and high tolerance to physical and electrical stress. Cadmium coatings provide good corrosion resistance to vessels and other vehicles, particularly in high-stress environments such as marine and aerospace. Other uses of cadmium are as pigments, stabilizers for polyvinyl chloride (PVC), in alloys and electronic compounds. Cadmium is also present as an impurity in several products, including phosphate fertilizers, detergents and refined petroleum products. In addition, acid rain and the resulting acidification of soils and surface waters have increased the geochemical mobility of Cd, and as a result its surface-water concentrations tend to increase as lake water pH decreases (Cambell, 2006). Cadmium is produced as an inevitable by-product of Zn and occasionally lead refining. The application of agricultural inputs such as fertilizers, pesticides, and biosolids (sewage sludge), the disposal of industrial wastes or the deposition of atmospheric contaminants increases the total concentration of Cd in soils, and the bioavailability of this Cd determines whether plants' Cd uptake occurs to a significant degree (Weggler, 2004). The Joint FAO/WHO has recommended the PTWI as 0.007 mg/kg body weight for cadmium (JEFCA, 2004). The EPA maximum contaminant level for cadmium in drinking water is0.005 mg/L whereas the WHO adopted the provisional guideline of 0.003 mg/L (WHO, 2004).

Copper (Cu): Copper is the third most used metal in the world (VCI 2011).Copper is an essential micronutrient required in the growth of both plants and animals while in humans, it helps in the production of blood hemoglobin (Raymond and Felix, 2011). In plants, Cu is especially important in seed production, disease resistance, and regulation of water. Copper in high doses can cause anemia, liver and kidney damage, and stomach and intestinal irritation in human (Yrule, 2005). Copper normally occurs in drinking water from Cu pipes, as well as from additives designed to control algae growth. While Cu's interaction with the environment is complex, research shows that most Cu introduced into the environment is, or rapidly becomes, stable and results in a form which does not pose a risk to the environment (Raymond and Felix, 2011). He also added that the solubility of Cu is drastically increased at pH 5.5, which is rather close to the ideal farmland pH of 6.0–6.5. Copper and Zn are two important essential elements for plants, microorganisms, animals, and humans (Cambell, 2006). The connection between soil and water contamination and metal uptake by plants is determined by many chemical and physical soil factors as well as the physiological properties of the crops. Soils contaminated with trace metals may pose both direct and indirect threats: direct, through negative effects of metals on crop growth and yield, and indirect, by entering the human food chain with a potentially negative impact on human health (Raymond and Felix, 2011). Most countries that imports agricultural products now specifies acceptable maximum contents of metals in food, which might limit the possibility for the farmers to export their contaminated crops (Bjuhr., 2007).

Mercury: The primary source of mercury is the Sulphide ore cinnabar, mercury(II)forms strong complexes with a variety of both inorganic and organic ligands, making it very soluble in oxidized aquatic systems (Alysson and Fabio, 2014). He also stated that mercury may also be removed from solution by co-precipitation with sulphides. Under anaerobic conditions, both organic and inorganic forms of Hg may be converted to alkylated forms by microbial activity, such as by sulfur reducing bacteria. Elemental mercury may also be formed under anaerobic conditions by demethylation of methylmercury, or by reduction of Hg (II). Acidic conditions (pH<4) also favor the formation of methyl mercury, whereas higher pH values favor precipitation of HgS (s) (Sharma and Dubey 2005). It has been established medically that mercury is associated with kidney damage (Scragg, 2006). In the year 2003, JECFA revised its risk assessment on methylmercury in fish and adopted a lower PTWI of 1.6 µg/kg body weight/week to replace the previous PTWI of 3.3µg/kg body weight/week of total mercury for the general population (JECFA, 2004).

Nickel: Nickel is a transition element with atomic number 28 and atomic weight 58.69. In low pH regions, the metal exists in the form of the nickelous ion, Ni (II). It is neutral to slightly alkaline solutions, it precipitates as nickelous hydroxide ($Ni(OH)_2$), which is a stable compound. This precipitate readily dissolves in acid solutions forming Ni (III) and in its alkaline conditions; it forms nickelite ion ($HNiO_2$) which is soluble in water. In oxidizing and alkaline conditions, nickel exists in the form of stable nickelo-nickelic oxide (Ni_3O_4) which is soluble in acid solutions. Other nickel oxides such as nickelic oxide (Ni_2O_3) and nickel peroxide (NiO_2) are unstable in alkaline solutions and decompose by giving off oxygen. In acidic regions, however, these solids dissolve producing Ni^{2+} (Alysson and Fabio, 2014). Nickel is an element that occurs in the environment only at very low levels and is essential in small doses, but it can be dangerous when the maximum tolerable amounts are exceeded (Sreekanth *et al*., 2013). This can cause various kinds of cancer on different areas within the bodies of animals and humans, especially those that live near refineries. The most common application of Ni is an ingredient of steel and other metal products. The major sources of nickel contamination in the soil are metal plating industries, combustion of fossil fuels, and nickel mining and electroplating (Khodadoust *et al*., 2004). It is released into the air by power plants and trash incinerators and settles to the ground after undergoing precipitation reactions. It usually takes a longtime for nickel to be removed from air. Nickel can also end up in surface water when it is a part of wastewater streams (Alysson and Fabio, 2014). The larger part of all Ni compounds that are released to the environment will adsorb to sediment or soil particles and become immobile as a result. In acidic soils, however, Ni becomes more mobile and often leaches down to the adjacent groundwater. Microorganisms can also suffer from growth decline due to the presence of Ni, but they usually develop resistance to Ni after a while (shanker *et al*., 2005). Alysson and Fabio, (2014) also stated that nickel is not known to accumulate in plants or animals and as a result Ni has not been found to biomagnify up the food chain, but for animals, Ni is an essential foodstuff in small amounts.

