



Full Length Research

Risk Assessment of Heavy Metal in Soil Content and Portable Water: A Review of the Literature

¹UKONU, Christian Ugochukwu & ²LASISI, Halimat Olasunbo

^{1,2}Department of Biochemistry (Science Laboratory Technology),
Faculty of Applied Science,
Federal Polytechnic Ilaro,
Ilaro, Nigeria.

¹Principal Author Email ukonuchristianu@yahoo.com

²Corresponding Author Email lasisi.olasunbo@gmail.com

³ADEWOLE, Esther Abisola

Department of Chemistry,
Faculty of Physical Sciences,
Federal University of Technology,
Akure, Nigeria

³Co Author Email: estheradewole32@gmail.com

⁴OKUNOLA, Marufat Gbemisola

³Department of Microbiology,
Faculty of Science,
Usmanu Danfodiyo University,
Sokoto, Nigeria.

⁴Co Author Email: marufatgbemisola@gmail.com

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Abstract: Extant studies have revealed that water and soil pollution are among the major global challenges that society must address in the 21st century aiming to improve water quality and reduce human and ecosystem health impacts. Industrialization, climate change, and expansion of urban areas produce a variety of water and soil contamination. In this study, the authors discussed some of the relevant findings in extant literature related to the release of heavy metals into water and soil content, that is affecting agricultural practices, and hence, serve as possible risks for human health. Thus, the aim of this study is to review previous research work done by other authors on heavy metals in water and soils, detection, poisoning, damages to human health and treatments of agricultural soils as noted in some studies. The study adopts an extensive review of literature such as conference papers, journal articles, internet sources, books to find out concentration of heavy metals in agricultural soils and water. After analysis and review of such secondary articles, the current studies found that heavy metal in portable water and soil is a source of major concern and should be regularly checked and monitored by appropriate regulatory agencies. In addition, some previous researchers found that anthropogenic activities are identified as the main source of the increasing amounts of heavy metals found in water and soil. Some of the health hazards derived from repeated exposure to traces of heavy metals, including lead, cadmium, nickel, and zinc, were also reported in this study. The authors also stated the methods in which this contamination occurs and ways to prevent future contamination as discussed by various authors. This study concluded that heavy metals are the main cause of water pollution and impact human health worldwide.

Keywords: Heavy Metal: Water: Contamination: Pollution: Human Health: Anthropogenic Factors: Nigeria.

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1.0 Introduction of the Study

Pollution is the introduction of contaminants into an environment, soil, food and water that causes instability, disorder, harm or discomfort to the ecosystem or living organisms (Gari, 2002; Ademoroti, 1996; Alloway, 1995; Alloway, 1999). Sources of pollution can be natural or man-made. The major sources of heavy metal pollution in urban areas are anthropogenic (human activities) while contamination from natural sources predominate in the rural areas (Hutchinson & Meema, 1987). High concentration of toxic contaminants like heavy metals is generally found in the urban areas with large population, high traffic density and industries (Hutchinson & Meema, 1987; Amusan et al., 1999; Andersen, 1983; Ano et al., 2007). Consequently, their undue presence in the environment through industrial emission, effluent discharges, solid waste disposal, usage of agrochemicals and sewage sludge in agricultural practices, traffic pollution, atmospheric pollution, automobile activities, combustion of fossil fuels, coal, steel, plastics e.t.c, are more prominent in urban areas where multitudes of stationary and mobile sources release large quantities of toxic contaminants into the atmosphere (Agency for Toxic Substances & Disease Registry, 1997; Audsley, 1988; Barceloux, 1999; Baselt, 2008).

Water is a transparent and nearly colorless chemical substance that is the main constituent of Earth's streams, lakes, and oceans, and the fluids of most living organisms (Charles et al., 1966; Chlopecka et al., 1996; Lasisi, 2018). Water is essential for human survival and important to many sectors of the economy. The contamination of water resources should be a matter of concern to human health because of its degree of effect to human existence. Some anions are found in water which is useful to human body while many others are harmful (Tayfur *et al.*, 2008). The term heavy metals, is a group name for some metals and metalloids associated with pollution and toxicity, but also includes some elements which are essential for living organisms at low concentrations. Heavy metals like zinc, manganese, copper, chromium, iron, cobalt, selenium, magnesium and calcium are essential trace elements for man, animal and plants but become toxic if the homeostatic mechanisms maintaining their physiological limit are disrupted or they become toxic if their concentration is very high in the body while lead, cadmium, nickel, mercury, arsenic are potentially toxic at certain levels (Kaur *et al.*, 2009; Coby et al., 2004; Drobiora et al., 2004). Despite the fact that some heavy metals are beneficial, essential and non-essential, they can cause morphological abnormalities, reduced growth, increased human mortality rate and mutagenic effect in human when present in excessive levels (Khursid & Qureshi, 1984). Also, excessive accumulation of heavy metals in the human body system usually results from increased human exposure to the metals and this may cause health problems such as cancer, anemia, neurological problems, renal dysfunction, damage to the hepatic, hematological, neuromuscular, reproductive, renal and central nervous system (Khursid & Qureshi, 1984).

