ASSESSMENT OF HEAVY METAL POLLUTION IN SOME NIGERIAN SOILS: A REVIEW

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ABSTRACT

Nigeria is one of the fast developing African Nation with a population of about 170 million. Over the years, industrialization, urbanization and agricultural activities have generated great amount of waste in the societies, about 0.57 kg/capital/day is generated in around Nigerian Cities. It has being noted that municipal waste contains heavy metals and their accumulation contaminates agricultural soil. This paper reviews the various sources of soil contamination, heavy metal concentration and its related health effects. A long term exposure and accumulation above the acceptable levels of this metals whether due to natural or human factors may leads to environmental and health problems. Residue of cadmium (Cd), nickel (Ni), copper (Cu), lead (Pb), arsenic (As), chromium (Cr), tin (Sn) and zinc (Zn) in soil above Standard level requirement are toxins in the environment, polluting the soil.

***Keywords**: Heavy metals, contamination, soil, health risk, environment.*

INTRODUCTION

Due to increasing population growth, agriculture, industries and urban infrastructures in Nigeria, considerable degradation of the environment is occurring. Heavy metals are being release into the soil as a result of human activities to meet the everyday demand for life. The occurrence of heavy metals in soil can be of natural or as a result of human activities. The human activities include mining, smelting, domestic waste and various Industrial activities and they are the major source of soil toxin. The direct activities of extraction, processing for industrial and consumer use contributes to the mobilization of heavy metals into the soil. According to Yahaya *et al*, (2009) and Edorh (2007) the situation of heavy metal pollution is more worrisome in the developing countries where research efforts towards monitoring the environment have not been given the desired attention by the stakeholder. Industrial scale mining activity is comparatively low in Nigeria, yet at this level of mining, the nation is increasingly becoming exposed to the unwanted ecological effects of heavy metals (Olatunji and Osibanjo, 2012).

Heavy Metals has being defined by several researchers, Amo- Asare (2012) defined heavy metals as any metallic chemical element that has a relatively high density (density higher than that of water) and is toxic or poisonous at low concentrations. as elements in the periodic table having atomic number more than 20 or densities more than 5g/cm3 (Morris, 1992; Lozet and Mathieu, 1991). Individual metals and metal compounds can impact human and aquatic health. Five common heavy metals are discussed in this review: arsenic, cadmium, chromium, lead, and mercury. These are all naturally occurring substances which are often present in the environment at low levels and if in larger amounts they are dangerous, health risk due to heavy metal contamination of soil has been widely reported (Eriyamremu et al, 2005; Muchuweti et al, 2006; Satarug et al, 2000).

The use of dumpsites as a farmland is a common practice in urban and sub-urban centre in Nigeria because of the decayed and composted wastes enhances soil fertility (Ogunyemi *et al*, 2003). When agricultural soils are contaminated, these toxins are taken up by plants and accumulate in their tissue. 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 accumulates such metals in their tissue and milk (Garbarino *et al*, 1995). Industrial, agricultural and municipal activities have all resulted in soil and groundwater pollution by a variety of contaminants (Sabri, *et al.*, 2013, Oguzie *et al.*, 2002, Lawson, 2011, Lee *et al*., 2001, Vidal, *et al*., 2000, Speir *et al.*, 2003, Remon, *et al*, 2005) such heavy metals as cadmium (Cd), nickel (Ni), copper (Cu), lead (Pb), arsenic (As), chromium (Cr), tin (Sn) and zinc (Zn) and so on which end up in the soil as the sink when the leached out from the dumpsites (Yahaya *et al*, 2009). This Contaminated soil can be a primary route of human exposure to (Nabulo, 2010) heavy metals which is viewed as an international problem because of the effects on ecosystem in most countries. (Egila, *et al*, 2014).

In Nigeria the situation is no better by the activities of most industries and populace towards waste disposal and management which usually lead to increasing levels of pollution of the environments. Many studies have shown municipal refuse may increase heavy metal contamination in soil and underground water (Okoronkwo *et al*, 2005, Okoronkwo *et al*, 2006) which may have effects on the host soils, crops and human health (Reyes-Gutiérrez et al., 2007). Thus the environmental impacts of municipal refuse are greatly influenced by their heavy metal contents. (Egila *et al*, 2014). However, while total heavy metal contents is a critical measures in assessing risk of refuse dumpsite, total metal content alone does not provide predictive insight on mobility and fate of the heavy metal contaminants (Uba *et al*, 2008), Thus it is the chemical or species of the heavy metal that is an important factor in assessing their impacts on the environment. This is because it is the chemical form of the heavy metal that controls its mobility (Norvell, 1984).