3. Conclusion

Heavy metals have been proved to be toxic to both human and environmental health. Owing to their toxicity and their possible bioaccumulation, the compounds of heavy metals should be subjected to mandatory routine monitoring. Several suitable separation and detection methods are available for laboratories engaged daily in routine analysis of a large number of biological or environmental samples. Governments should promote harmonized data collection, research, legislation and regulations, and consider the use of indicators. This two assessment methods (determining the chemical concentration scenario and the use of biomarkers) will provide useful data to set standards and guideline values designed to protect human and environmental health from heavy metals contaminants. Standard measures are essential for the protection of high risk populations and subgroups. Furthermore, governments should, when setting acceptable levels or criteria related to chemicals, take into consideration the potential enhanced exposures and/or vulnerabilities of children.

References

Aguilar RB., Bautista, F., Goguitchaichvili, A., Quintana, P., Carvallo, C., and Battu. J. 2013. Rock-Magnetic properties of top soils and urban dust from Morelia, Mexico: implications for anthropogenic pollution monitoring in medium-size cities. Geofis. Int. 52- 2, 121-133.

Akhilesh, J., Savita, D., and Suman, M. 2009. Some Trace Elements Investigation in Ground Water of Bhopal and Sehore District in Madhya Pradesh: India, J. Appl. Sci. Environ. Manage. *December*, 2009 Vol. 13(4) 47 – 50, JASEM ISSN 1119-8362

Alloway BJ. 2013. Introduction. In: Alloway BJ. (ed.) Heavy metals in soils: trace metals and metalloids in soils and their bioavailability. 3rd ed. Dordrecht: Springer; p3-10.

Alysson RBS., and Fábio, C. 2014: Risks of Heavy Metals Contamination of Soil-Pant System by Land Application of Sewage Sludge: A Review with Data from Brazil, http://dx.doi.org/10.5772/58384

Bjuhr J. 2007. *Trace Metals in Soils Irrigated with Waste Water in a Periurban Area Downstream Hanoi City, Vietnam, Seminar Paper*, Institutionenf¨ormarkvetenskap, Sveriges lantbruks universitet (SLU), Uppsala, Sweden, 2007.

Campbell PGC. 2006. Cadmium-A priority pollutant. *Environmental Chemistry*, Vol. 3, no. 6, pp. 387–388.

Castillo-Michel H., Parsons, JG., Peralta-Videa, JR., Martínez-Martínez, A., Dokken, KM., and Gardea-Torresdey, JL. 2007. Use of X-ray absorption spectroscopy and biochemical techniques to characterize arsenic uptake and reduction in pea (*Pisumsativum*) plants. Plant Physiology and Biochemistry, 45 (6, 7) 457-463.

Cui YL., Zhu, YG., Zhai, RH., Chen, DY., Huang, YZ., and Qiu, Y. 2004.Transfer of metals from soil to vegetables in an area near a smelter in Nanning, China. Environ. Int. 30:785-791

Dasgupta, PK., Dyke, JV., Kirk, AB., and Jackson, WA. 2006. Perchlorate in the United States. Analysis of Relative Source Contributions to the Food Chain. *Environ. Sci. Technol.*, 40 (21), pp 6608–6614. DOI: 10.1021/es061321z

FAO/WHO Expert Committee on Food Additives, Arsenic. 2005. Retrieved 14 October, 2015, from http://www.inchem.org/documents/jecfa/jeceval/jec_159.htm

Garba, ZN., Hamza, SA., and Galadima, A. 2010. Arsenic Level Speciation in Fresh Water from Karaye, Local Government Area, Kano State, Nigeria. International Jour. Chem. Vol. 20, No. 2, (2010) 113-117

Greany, KM. 2005. An assessment of heavy metal contamination in the marine sediments of Las Perlas Archipelago, Gulf of Panama. M.Sc. thesis, Heriot-Watt University, Edinburgh, Scotland.

Joint FAO/WHO Expert Committee on Food Additives (JECFA). 2004. Safety evaluation of certain food additives and contaminants. WHO Food Additives Series No 52.

Khodadoust AP., Reddy, KR., and Maturi. K. 2004. Removal of nickel and phenanthrene from kaolin soil using different extractants. *Environmental Engineering Science*, Vol. 21, no. 6, pp. 691–704

Mapanda F., Mangwayana, EN., Nyamangara, J., and Giller. KE. 2005. The effect of long-term irrigation using wastewater on heavy metal contents of soils under vegetables in Harare, Zimbabwe. Agric. Ecosyst. Environ., 107: 151-165.