A processed product from cassava, popularly known as “fufu” in Yoruba language is a staple food in Nigeria which contains essential and beneficial minerals needed for the body morphological processes (Samans, 1949; Schmidt & Andren, 1980; Scoullou et al., 2001). It is a rich source of carbohydrate, often referred to as the major fuel of the body tissues that releases energy needed by the body to function properly in its daily activities. Kaur *et al.* (2009) reported that human activities (anthropogenic sources) could favor the presence of toxic contaminants like heavy metals in cassava which may render it unfit for human consumption especially when they are in high concentration. Researchers have it that particulate from air pollution and vehicle emissions are the main causes of heavy metals contamination in the urban areas. Ano *et al.* (2007) reported that atmospheric deposition of heavy metals on cassava and soils along express road is higher than on cassava and soils in remote villages (non-road side environment) because of low vehicle emission in the remote villages. Alloway (1995) reported that plants accumulate considerable amount of heavy metals in root and leaves. Amusan *et al.* (1999) also reported that there is high concentration of heavy metal in vegetables grown in waste dump soil. Ugwu *et al.* (2011) reported high concentrations of lead, cadmium and nickel in cassava flour sundried along a major highway. Detailed studies of the fate and contents of these heavy metals in various food and human being have become a major task in research and there is continuous challenge to develop new methodology and optimize the already existing methodologies. When the metals intake is at low concentration, the body system might not be able to remove it and it will remain in the body as impurities for a short time (Alloway, 1995).

2.0 Review of Relevant Literature

2.1 Chemistry of Heavy Metals

2.1.1 Lead

Lead is a main-group element with the symbol Pb (from latin word “Plumbum” for lead), present below tin in group 14, belong to period 6 and p block of the periodic table with the atomic number of 82 and atomic mass of 207.2 gmol⁻¹. Generally, lead is the end product of a radioactive decay; hence it is harmful in nature. Like the element, mercury another heavy metal, lead is a potent neurotoxin that accumulates both in soft tissues and the bones (Brady *et al.*, 1996; Sutherland et al., 2000; Ugwu et al., 2011; Weeks, 1932). Lead occurs naturally in the environment. However, most lead concentrations that are found in the environment are as a result of human activities. Metallic lead does occur in nature, but it is rare. Lead is usually found in ore with zinc, silver and most abundantly, copper and is extracted together with these metals. The primary lead mineral is galena (PbS) that contains 86.6% lead.

Some other common varieties of lead are anglesite (PbSO_4) and cerussite (PbCO_3). Sources of lead are children's jewelry and toys, cosmetics, herbal medicines etc (Chlopecka et al., 1996).

Lead poisoning also known as plumbism, colicapictonium, saturnism, painter's colic is a medical condition caused by increased levels of the heavy metal lead in the body. Lead interferes with a variety of body processes and is toxic to many organs and tissues including the heart, bone, intestines, kidneys, reproductive and nervous systems. The main target of lead poisoning is nervous system both in adults and children and is therefore particularly toxic to children causing potentially permanent learning and behavior disorders. Lead can enter the human body through uptake of food (65%), water (20%) and air (15%) but may also occur after accidental ingestion of contaminated soil, dust or lead based paint (Rooney, 2007). The most common cause of lead poisoning is dust and chips from old paint. Lead seldom occurs naturally in water supplies like rivers, lakes, soil e.t.c. It gets into drinking water primarily as a result of corrosion or wearing a way of materials containing lead in the water distribution systems, household or building plumbing or gets into the food through the soil or as a result of food stored in ceramics, pottery, lead-glazed dishes e.t.c. Lead can also be found in imported candies or food, batteries, radiators for cars and trucks and ink colors (Samans & Carl, 1949; Stanley, 1992; Stephen, 1995; Stone, 2002; Sunderman, 1977). Long term exposure to lead or its salt can cause nephropathy and colic-like abdominal pains. It may also cause weakness in fingers, wrists or ankles, small increase in blood pressure, particularly in middle-aged and older people and can cause anemia. It can damage nervous connections (especially in young children), causes blood and brain disorders. Exposure to high lead levels can severely damage the brain and kidneys in adults or children and ultimately cause death. In pregnant women, it may cause miscarriage and reduce fertility in males through sperm damage. For environmental effect, lead can end up in water and soils through corrosion of leaded pipes in a water transporting system and through corrosion of leaded paint. Soil functions are disturbed by lead concentration especially near highways and farmland (Sharma et al., 2008; Spears, 1984; Stangl & Kirchagessner, 1996; Lasisi, 2018). Lead accumulates in the bodies of water organisms and soil organisms and they experience effects from lead poisoning. Health effects on shellfish can take place even when only very small concentration of lead are present, also, body functions of phytoplankton can be disturbed when lead interferes. Phytoplankton is an important source of oxygen production in seas and larger sea-animals eat it.

