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An Overview of Heavy Metal Contamination of Water and Its Effect on Human Health

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Abstract
Heavy metals are naturally occurring elements that have a high atomic weight and a density at least five times greater than that of water. The continuous industrial activities that generate metals have led to their wide distribution in the environment which raised a concern over the effects of such metals on human health and the environment itself. These metals are of great concern as some of them were found to be toxic and persistent even at low concentration. Industrial activities that includes; tannery, textile and other industries use chemicals must of which contains certain amount of heavy metals, discharges their untreated effluents into the nearest water bodies and lead to modification and increase in the background concentration of the metals (including those naturally in the water body). The aim of this review is to assess the contamination of water bodies by heavy metals as a result of industrial discharge of untreated waste into the water and also the health effect related to heavy metals on the human populace. Available information on current publications from scientific journals and other relevant sources were carefully used for this review. Some of the reviewed literatures indicated that must heavy metals are found to be toxic depending on their concentrations and persistent nature. Other factors that affect the toxicity of metals include; their biological role, pH of the medium, and the organisms in question (Human). Upon all the heavy metals present in the environment, Pb, Zn, Cd, Mn, and Co were given more attention in terms of water pollution. Many of these metals undergo methylation as a result of accumulation where bacteria absorb the metals and convert them into a toxic organometallic compounds. As these metals become incorporated with organic components, they tend to be readily available for uptake into the food chain. These heavy metals become toxic in the living system when they are not metabolized by the body and leads to accumulation in the soft tissue. It was observed that this toxic effect can result into damaged or reduced mental and central nervous system function, lower energy levels and damage to blood composition, lungs, kidney, liver, and other vital or essential organs in human beings and other mammals. Prolonged exposure may result in retard progressing physical, muscular, and neurological degenerative processes, allergies and to some extent continuous exposure may lead to cancer. Metal contamination of water pose a serious risk of exposure to both plants and animals including humans. Therefore, continuous use of such contaminated water for both agricultural and domestic purposes may affect the populace either at short or long term.
Key words: *Accumulation, Effluents, Exposure, Heavy metals, and Toxic.*

INTRODUCTION

Water is a universal solvent and take part in almost all life activities as it is required for survival. As a result of industrialization, water bodies become polluted and contaminated due to discharge of untreated waste and effluent into the water bodies. Most industrial activities requires water in one way or the other for processing of materials, cooling, and cleaning and at the end discharge such water into the environment without treatment. Industries that includes; tannery, textile, and other industries uses chemicals most of which contain certain amount of heavy metals at a concentration that is detrimental to the environment. Insufficient environmental monitoring often result in discharging industrial waste and effluent into water bodies which lead gradual contamination (Bernerd and Ogunleye, 2015). As a result of this untreated industrial waste, many harmful chemicals (toxic heavy metals) and other substances gets into the water bodies and affect the aquatic life directly or be taken by plants or animals and eventually gets into human body through food.

Studies reported that, continuous release of effluent and waste into the water bodies pose a negative effect on both the quality of the water and the aquatic life (Udosen, 2006, Dan azumi and Bichi, 2010). Utilization of natural resources in unsustainable way in both developed and developing countries have led to degradation of the environment, pollution of different kind, incurable diseases, poverty, and social conflict (Osibanjo 2009).

Heavy metals are naturally occurring elements that have high atomic weight and a density at least five times greater than that of water and are classified as toxic elements as a result of their persistent nature and ability to accumulate in a living system/tissue. They are major pollutants in the water bodies as a result of industrial and municipal discharges of waste and effluents into the environment (Bichi and Bello, 2013).

It was observed that rapid increase in population (population explosion) merged with other factors like; industrialization, urbanization, mining, and agriculture led to vast accumulation of waste and contaminants that end up in the water bodies thereby affecting the aquatic environment (Dike *et al*, 2004). According to Ferner (2001), toxicity of metals represent an uncommon, yet clinically significant health condition. These heavy metals are harmful and detrimental to plants, animals, and the environment at large as they stay long in the environment and are persistent in nature.

However, not all the heavy metals are toxic at low concentration, some are essential to the body and are required at some concentration like zinc and copper. Although, at high concentrations are toxic and detrimental to the body(Hogan, 2010). Other metals are toxic even at low concentration and are not required by the body as they cause harm even at minor concentrations like Arsenic and mercury that are regarded as systemic toxicants (Arif, et al., 2015). As a result of these, this review aimed to assess the heavy metal contamination of water bodies as a result of industrial discharge of untreated waste and effluent into the water bodies and human health effect related to heavy metal toxicity.