The strategy for minimisation of the effects of heavy metals in waste is partly to reduce today and future environmental and human exposure to the heavy metals in the waste, partly to reduce the content of heavy metals in products marketed.

SOURCE OF HEAVY METALS

In arable lands in most countries, the source of heavy metal include natural source, mining, smelting, agrochemicals and sewage sludge applications, and livestock manure uses. Heavy metal in waste is primarily a result of the intended use of heavy metals in domestic, agricultural and industrial products. At the end of their useful life all products will end up in waste to the extent, they are not attractive for recycling. These metals may also be lost to waste during production and use phases. Losses in the manufacturing process are often disposed of as manufacturing waste, while products may be exposed to wear and tear inclusive corrosion during the use phase (European Commission, 2002).

Municipal Waste

Municipal soils receive loads of noxious waste than the sub-urban or rural areas due to the concentration of anthropogenic activities of urban settlements (Komarnicki, 2005; Lee *et al*., 2006; Srivastava and Jain, 2007). According to Adelekan and Alawode (2011) research carried out on various municipal refuse dumps site in Ibadan Nigeria shows elevated values of Pb, Cd, and Cr in soils at the refuse dumps. Mustapha *et al* (2015) reported a high level of contamination of the soil in various dump site in Kano State, Nigeria, the concentration of most of these metals have exceeded the permissible level. Other researches have recognised the occurrence of some trace element in municipal and industrial effluents discharged into the municipal streams, and in the waters used for irrigation (Binns *et al*., 2003; Dawaki and Alassan, 2008). Maharazu (2010) evaluation in Kano, Northern Nigeria reported the concentration and accumulation of Cd to be seriously noticeable in both Domestic source pollution and Industrial source pollution where the values was close to the allowable limit of 3.00 mg/kg in the Industrial source pollution(2.94 mg/kg) and even above in the domestic source pollution (3.06 mg/kg).

Industrial Activities

Refinery and petrochemical plants generate solid waste and sludge composed of organic, inorganic compounds including heavy metals (Uzoekwe and and Oghosanine, 2011). Amadi *et al*, (2014) also reported the contamination of the soil and groundwater in parts of the surrounding environs' of the Kaduna refinery, the concentrations of the heavy metal were found to exceed the recommended maximum permissible limit. Their enrichment were similar in both soil and groundwater in the order of Fe>As>Cu>Zn>Pb>Cr>Cd>Mn. Due to the ineffectiveness of purification systems, waste water may become dangerous, leading to the accumulation of toxic products in the receiving water bodies with potentially serious consequences on the ecosystem. (Bay et al., 2003, Amadi *et al*, 2014). In Nigeria, Pb in petrol is banned, but with the recent importation of petroleum products into the country, the source may not be fully verified can also constitute a source of Pb introduction into the environment (Edori and Edori, 2012).

At Automobile Mechanic Villages in Ibadan, Adelekan and Abegunde (2011) research shows high level of soil contamination of various heavy metals in different soil and at different depth. According to Idugboe *et al*, (2014) research on an auto-mechanic villages in Benin City, Nigeria, heavy metal analysis of the soils in the three stations revealed the presence of Iron(Fe), Zinc(Zn), Manganese(Mn), Lead(Pb), Copper(Cu), Cadmium(Cd), Chromium(Cr), Nickel(Ni) in the order of decreasing concentration in the soils of the auto-mechanic villages. The concentrations of heavy metals in both soils were considerably higher than those of the control and were above the maximum allowable limits of NESREA, 2007 and WHO, 2007.