Elevated lead in the body can be detected by the presence of changes in blood cells visible with a microscope and dense lines in the bones of children seen on X-ray. However, the main tool for diagnosis is measurement of the blood lead level. Analysis of lead in whole blood is the most common and accurate method of assessing lead exposure in human. Erythrocyte Protoporphyrin (EP) tests can also be used to measure lead exposure, but are not sensitive at low blood levels ($< 0.2 \text{ mg/l}$) (Lightfoot *et al.*, 2008). Lead in blood reflects recent exposure, bone lead measurements are an indicator of cumulative exposure, and they are not reliable. Treatment of organic lead poisoning involves removing the lead compound from the skin, preventing further exposure, treating seizures and possibly chelation therapy (administration of agents that bind lead so it can be excreted) for people with high blood lead concentrations. A chelating agent is a molecule with at least two negatively charged groups that allow it to form complexes with metal ions with multiple positive charges such as lead. The chelate formed is nontoxic and can be excreted in the urine initially at up to 50 times the normal rate. The chelating agents used for the treatment of lead poisoning are edetate disodium calcium (CaNa_2EDTA), dimercaprol (BAL) which is injected and succimer and d-penicillamine which are administered orally (Lightfoot *et al.*, 2008). To reduce lead poisoning is to prevent exposure to lead. Recommended steps to reduce blood lead levels in adults and children include increasing frequently hand washing, increase intake of calcium and iron, eliminating lead containing objects like blinds and jewelry in the house. In houses with lead pipes or plumbing solder, run water in the morning to flush out the most contaminated water and to prevent corrosion of pipes (Lightfoot *et al.*, 2008; Robert et al., 2000; Rooney, 2007; Rossi, 2008; Routledge & Steve, 1998). Lead testing kits should be provided in the house to screen and test the blood of children for exposure. Using cold water for drinking, cooking and for making baby formula can avoid lead exposure. Hot water is more likely to contain higher amounts of lead than cold water (Rossi, 2008).

2.1.2 Cadmium

Cadmium is a transition metal with the symbol Cd, atomic number of 48 and atomic mass of 112.411 g/mol , belong to period 5 and block d of the periodic table. It is a soft, bluish white metal which is chemically similar to the two other metals in group 12, zinc and mercury (Scoullos *et al.*, 2001). Similar to zinc, it prefers oxidation state +2 in most of its compounds and similar to mercury, it shows a low melting point for a transition metal. Cadmium can mainly be found in the earth crust. It always occurs in combination with zinc. After being applied, it enters the environment mainly through the ground because it is found in manures and pesticides. Naturally, a very large amount of cadmium is released into the environment about 25,000 tons a year through weathering of rocks and volcanoes and through forest fires. The rest is released through human activities such as manufacturing. Human uptake of cadmium takes place mainly through food. Food stuffs that are rich in Cadmium can greatly increase the cadmium concentration in human bodies. Examples are liver, mushrooms, shellfish, mussels, cocoa powder and dried seaweed. An exposure to significantly higher cadmium levels occur when people smoke tobacco, smoke transports cadmium into the lungs, blood will transport it through the rest of the body where it can increase effects by potentiating cadmium that is already present from cadmium rich food (Scoullos *et al.*, 2001; Nielsen, 1991; Oller, 2011; Payne, 2008). When people breathe in cadmium, it can severely damage the lungs and this may cause death. Cadmium is first transported to the liver through the blood. Therefore, it is bonded to protein to form complexes that are transported to the kidneys where it damages filtering mechanisms. This causes the extraction of essential proteins and sugars

from the body and further kidney damage. It takes a very long time before cadmium accumulated into the kidney is excreted from human body (Lane *et al.*, 2005).