Industrial pollution of water

Discharge of effluents from industries around the world serves as the main source of pollutants of water ecosystem which has a long term effect on the functioning of the community of both living and nonliving parts of the water environment (Smolders *et al.,* 2004). Grover and Kaur, (1999) reported that pollution of all kinds lower the quality of life, health and life span. Industries around the world have improper methods of waste treatment and discharge. Studies have shown that industrial effluents have hazardous effect on the quality of water and also affect the safety of habitats in the water environment (Ethan *et al*., 2003). Amuda (2006) reported that industries differ from one another in terms of technology, size, products use, and complexity of waste discharged. World Health Organization (1982) reported that most industries produces detrimental waste that causes pollution of different kind. According to Ahmed *et al*., (1993), the quality of dissolved minerals in water depends upon the sources of water and its path before use. The effluents discharged by the industries gets into the water through channels and tributaries as the water moves from one particular location to another carrying the metal ions.

Pollution of water as a result of discharge of untreated waste industrial effluent into the bodies of water has a detrimental effect on the water and it is of a global concern (Mathuthu, *et al*., 1997). Most industrial activities are water dependent and as such, released large volume of effluents into the water bodies most of which are not treated. This leads to pollution or contamination of both surface and ground water (Sarker *et al*., 2013).

People in developing countries like Nigeria depends mostly on groundwater for domestic and agricultural purposes. The quality of groundwater is at risk as a result of increase released of effluents and waste from industries which may find its way into the underground reservoir through the pore spaces on the soil and contaminate the groundwater. Malarkodi, *et al*., (2007) reported that groundwater resources are experiencing continuous threat of pollution coming from industrial discharge of effluent that contain high amount of heavy metals and other pollutants which are toxic, mutagenic, carcinogenic, and teratogenic especially; chromium, arsenic, copper, and cadmium. Most industrial waste released on land or in water finds their way into the groundwater (aquifer) and affects its quality which is very difficult to remediate as recharging is very slow.

Toxicity of Heavy Metals

Heavy metals are members of a loosely defined subset of elements that exhibit metallic properties. It mainly includes the transition metals, some metalloids, lanthanides, and actinide. Heavy metals are elements with a specific gravity at least 5 times that of water. The specific gravity of water is 1 at 4°C (39°F). Specific gravity is a measure of density of a given amount of a solid substance when it is compared to an equal amount of water. Some well-known toxic metals with a specific gravity 5 or more times that of water are arsenic (5.7), cadmium (8.65), iron (7.9), lead (11.34), and mercury (13.546) (Lide, 1992). Heavy metals occur naturally in the ecosystem with large variations in concentration and are metallic elements. They are toxic and have high density, specific gravity or atomic weight. They have a potential negative health effect or environmental impact (Mohsen and Salisu, 2008).

There are over 50 elements that can be classified as heavy metals, but only 17 that are considered to be both very toxic and relatively accessible. Lead, zinc, cadmium, magnesium and cobalt should be given particular attention, in terms of water pollution.

Toxicity of heavy metals depend on the type of metal, its biological role, and types of organism that are exposed to it, toxic metals are often added to the streams as salt (sulfides, phosphate and carbonates), are very insoluble in hard water and usually travel with sediment. The transformation into readily accessible materials is a complex process and depends on many factors such as pH, sediment presence and hardness. The availability of these metals is determined by precipitation-dissolution reactions which are strongly affected by pH. Therefore at lower pH, heavy metals are more available and more reactive. Many of these metals then undergo Methylation, as a result of bioaccumulation where bacteria absorb these elements and convert them from a metallic state into a toxic organ metallic state. By becoming incorporated with an organic component, these metals become readily available to the first tropic level of the food chain and eventually lead to biological magnification throughout the system (Laura and Susan, 2009).

Toxic heavy metals

Heavy metals become toxic when they are not metabolized by the body and accumulate in the soft tissues. Heavy metals may enter the human body via food, water, air, or absorption through the skin in agriculture, manufacturing, pharmaceutical, industrial, or residential settings. Industrial exposure is common in adults. Ingestion is the most common route in children (Roberts, 1999). Children may develop toxic levels from normal hand-to-mouth activity (i.e. coming in contact with contaminated soil or eating objects that are not food such as dirt or paint chips) (Dupler, 2001). Less common sources of exposure to heavy metals include; radiological procedure, inappropriate dosing or monitoring during intravenous (parenteral) nutrition, a broken thermometer or a suicide or homicide.

The Agency for Toxic Substances and Disease Registry (ATSDR) in Atlanta, Georgia (a part of the U.S. Department of Health and Human Services) was established by congressional mandate to perform specific functions concerning adverse human health effects diminished quality of life associated with exposure to hazardous substances. The ATSDR is responsible for assessment of waste sites and providing health information concerning hazardous substances, response to emergency release situations, and education and training concerning hazardous substances (ATSDR Mission Statement, 2001). In cooperation with the U.S. Environmental Protection Agency, the ATSDR has compiled a Priority List for 2001 called the "Top 20 Hazardous Substances." The heavy metals arsenic (1), lead (2), mercury (3), and cadmium (7) appeared on the list.

Exposure to Heavy Metals

Exposure to heavy metals depend on the nature of the metal and its form. Most people come in contact with metal through occupational exposure but others sources includes through drinking water (contaminated water), contaminated food (food grown on metal contaminated environment that is capable of absorbing and accumulating metal in its tissue) air polluted by heavy metals (combustion of fuel containing Pb and other associated metals), and eating contaminated soil (mostly by children) (Duruibe, et al., 2007).