Olatunji and Osibanjo, (2012) researched the level of heavy metal concentration around the Itakpe Iron-ore Mining Field, Itakpe, Kogi State, Nigeria and reported that the concentration levels of Cd, Mn, Cr, Ni, Cu, Zn and Pb in soil around Itakpe iron-ore deposit and industrial area were low and within natural concentration levels. Thus the soil around Itakpe iron ore deposit and mining field are yet to be impacted negatively by heavy metals. There is a need to develop an environmental monitoring and management programme for heavy metals as small scale mining is on-going though the industry is not in full working capacity.
A study by Ezenwa *et al* (2014) on ESPRO Asphalt Plant and Quarry site in South-western Nigeria shows the concentration of heavy metals in soil at a depth of 0 – 15 cm varied with distances to the quarry site. The concentration of Cd and Cr decreased with increase in distance to the quarry site. The influence of the distance on Pb and Se concentrations in the soil did not follow a definite pattern. The concentration of Ni and Co also decreased with increasing distance from the quarry site. The effect of increasing distance on the concentration of Mn, Fe and Zn was rarely observed at 300m from the quarry, although the values of Fe and Zn at 300m were lower than the values at 1-250m. Yusuf *et al* (2015) reported the pollution of Illela Garage in Sokoto State, Nigeria with Fe, Pb and Cr to have exceeded the permissible limit prescribed by World Health Organization WHO, 2007 and Federal Environmental Protection Agency.

Agricultural Practices

Research carried out by Hong *et al* (2014) on River Benue plot wastewater irrigation site (RBS) and Shinko municipal wastewater irrigation site (SHS) revealed that the concentration of heavy metals at RBS and SHS sites soil was highly elevated above the maximum permissible level for soils standard obtainable from European Union and the United Kingdom. Hong *et al* (2014) noted a case of lead poisoning in Zamfara State in the North Western part of Nigeria as reported by Nigerian Daily Trust in 2013 where over 2000 children and pregnant women were affected. An experiment performed by Chiroma *et al* (2012) indicated that the mean concentrations of heavy metals in treated and untreated Urban Sewage Waters used for Irrigation are above the maximum permissible levels set by the World Health Organization (WHO), analysis of the farm soil where the sewage water was used indicate high level contamination by heavy metals. The plant grown on the plot also show variations in concentrations of the heavy metals in different parts of the vegetables plants irrigated with treated and untreated sewage waters exceeding the maximum permissible level. Experiment carried out by Thomas *et al* (2012) shows high level of Zn and Ni in soil after the application of phosphate fertilizer. Poultry manure contains considerable amounts of nutrients and heavy metals which are introduced through feed (Steinfeld *et al*, in FAO, 2006). With increasing use of metals not only as growth promoters, but also as feed additives to combat diseases in intensive poultry production, the application of poultry manure has emerged as an important source of environmental contamination with some of these metals. This manure contains appreciable quantities of potentially toxic metals such as arsenic, cobalt, copper, iron, manganese, selenium and zinc which are added to feeds as a means to prevent disease, improve weight gain and feed conversion, and increase egg production (Bolan et al., 2004; Jackson et al., 2003). In excess, these elements become toxic to plants, can adversely affect animals that feed on these plants, and can enter the soil and water systems through surface run-off and leaching.

EFFECT OF HEAVY METALS ON HUMANS AND THE ENVIRONMENT

Lead (Pb)

Lead is a metal ion toxic to the human biosystem, and is among the common global pollutants arising from emergent industrialisation. The allowable permissible threshold in the European Union is 300mg/kg (CCME, 2003). The assimilation of relatively small amounts of lead over a long period of time in the human body can lead to the malfunctioning of the organs and chronic toxicity (Badmus *et al*, 2007) In general, Lead does not bioaccumulate and there is no increase in concentration of the metal in food chains (European Commission, 2002). Many urban soils are contaminated with high concentrations of lead and exposure to it disrupts the development of the nervous system, causing delays in growth and learning disabilities (Ilaria *et al* in 19th WCSS, 2010). The Queensland doctors Gibson (1904) and Turner (1909) first identified the problem of environmental lead exposure in children from paint and dust over a century ago (Mark *et al*, 2011). In addition, another potentially important exposure pathway for Pb into humans may be via ingestion of contaminated vegetables (Finster *et al*, 2004; Kachenko *et al*, 2004, 2006)
In humans, lead can result in a wide range of biological effects depending upon the level and duration of exposure. For infants and young children lead in dust and soil often constitutes a major exposure pathway and this exposure has been one of the main concerns as to the exposure of the general population ago (Mark *et al*, 2011). In adult approximately 10% of the dietary lead is absorbed. Effects may range from inhibition of enzymes to the production of marked morphological changes and death. Of particular concern for the general population is the effect of lead on the central nervous system. Epidemiological studies suggest that low level

exposure of the foetus and developing child may lead to reprotoxic effects, i.e. damage to the learning capacity and the neuropsychological development (Howard, *et al.,* 2002, Mark, *et al*, 2011, World Health Organization, 2007). Studies of children indicate a correlation between higher lead contents in the blood and a lower IQ. Slowing of nerve conduction velocity has been found at low lead blood levels. Impairment of psychological and neurobehavioural functions has also been found after long-term lead exposure of workers (Schwartz, *et al.*, 2001).