Cadmium poisoning can cause diarrhea, stomach pains, severe vomiting, bone fracture, reproductive failure and infertility, damage to the central nervous system, damage to immune system, psychological disorders, possibly DNA damage or cancer development and eventually lead to death. Cadmium is strongly absorbed by organic matter in soils and when cadmium is present in soils as a result of waste streams from industries like zinc production, phosphate ore, bio industrial manure, burning of household waste and fossil fuel, it can be extremely dangerous as the uptake through food will increase. Soils that are acidified enhance the cadmium uptake by plants. This is potential danger to the animals like cow that are dependent upon the plants for survival, cadmium can accumulate in their bodies and kidney especially when they eat multiple plants and they can sometimes get high blood pressure, liver disease and brain damage. Earthworms and other essential soil organisms are extremely susceptible to cadmium poisoning (Lane *et al.*, 2005). They can die at very low concentration and this has consequences for soil structure. When cadmium concentrations in soil are high, they can influence soil processes of microorganisms and threaten the whole soil ecosystem. In aquatic ecosystems, cadmium can bio accumulates in muscle oysters, shrimps, lobsters and fish. The susceptibility to cadmium can vary greatly between aquatic organisms. When cadmium is transported over a great distance, it is absorbed by sludge and cadmium rich sludge can pollute surface water as well as soil (Lane *et al.*, 2005; Lightfoot & Yeager, 2008; Zarel *et al.*, 2003-2007). Cadmium can be detected when about 10 milligrams of cadmium contents has been absorbed either through the skin, inhalation or ingestion. The following signs can help to detect cadmium level in the body. Elevated levels of creatine in the blood and urine may confirm cadmium poisoning generally. When a person or animal is exposed to cadmium over a long period of time and in smaller doses, he or she starts noticing shortness of breath, tooth-staining and weight loss resulting in damaged liver and kidney, sweet or metallic taste in the mouth, increased amount of saliva, vomiting, choking, anemia, abdominal pains and spasm of ingested cadmium, chest pain, wheezing, inflammation of the lungs, weakness in muscles and leg pain.

2.1.3 Cadmium poisoning treatment

Although cadmium cannot be treated because of its stability and cannot be broken or destroyed, but can be cured by preventing the body from exposure. The following steps will prevent a case of cadmium poisoning. Such steps are; get a medical examination to diagnose cadmium poisoning. This is usually done clinically by diagnosing the symptoms especially when cadmium exposure is already suspected (Weeks *et al.*, 1932). Provide gastric leverage or induce vomiting within one hour if cadmium salts have been ingested. Get away from the cadmium exposure immediately and administer oxygen. Chelating therapy is contradicted because it is generally toxic to kidney when combine with cadmium. Prevent future exposures to cadmium, stop smoking and check products in your home for cadmium containing compounds, especially fungicides. Store any nickel-cadmium out of reach of children. If you use a well, check the cadmium level in your water.

2.1.4 Nickel

Nickel is a hard silvery white transition metal with the symbol Ni, atomic number of 28 and atomic mass of 58. 71 g/mol, belongs to group 10, period 4 and the d block of the periodic table. It is the 24th element in order of natural abundance in the earth crust. It is of the iron group and it takes on a high polish (Weeks *et al.*, 1932). Nickel is widely distributed in nature forming about 0.008% of the earth crust. The core of the earth contains 8.5% nickel, deep-sea nodules 1.5%, meteorites have found to contain 5-50% nickel (International Agency for Research on Cancer, 1990). Natural sources of atmospheric nickel include dust from volcanic emissions and weathering of rocks and soils. Global input of nickel into the human environment is approximately 150,000 metric tons per year from natural sources and 180,000 metric tons per year from anthropogenic sources, including emissions from fossil fuel consumption and industrial production, use and disposal of nickel compounds and alloys (International Agency for Research on Cancer, 1990). Other sources of route of exposure to nickel include air, when air borne nickel is inhaled, ingested and absorbed through the skin thereby entering the respiratory tract. Also in drinking water, nickel may however be leached from nickel containing plumbing fittings and levels up to 500 mg/litre have been recorded in water left over night in such fittings (Andersen *et al.*, 1983). High concentration of nickel have been found in aquatic plants, cocoa and chocolate, soya beans, root and vegetables, oatmeal, almonds, bread and cereal food group, some legumes and various nut. Nickel was found to be higher in the organs of wild ruminants than those of domestic animals, because of the higher nickel content in their grazing area. Since 1970, nickel has been known to be essential for proper functioning of human, animal, organism and plants. Food has been found to be the main sources of nickel intake by man. Nickel is one of the trace mineral or micro nutrient in our body since it is present in very small amount in our body but it plays an important part in overall health of the human body and in bodily processes. Nickel is found to be beneficial being an important cofactor to various enzymes where it acts to accelerate the normal chemical reactions occurring in our body (Nielsen, 1991). This element has been shown to take part in reaction catalyzed by oxidoreductase and hydrolyses (e.g urease). Nickel is in RNA and DNA of our body where it functions in association with these nucleic acids. It probably has a role in stabilizing RNA structure. It is found to be helpful in normal bone functioning and health, cell membrane and lipid also. Also for plants, it is required for the enzyme urease to breakdown urea to liberate the nitrogen into a usable form for plants. Nickel is required for iron absorption; seeds need nickel in order to germinate. Plants grown without additional nickel will gradually reach a deficient level at about the time they mature and begin reproductive growth. If nickel is deficient in plants, plants may fail to produce viable seeds (Alloway, 1999). Nickel produces red blood cells in the human body.