Morgan, SC., Relaix, F., Sandell, LL., and Loeken, MR. 2008. Oxidative stress during diabetic pregnancy disrupts cardiac neural crest migration and causes outflow tract defects. Clinical and Molecular Teratology, Volume 82, Issue 6, Pages 453–463. DOI: 10.1002/bdra.20457

Na Z., W. Qichao, Z. Dongmei. 2007. Health risk of Hg, Pb, Cd, Zn, and Cu to the inhabitantsaround Huludao Zinc Plant in China via consumption of vegetables. Science of the Total Environment 383 (2007) 81-89

National Safety Council (NSC). 2009. Lead Poisoning, Retrived on the 15 October, 2015, from http://www.nsc.org/news resources/Resources/Documents/Lead Poisoning.pdf.

Rajesh, KS., Madhoolika, A., and Fiona, M., 2007. Heavy metal contamination of soil and vegetables in suburban areas of Varanasi, India. Ecotoxicology and Environmental Safety 66 (2007) 258-266.

Raymond, AW., and Felix. EO. 2011. Heavy Metals in Contaminated Soils: A Review of Sources, Chemistry, Risks and Best Available Strategies for Remediation. International Scholarly Research Network, ISRN Ecology, Volume 2011, 20 pages doi:10.5402/2011/402647

Requejo, R., and Tena, M. 2005. Proteome analysis roots reveal that oxidative stress is a main contributing factor to plant arsenic toxicity. Phytochemistry, 66(13) 1519-1528.

Rodríguez-Serrano M., Romero-Puertas, M.C., Pazmiño, DM., Testillano, OS., Risueño, MC., del Río, LA., and Sandalio, LM. 2009. Cellular response of pea plants to cadmium toxicity: cross talk between reactive oxygen species, nitric oxide, and calcium. Plant Physiology, 150(1) 229-243.

Scragg A. (2006): *Environmental Biotechnology*, Oxford University Press, Oxford, UK, 2nd edition.

Sreekanth TVM., Nagajyothi, PC., Lee, T.N.V.K.V. Prasad. 2013. Occurrence, physiological responses and toxicity of nickel in plants. International Journal of Environmental Science and Technology, 10(5) 1129-1140.

Shanker A.K., Cervantes, C., Loza-Tavera, H., and Avudainayagam, S. 2005. Chromium toxicity in plants. Environmental International, 31(5) 739-753.

Sharma P., and Dubey, RS. 2005. Lead toxicity in plants. Brazilian Journal of Plant Physiology, 17(1) 35-52.

Taylor, MP., Mackay, AK., Hudson-Edwards, KA., and Holz, E. (2010). Soil Cd, Cu, Pb and Zn contaminants around Mount Isa city, Queensland, Australia: Potential sources and risks to human health. Applied Geochemistry, Volume 25, Issue 6, Pages 841–855. http://dx.doi.org/10.1016/j.apgeochem.2010.03.003

Thomas IHL., Francisco, B., Fredy, RCR., Maria, DCD., Patricia, QO., Daniel, A., and Avto. G. 2015. Concentration of toxic elements in top soil's of the metropolitan area of Mexico city: Spatial analysis using ordinary kriging and indicator kriging. Rev. Int. Contam. Ambie. 31 (1) 47-62

United States Environmental Protection Agency (USEPA). 2005. Arsenic in drinking water fact sheet. Retrieved 10 July, 2015, from http://www.epa.gov/safewater/arsenic.html.

Vijaya, CB., Kiran, K., and Nagendrappa. G. 2010. Assessment of Heavy Metals in Water Samples of Certain Locations Situated Around Tumkur, Karnataka, India. CODEN ECJHAO E-Journal of Chemistry. 7(2), 349-352.

VCI, Copper history/Future, Van Commodities Inc., 2011, Retrieved 16 November, 2015, from http://trademetalfutures.com/copperhistory.html.

Weggler K., McLaughlin, MJ., and Graham. RD. 2004. Effect of Chloride in Soil Solution on the Plant Availability of Biosolid-Borne Cadmium. Journal of Environmental Quality,Vol. 33, No. 2, pp. 496–504

WHO. 2004. Guidelines for drinking-water quality. Sixty-first meeting, Rome, 10-19 June2003. Joint FAO/WHO Expert Committee on Food Additives, Retrieved 14 December, 2015, from http://ftp.fao.org/es/esn/jecfa/jecfa61sc.pdf

Wuana, RA., and Okieimen, FE. 2011. Heavy Metals in Contaminated Soils: A Review of Sources, Chemistry, Risks and Best Available Strategies for Remediation. International Scholarly Research Network, Ecology, 20 pages. doi:10.5402/2011/402647

Xilong W., Sato, T., Baoshan, X., and Tao, S. 2005.Health risk of heavy metals to the general public in Tianjin, China via consumption of vegetables and fish. Science of the total Environment 350: 28-37.

Yruela, I. 2005. Copper in plants. Brazilian Journal of Plant Physiology, 17(1) 145-156.