Lead has been shown to have effects on haemoglobin synthesis and anaemia has been observed in children at lead blood levels above 40 µg/dl (Howard, *et al.*, 2002, Ogwuegbu, and Muhanga, 2005). Lead exposure is associated with a small increase in blood pressure (World Health Organization, 2007). Lead is known to cause kidney damage. Some of the effects are reversible, whereas chronic exposure to high lead levels may result in continued decreased kidney function and possible renal failure (Ogwuegbu and Muhanga, 2005). Renal effects have been seen among the general population when more sensitive indicators of function were measured (European Commission, 2002, Howard, *et al.*, 2002, Kim, *et al.*, 1996). It also said to affects the male sperm morphology and count (Ogwuegbu and Muhanga, 2005).

Mercury

Mercury is a peculiar metal. Most notable is its fluidity at room temperature, but two other properties are more important for the possible exposure of man and the environment to mercury (European Commission, 2002) which is the volatility and its chemically or biologically transformation to organic mercury. The main human exposure to mercury is via inhalation of the vapour of elemental mercury and ingestion of mercury and methylmercury compounds in food. Mercury and its compounds are toxic to humans. The toxicity varies among the different types of mercury. Generally, organic forms are much more toxic than the inorganic forms (European Commission, 2002).

Methylmercury represents the most important toxic impact of mercury to humans. It is present worldwide and the general population is primarily exposed to methylmercury through their diet, in particular through the consumption of fish and fish products (European Commission, 2002, Mark, 2004). Most of the total mercury in fish is in the form of methylmercury (may be close to 100% for older fish, especially in predatory species). This implies that population groups particularly dependent on or accustomed to marine diets, for instance the Inuit's of the Arctic, as well as populations depending on fishing and marine hunting anywhere else on the globe, are particularly at risk. (AMAP, 1998).

Several researchers have identified that Methylmercury has been found to have adverse effects on several organ systems in the human body as well as in animals. These include the central nervous system (Mark, 2004, European Commission, 2002, Sabine *et al*., 2009) i.e. mental retardation, deafness, blindness, impairment of speech, changes in vision or hearing, and memory problems and the cardiovascular system (blood pressure, heart-rate variety and heart diseases) also Renal toxicity includes proteinuria, renal syndrome, and acute renal failure (Mark, 2004). Research on animals has given evidence of effects on the immune system and the reproduction system. Recently, an extensive evaluation of the toxicological effects of methylmercury was performed under the U.S. National Research Council (NRC, 2000). Here, it was concluded that the effects on the developing nervous system in unborn and newborn children are the most sensitive.

Methylmercury in our food is rapidly absorbed in the gastrointestinal tract (stomach and intestine), readily crosses the placental barrier and enters the brain. A series of large epidemiological studies have recently provided evidence that methylmercury in pregnant women's marine diets appears to have subtle, persistent effects on the children's mental development (cognitive deficits) as observed at about the age of school start (NRC, 2000).

Cadmium (Cd)

Cadmium and cadmium compounds are relatively water soluble, compared to other heavy metals. Making them more mobile in soil and generally more bioavailable and tends to bioaccumulate. The allowable permissible threshold in the European Union is 3.0 mg/kg (CCME, 2003). The major route of exposure to cadmium for the non-smoking general population is via food; the contribution from other pathways to total uptake is small. Tobacco is an important source of cadmium uptake in smokers (i.e. about 50% absorption of intake), as tobacco plants like other plants accumulate cadmium from the soil (European Commission, 2002).

It has been reported that increases in soil Cd content will result in an increased uptake by vegetables (Al-Chaarani *et al*, 2009). The Cd uptake by vegetables from soil is also higher at a low pH of soil (Akinola *et al*, 2008, Al-Chaarani *et al*, 2009).