Effect of nickel deficiency includes depressed growth, reproductive performance and plasma glucose. Nickel deficiency results in lower activities of different hydrogenases and transaminases and above all, of alpha-amylase and particularly affects carbohydrate metabolism. Nickel deficiency causes a significant triacylglycerol accumulation in liver with greater concentration of saturated fatty acids and polyunsaturated fatty acids than nickel adequate. Nickel deficiency also slightly compromised iron status, it has been suggested that at least some of the observed alterations are due to moderate iron deficiency (Stangl *et al.*, 1996). Nickel deficiency also affects distribution and proper functioning of other nutrients including calcium, iron, zinc and vitamin B12 (Nielsen, 1991).

This metal is not a cumulative poisoning in animals or in human (Barceloux, 1999). Human exposure to highly nickel polluted environment such as those associated with nickel refining, electroplating and welding has the potential to produce a variety of poisoning effects. Pathological alterations of nickel metabolism are recognized in several human diseases. Pathological alterations of nickel metabolism are recognized in several human diseases. The diverse clinical manifestations of nickel poisoning include; acute pneumonitis from inhalation of nickel carbonyl, chronic rhinitis and sinusitis from inhalation of nickel aerosols, cancer of nasal cavities and lungs in nickel workers, dermatitis and other hypersensitive reactions from cutaneous and parental exposure to nickel alloys (Sunderman, 1977). Almost all cases of acute nickel poisoning result from exposure to nickel carbonyl. The initial effects involve irritation of the respiratory tract and non-specific symptoms. Patients with severe poisoning develop intense pulmonary and gastrointestinal toxicity. The most common harmful effects of nickel in human is allergic reaction. Most cases of nickel allergy can be related to skin contact with nickel containing metallic items as buttons, suspender, ear ornaments. Soluble nickel appears to increase respiratory cancer risks at lower exposure concentration (>1 mgNi/m³ work-place dust) (Barceloux, 1999).

i) Nickel poisoning detection

Nickel poisoning can be detected in the saliva, urine, water etc. The following signs can help to detect nickel poisoning in the body (The Agency for Toxic substances and Disease Registry 2009). Know that nickel poisoning will occur if nickel carbonyl is inhaled, contaminated food or water taken or can be absorbed through the skin from contaminated soil, water or by handling coins. Watch for common symptoms like insomnia, frontal headaches, irritability, vertigo, nausea, vomiting, and difficulty in sleeping, pneumonia like chest pain, rapid heart rate, dry cough, sweating and weakness. Look for allergic reaction to nickel, although rare, manifest in a rash of little red bumps. Areas of the skin that encounter items such as belts or jewelry are generally affected. Get tested. A urine test can measure the level of nickel in body to determine the severity of acute nickel carbonyl poisoning.

ii) Nickel Poisoning Treatment

In case of outbreak of nickel poisoning, get out of the area immediately, remove any contaminated clothes and see a doctor immediately, make sure there is plenty of access to clean air or hospital may provide the oxygen (Lane *et al.*, 2005; Li *et al.*, 2001; Lasisi, 2018). Chelation therapy can also be administered whereby Doctor gives drug that will bond with the nickel, reduce its toxic level and move it out of the body through urine or faeces. The drug is usually combined with antibiotics to the body to keep its strength up. Recovering from nickel poisoning takes a long time, physical exercise can delay recovery and cause other complications as well, so a lot of rest is needed (The Agency for Toxic Substances and Disease Registry, 2009).