Heavy metal pollution of surface and underground water sources results in considerable soil pollution and pollution increases when mined ores are dumped on the ground surface for manual dressing (INECAR, 2000). When plants are grown on contaminated soil and with contaminated water, they tend to absorb and accumulate the metals in their tissue which can later on be taken by man (Trueby, 2003).

Effects of Heavy Metals on Human Health

Small amounts of heavy metals are needed in our environment and diet and are actually necessary for good health, but large amount of any of them may cause acute or chronic toxicity (poisoning). These essential metals include; copper, cobalt, and nickel (Hogan, 2010). Heavy metal toxicity can result in damaged or reduced mental and central nervous function, lower energy levels and damage to blood composition, lungs, kidneys, liver, and other vital organs (Arif, et al., 2015). Long term exposure may result in slowly progressing physical, muscular, and neurological degenerative processes, allergies are not uncommon, and repeated long-term contact with some metals (or their compounds) may cause cancer (WHO, 2006). For some heavy metals, toxic levels can be just above the background concentrations naturally found in nature like cadmium, Lead, and mercury. Therefore, it is important to learn about heavy metals and take protective measures against excessive exposure.

The association of symptoms indicative of acute toxicity is not difficult to recognize because they are usually severe, occur very fast, and associated with a known ingestion or exposure. Symptoms include: cramping, nausea and vomiting; pain; sweating; headache difficulty in breathing impaired cognitive motor, and language skills, mania and convulsions symptoms of chronic exposure (impaired cognitive and language skills, learning difficulties; nervousness and emotional instability; and insomnia, nausea, lethargy, and feeling ill) are also usually recognized; however, they are much more difficult to associate with their cause (Jarup, 2003). Acute exposure manifest rapidly and can easily be notice as the time of exposure and manifestation are closed. However, chronic exposure takes longer time to manifest and as such, it is difficult to understand. Symptoms resulting from chronic exposure are very similar to symptoms of other health conditions and often develop slowly over months or even years. Sometimes, symptoms of chronic exposure subside; thinking the symptoms are related to something else people postpone seeking treatment. (Khillare *et al.*, 2004).

Toxicity of metals ions to man is as a result of chemical reactivity of the ions with cellular structural proteins, enzymes, and membrane system (Arif, et al., 2015). The target organs to specific metal toxicity are those that accumulate the highest amount of the metal in-vivo. This depends on the route of exposure and chemical compound of the metal (valiancy state, volatility, and lipid solubility) (Manjur, 2015). Heavy metals have been shown to cause short term acute as well as long term chronic poisoning in human and other animals.

Table 1: Clinical Effects of Chronic Toxicities in Humans of selected Heavy Metals (Table adapted from Manjur, 2015)

Metal	Target Organs	Primary Sources	Clinical effects
Arsenic	Pulmonary Nervous System, Skin	Industrial Dusts, Medicinal Uses Of Polluted Water	Perforation of Nasal Septum, Respiratory Cancer, Peripheral Neuropathy: Dermatomes, Skin, Cancer
Cadmium	Renal, Skeletal Pulmonary	Industrial Dust And Fumes And Polluted Water And Food	Proteinuria, Glucosuria, Osteomalacia, Aminoaciduria, Emphysemia
Chromium	Pulmonary	Industrial Dust And Fumes And Polluted Food	Ulcer, Perforation of Nasal Septum, Respiratory Cancer
Manganese	Nervous System	Industrial Dust And Fumes	Central And Peripheral Neuropathies
Lead	Nervous System, Hematopoietic System, Renal	Industrial Dust And Fumes And Polluted Food	Encephalopathy, Peripheral Neuropathy, Central Nervous Disorders, Anemia.
Nickel	Pulmonary, Skin	Industrial Dust, Aerosols	Cancer, Dramatis
Tin	Nervous , Pulmonary System	Medicinal Uses, Industrial Dusts	Central Nervous System Disorders, Visual Defects And EEG Changes, Pneumoconiosis.
Mercury	Nervous System, Renal	Industrial Dust And Fumes And Polluted Water And Food	Proteinuria

From the Table 1, it can be observed that most of the metals pose a significant health issue as a result of exposure to contaminated substances or dust from industrial activities.

CONCLUSION

Conclusively, heavy metals are harmful, toxic, and detrimental to health and the environment as they are persistent and have the ability to accumulate in a living system and the environment. Also, there exist a direct relation between heavy metal toxicity and human health effect. Heavy metals takes part in body biochemistry, replacing essential elements in the body there by affecting the enzymes activities. Continuous contamination of water by man as a result of industrial, agricultural, and domestic activities pose a significant risk to man and the environment. Children are at more risk to the effect of metal toxicity as they are prone to ingest even contaminated soil. Measures need to be taken to abate the activities that leads to the contamination of water all over the world, as water plays a major role in survival. Remediation methods need to be taken into account to clean already polluted environment (bioremediation).

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