Occupational exposure is linked to lung cancer and prostate cancer. According to a recent review, the epidemiological data linking cadmium and lung cancer are much stronger than for prostatic cancer, whereas links between cadmium and cancer in liver, kidney and stomach is considered equivocal (Waalkes, 2000). Cd

contaminated vegetables are known to result in bone fracture, bone diseases, kidney and lung problems, anaemia, diarrhea, stomach pains and severe vomiting, reproductive failure, damage of central nervous system and DNA, in addition to cancer development (Oti *et al*, 2013, Hardy *et al*., 2008, Adelekan and Abegunde, 2011, Asio, 2009).
European Commission, (2002) reported that cadmium is toxic to a wide range of microorganisms as it affect the growth and replication of some soil microorganisms like fungi, some species are eliminated after exposure to cadmium in soil.

Chromium

Chromium occurs in a number of oxidation states, but Cr(III) (trivalent chromium) and Cr(IV) (hexavalent chromium) are of main biological relevance. There is a great difference between Cr(III) and Cr(VI) with respect to toxicological and environmental properties (Assem and Zhu 2007), and they must always be considered separately. Chromium is in general not bioaccumulated and there is no increase in concentration of the metal in food chains (European Commission, 2002). The allowable permissible threshold for soil in the European Union is 180 mg/kg (CCME, 2003). Cr(III) is considerably less toxic than Cr(VI). Cr(VI) has been demonstrated to have a number of adverse effects ranging from causing irritation to cancer.
Contrary to the three other mentioned heavy metals, Cr(III) is an essential nutrient for man. Chromium is necessary for the metabolism of insulin (European Commission, 2002, Krejpcio, 2001). Most of the daily chromium intake is ingested with food and is in the trivalent form about 0.5-3% of the total intake of trivalent chromium is absorbed in the body (European Commission, 2002, Krejpcio, 2001). The gastrointestinal absorption of Cr(VI) is 3-5 times greater than that of trivalent forms; however, some of it is reduced by gastric juice.
Skin exposure of the general public to chromium can occur from contact with products containing chromium e.g. leather or preserved wood or chromium containing soil. Airborne chromium may contribute significantly to occupational exposure. High level exposed of chromium or its compounds, primarily Cr(VI) by inhalation, may lead to irritating respiratory effects, possible circulatory effects (Krejpcio, 2001, Sabine *et al*., 2009)), effects on stomach and blood , liver and kidney effects, can lead to dermal ulcers, effects on the renal, haematological and cardiovascular system (Assem and Zhu, 2007), Reyes-Gutiérrez *et al.*, 2007) and increased risk of death from lung cancer (RTI. 2000).

Arsenic

Aside from occurring naturally in the environment, arsenic can be released in larger quantities through volcanic activity, erosion of rocks, forest fires, and human activity. The wood preserving industry uses about 90% of the industrial arsenic in the U.S. Arsenic is also found in paints, dyes, metals, drugs, soaps and semi-conductors. Animal feeding operations and certain fertilizers and pesticides can release high amounts of arsenic to the environment, as industrial practices such as copper or lead smelting, mining, and coal burning (Sabine *et al*., 2009)
Inorganic arsenic is a known carcinogen and can cause cancer of the skin, lungs, liver and bladder. Lower level exposure can cause nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and a sensation of "pins and needles" in hands and feet. Ingestion of very high levels can possibly result in death.
Arsenic exposure occurs from inhalation, absorption through the skin and ingestion of contaminated drinking water or food. Seafood, fish, and algae are the richest organic sources. These organic arsenic compounds cause raised arsenic levels in blood but it may be excreted in urine. Arsenic intake is higher from solid foods than from liquids including drinking water. Organic and inorganic arsenic compounds may enter food chain from soil irrigated with arsenic contaminated water (Ratnaike, 2003). Long-term low-level exposure can cause a darkening of the skin and the appearance of small "corns" or "warts" on the palms, soles, and torso (Sabine *et al*., 2009).

CONCLUSION

Soil is a great reservoir for contaminant as well as a natural buffer for transportation of chemical materials and elements in the environment. The contamination of the soil poses serious danger to the overall quality of human life. The most adverse effect of heavy metals is that they can be introduced into the food chain and threaten human health. Agricultural products growing on soils with high metal concentrations are source of metal accumulations at levels harmful to human and animal health as well as to the bio-environment, this metals may have been mixed with groundwater by leaching.

To control soil contamination, legislative measures must be taken, legally binding the individual and industries, proper waste management system must be established, forbidding discharge of unsorted and untreated or poorly treated waste into the environment.
Appropriate remediation measures should be taking promptly to remove excess metal contamination in the soil. Regular monitoring of toxic metals in the agricultural soil is needed to ensure safe environmental.

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