2.1.5 Zinc

Zinc is a chemical element with symbol Zn and atomic number 30. It is the first element in group 12 of the periodic table. In some respect zinc is chemically similar to magnesium both element exhibit only one normal oxidation state (+2), and the Zn²⁺ and Mg²⁺ ions are of similar size. Zinc is the 24th most abundant element in earth's crust and has five stable isotopes. The most common zinc ore is sphalerite, a zinc sulphide mineral. The largest workable lodes are in Australia, Asia, and the United states. Zinc is refined by froth flotation of the ore, roasting and final extraction using electricity (electro winning). During magmatic processes, Zn, like most other first-row transition metals, shows compatibility during early fractionation and thus becomes enriched in mafic relative to felsic rocks. The principal Zn carrier in mafic rocks is magnetite, while biotite is generally the most important in granite (Ure & Berrow 1982). Zinc makes up about 75ppm (0.0075) of earth's crust, making it the 24th most abundant element. Soil contains zinc in 5 – 770 ppm with an average 64ppm. Seawater has only 30ppb and the atmosphere, 0.1_4µg/m³. The element is normally found in association with other base metals such as copper and lead in ores. Zinc is a chalcophile meaning the element has a low affinity for oxides and prefers to bind with sulfides. Chalcophiles formed as the crust solidifies under the reducing conditions of the early earth's atmosphere. Sphalerite, which is a form of zinc sulfide, is the most heavily mined zinc containing ore because its concentrate contains 60 – 62% zinc (Mihaljevic 1999b). Other source minerals for zinc include smithsonite (zinc carbonate), hemimorphite (zinc silicate), wurtzite (another zinc sulfide), and sometimes hydrozincite (basic zinc carbonate). With the exception of wurtzite, all these other minerals were formed by weathering of the primordial zinc sulfides. Identified world zinc resources total about 1.9 – 2.8 billion tons. Large deposits are in Australia, Canada and the United States, with the largest reserves in Iran. The most recent estimate of reserve base for zinc (meets specified minimum physical criteria related to current mining and production practices) was made in 2009 and calculated to be roughly 480Mt (Kabata-Pendias, 2001).

Zinc reserves on the other hand, are geologically identified ore bodies whose suitability for recovery is economically base (location, grade, quality and quantity) at the time of determination. Since exploration and mine development is an ongoing process, the amount of zinc reserves is not a fixed number and sustainability of zinc ore supplies cannot be judged by simply extrapolating the combined mine life of today's zinc mines (Kaur & Gupta, 2009; Kleeman *et al.*, 2000). This concept is well supported by the United States

Geological Survey (USGS), which illustrates that although refined zinc production increased 80% between 1990 and 2010, the reserve lifetime for zinc has remained unchanged. About 346 million tons have been extracted throughout history to 2002, and scholars have estimated that about 109 – 305 million tons are in use (Kabata-Pendias, 2001). Zinc in rivers flowing through industrial and mining areas can be as high as 20ppm. Effective sewage treatment greatly reduces this: treatment along the Rhine for example has decreased zinc levels to 50ppb. Concentrations of zinc as low as 2ppm adversely affects the amount of oxygen that fish can carry in their blood. Soil contaminated with zinc from mining refining or fertilizing with zinc bearing sludge can contain several grams of zinc per kilogram of dry soil. Levels of zinc in excess of 500ppm in soil interfere with the ability of plants to absorb other essential metals such as iron and manganese (Hietanen *et al.*, 1982). Nearly two billion people in the developing world are deficient in zinc. In children, it causes an increase in infection and diarrhea and contributes to the death of about 800,000 children worldwide per year. The world health organization advocates zinc supplementation for severe malnutrition and diarrhea. Zinc supplements, help prevent disease and reduces mortality, especially among children with low birth weight or stunted growth. However, zinc supplements should not be administered alone because many in the developing world have several deficiencies and zinc interacts with other micro nutrients (Reddy *et al.*, 1987).

Ingestion of some forms of zinc leads to the creation of zinc toxic salts in the acidic environment of the stomach. Exposure typically stems from dietary indiscretion (Huang, 1993; Hutchinsinon & Meema, 1987). Household sources of zinc include paints, batteries, automotive parts, zinc oxide creams, vitamin and minerals supplement, zipper pulls, board game pieces, pet carrier screws and nuts and cookware. One of the well-known sources of zinc that causes toxicity after ingestion is the USA Lincoln penny (which contains 2,440 mg of elemental zinc per coin), (The Agency for Toxic Substances and Disease Registry, 2009). Signs of zinc poisoning include vomiting, diarrhea, cyanosis, tachycardia, rhales, restlessness, fever and albuminuria several hours following exposure. Other symptoms include nausea, vomiting, headache, light-headedness, dyspnea, hypertension, pulmonary edema dysrhythmias and convulsions. When death is rapid, abnormal findings may be restricted to pulmonary edema or/and cerebral edema. Other findings that maybe present especially in persons who survive longer include centrilobular necrosis of the liver, tubular necrosis of the kidneys, mucosal hemorrhage of the stomach and bloody pleural, peritoneal, or pericardial fluids (The Agency for Toxic Substances and Disease Registry, 2009). Patients with zinc poisoning may experience dehydration and low blood pressure, requiring treatment with intravenous fluids. Zinc can prevent the absorption of copper and iron and may deplete magnesium stores, so patients may require iron and electrolyte replacement (The Agency for Toxic Substances and Disease Registry, 2009). Any zinc remaining in the stomach may be eliminated using gastric lavage, in which a tube is inserted down the throat or a nasal passageway into the stomach. Fluids are then introduced through the tube and the stomach contents are suctioned. Solid objects may be allowed to pass normally or removed with polyethylene glycol bowel irrigation or endoscopy. Stomach acids usually dissolve zinc objects converting them into corrosive zinc chloride. This compound could cause ulcers in the stomach, which may require treatment with H₂ antagonist or other anti-ulcer medications (The Agency for Toxic Substances and Disease Registry, 2009).

2.1.6 Copper

Copper, an important trace metal, acts as a cofactor for a variety of proteins and enzymes required for maturation of cytoplasmic cuproproteins and assembly of enzymes in different cell organelles (ceruloplasmin and tyrosinase in case of Golgi apparatus and cytochrome c oxidase with respect to mitochondria). Copper uptake occurs in a tightly regulated process through specific high-affinity plasma membrane copper transporters or low-affinity permeases (De Feo *et al.*, 2007). Binding to chaperone proteins results in the transfer of copper to its final destination or any intermediate location from which its transport to other cell compartments or efflux out of cells can occur in cases in which concentration exceeds then optimum level. Acting as a cofactor for a wide range of metal-binding enzymes, it fluctuates between the oxidized Cu (II) and reduced Cu (I) forms. In humans, its average intake ranges between 260 and 700 μ g/day (Letavayova *et al.*, 2007). Although adequate intake of copper provides protection against lead, higher intake has been associated with increased lead absorption (Millier *et al.*, 1990).

Copper and its compounds are naturally present in the earth's crust. Natural discharges to air and water, such as windblown dust, volcanic eruptions, etc., may be significant (Eze & Madumere, 2012; Friberg, 1997; Gari, 2002). Therefore, it is important to consider the copper concentrations within a specific environment, geographical region, or human population study site that has been minimally affected by anthropogenic sources of copper in order to accurately assess the contribution of an anthropogenic activity to human exposures to copper. In air, the mean copper concentrations in the atmosphere range between 5 and 200 ng/m³ in rural and urban locations. Airborne copper is associated with particulates that are obtained from suspended soils, combustion sources, the manufacture or processing of copper-containing materials, or mine tailings. The median concentration of copper in natural water (e.g., rivers, lakes, and oceans) is 4–10 ppb. It is predominantly in the Cu (II) state. Most of it is complexed or tightly bound to organic matter. Little is present in the free (hydrated) or readily exchangeable form. The combined processes of complexation, adsorption, and precipitation control the level of free Cu(II). The chemical conditions in most natural water are such that, even at relatively high copper concentrations, these processes will reduce the free Cu(II) concentration to extremely low values. The mean concentration of copper in soil ranges from 5 to 70 mg/kg and is higher in soils near smelters, mining operations, and combustion sources. Sediment is an important sink and reservoir for copper. In relatively clean sediment such as those found in some of the bays and estuaries along the New England Coast, the copper concentration is <50 ppm; polluted sediment may contain several thousand ppm of copper. The form of copper in the sediment also will be site specific. In aerobic sediments, copper is bound mainly to organics (humic substances) and iron oxides. However, in some cases, copper is predominantly associated with carbonates. In

anaerobic sediments, Cu(II) will be reduced to Cu(I) and insoluble cuprous salts will be formed ((Zlotkin *et al.*, 1995; Lönnnerdal, 1996, 1997).

Diminished adrenal activity is perhaps the single most important physiological reason for copper problems today. The reason is that adrenal activity is required to stimulate production of ceruloplasmin, the primary copper-binding protein. When adrenal activity is insufficient, ceruloplasmin synthesis in the liver declines. Copper that is not bound cannot be used and unbound copper begins to accumulate in various tissues and organs. According to hair analysis research, 70–80 percent of people tested show weak adrenal glands! Estimates of copper intake from inhalation and ingestion in children in the United States are limited. From the work of Pennington *et al.* (1986), the copper intakes for a 6–11-month-old infant and a 2-year-old child were estimated to be 0.47 and 0.58 mg/day, values which are lower than the adult intake of ~1 mg/day. However, one study has provided estimated inhalation and ingestion exposures of copper for children in India (Raghunath *et al.*, 1997). Copper is essential for good health. However, exposure to higher doses can be harmful. Long term exposure to copper dust can irritate your nose, mouth, and eyes, and cause headaches, dizziness, nausea, and diarrhea. If you drink water that contains higher than normal levels of copper, you may experience nausea, vomiting, stomach cramps, or diarrhea. Intentionally high intakes of copper can cause liver and kidney damage and even death. We do not know if copper can cause cancer in humans. EPA does not classify copper as a human carcinogen because there are no adequate human or animal cancer studies. Chronic copper poisoning appears as an acute hemolytic crisis with death occurring within 24 to 48 hours. There is lack of appetite and weakness, mucous membrane and white skin are yellowish brown and hemoglobin in urine is a dark – red brown color (Raghunath *et al.*, 1997). Source should be identified and removed immediately, avoidance of stressful conditions, and treatment is based on inactivation of copper with molybdate and sulfate (Raghunath *et al.*, 1997).

3.0 Methodology

The study adopts an extensive review of literature such as conference papers, journal articles, internet sources, books to find out the determination of heavy metals concentration in water as determined by past authors with the help of standard literature procedures in their research work. The methods consist of Atomic Absorption Spectroscopy by Radulescu *et al.* (2014). The concentrations of resulting heavy metals were compared with the national and International organizations (WHO-2008, USEPA, EPA, EUC). The effects of heavy metals found more/less than the maximum admissible limits were noted. Thus the aim of this study is to review the research work done by previous authors on heavy metals in water, detection, poisoning, damages to human health and treatments all of which were noted.

4.0 Conclusion of the Study

From the literature review of existing studies, the quantities of heavy metals found in their research were stated with their maximum admissible limit. The resulting trace elements resulting with their concentration in drinking water were compared with several International Organizations such as WHO, USEPA, EPA etc. The Heavy metals in water samples resulted in respective authors were Pb, Cd, Cu, Zn, Cr, Ni, with their respective concentrations in their work. Heavy metals in water are related with chronic disease. The authors also listed their adverse effects on the human health, treatments and prevention. Figure 1 below is a table of some of the researches on heavy metals in water carried out in this review of the literatures of previous researches. However, on account of the research of authors, the portable water samples contain heavy metal concentration more than the admissible and desirable levels (WHO, EUC, EPA, USEPA). Most of the water samples were at populace level, which are not possible for portable purposes. The authors in their paper concluded from their work that the water samples needed constant monitoring of various water sources as the results showed levels of pollution which shows a major proportion of the populace are at a significant risk given the toxicity of these metals. There is a need that the portable water of areas should be filtered by the quality control agencies. The water can only be used for domestic purposes after it has passed through special water treatment as the water could be used for drinking and cooking as well. People may suffer through disease on drinking water with higher concentration of heavy metals. They may have physiological effects as on kidney, digestive system, circulatory system, nervous system etc. various other organs and various systems of the body.

Sr. No.	As µg/L	Cd mg/L	Cr mg/L	Cu mg/L	Fe	Pb mg/L	Co	Mn mg/L	Hg** Nd	Ni mg/L	Zn mg/L	WHO maximum permissible (mg/L) limit 2008.	Papers by various authors (Research work on heavy metals in water)
1	-	0.010 - 0.100	-	0.020 - 0.120	-	0.020 - 0.215		-	-	-	-	Ar=0.05 Cd=0.005	Ehi-Eromosele C.o et al.(2012)

2		0.00	0.00-0.02	0.00 - 0.01	-	0.00 - 0.03			-	0.00 - 0.10	0.00 - 0.16	Cr = 0.05 Cu = 0.05 Fe = 0.3 Pb=0.05	Javid Hussain et al.(2012)
3	320 - 1060	14µg/L - 21µg/L	92µg/L - 158 µg/L	-	97 µg/L - 1872 µg/L	5 µg/L - 1347 µg/L	6 µg/L - 36 µg/L	21 µg/L - 215 µg/L	-	31 µg/L - 459 µg/L	45 µg/L - 5055 µg/L	Mn=0.1 Hg=0.01 Ni = -	Gebrekidan M and Samuel Z (MEJS)(2011)
4		51.4 ppb - 0.02 ppb	150.86 ppb- 3.22 ppb	69 ppb - 8ppb	8295 ppb - 815 ppb	36.71 ppb - 3.18 ppb	-	365 ppb - 1.97 ppb			1578.5 ppb - 19.3 ppb	Zn = 5.0	N.H-Zarel et al.(2003-2007)

Figure 1: Literature Review on Heavy Metals in Water and Soil Content

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