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EVALUATION OF THE SAFE FACTOR INDICES OF SOME HEAVY METALS IN THE SOILS OF SAND FILTER BED OF DUTSIN-MA WATER TREATMENT PLANT

YARGAMJI, G.I. & ABUBAKAR, T.

Department of Chemistry, Isa Kaita College of Education, Dutsin-ma, Katsina State, Nigeria

ABSTRACT

The safe factor indices and percentage variations of ten heavy metals were evaluated based on their levels in the sand filter bed of the Dutsin-ma water treatment plant. The heavy metal levels were determined using standard laboratory procedure and high Tech. AAS machine. The results obtained revealed that the safe factor indices for the heavy metals were Cd(1.19), Cr(0.45). Co(2.26), Cu(12.50), Fe(3.84), Pb(5.31), Mn(3.92), Hg(1.04), Ni(4.00) and Zn(0.38) with only Cr and Zn having values that were within good safety limit (Ai < 1), all other metals had values that exceeded the approved safety limits. Copper, Lead, Nickel, Manganese and Iron were observed to have Azuka index (Ai) values that were extra ordinarily far above the

Introduction

The incidences of heavy metal contamination of soil, water and air from both geogenic (natural) and anthropogenic (artificial) sources has been an issue of global concern due to the health effects of their chronic levels as a result of human exposures to the heavy metals, particularly for people living in urban areas. This category of people are more likely to be threatened by problem due to high levels of industrial, urbanization and domestic activities taking place in urban areas. Some of the common heavy metals that pollute the air, water and soil environments include lead (Pb), cadmium (Cd), mercury (Hg), arsenic (As), chromium (Cr), copper (Cu), selenium (Se), nickel (Ni), silver (Ag), and zinc (Zn). Other less common metallic contaminants include aluminium (Al), cesium (Cs), cobalt (Co), manganese (Mn), molybdenum (Mo), strontium (Sr), and uranium (U) (Mcintyre, 2003). Natural and anthropogenic sources of soil and water contamination are widely spread and variable (Tahir et al, 2007). Heavy metals occur naturally in soils and rocks. However, most of their occurrences in urban soils and waters tends to originate from anthropogenic sources such as the release of industrial effluents (both solids and liquids), urbanization activities, and discharge of domestic wastes (solids and liquids) as well as transportation activities (Charlesworth et al, 2003, Strivastava et al, 2007). Many growing communities in the developing countries are vulnerable to air pollution resulting from widespread application of heavy metals containing aerosols which normally get deposited on soil surface and percolate into the soil alongside rain water where they get absorbed by plant roots or sometimes get deposited on plant leaves and penetrate into the leaves via the stomatal openings (Duruibe *et al*., 2007). The absorption of heavy metals by the plants from the soil depends on several factors, ranging from application of agrochemicals, solubility of the heavy metals, soil pH, soil type, to plant species (Young, 2005; Gupta *et al*., 2013). Other sources of heavy metals pollution in the environment includes, industrial effluents, mine tailings, application of fertilizers, atmospheric deposition and leaching of metal ions from the soil into lakes and rivers by acid rain (Chauhan & Chauhan, 2014; Sharma *et al*., 2008; Singh *et al*., 2010). Environmental pollution is very prominent in point source areas of soil like mining, foundries and smelters,

safety limit of their presence in the filter bed. For the percentage variations, the values obtained indicated that all the metal levels varied widely except for Ni (17.65%), Cd (20.00%) and Mn (27.42%). All others had %variations exceeding 50 percent each. Based on these results, it was concluded that there were high level heavy metals pollution activities emanating from natural geologic factors and from anthropogenic activities around the water sources that supplies the treatment plant. The high values for some of the metals calls for immediate heavy metal remediation especially in the filter bed and at the water reservoir to mitigate the heavy metal pollution of the water.

Key words: Heavy metals, safe factor index, Pollution, %Variation, Sand filter, Water Treatment Plant.

and other metal-based industrial operations (Goyer, 1997; Singh *et al*., 2010; Chauhan & Chauhan, 2014). The most common heavy metals found at contaminated sites, in order of abundance are Pb, Cr, As, Zn, Cd, Cu, and Hg (Gupta *et al*., 2013). Prolonged exposure to heavy metals such as cadmium, copper, lead, nickel, and zinc can lead to deleterious health effects in humans. Excessive levels of heavy metals in the body can be damaging to the organism.

Results obtained in many studies have suggested that, there is a possibility that, contaminated soil, water or dust, ingested either directly or indirectly as a result of hand to mouth activity, may represent a significant way of transferring toxic metals to humans, with children being the main sector of the population at highest risk (Lee et al, 2006, Yang et al, 2006, Kamarnicki, 2005). Children, especially toddlers, can easily ingest soil or indoor dusts unintentionally by either putting contaminated toys in their mouths or by picking up foods with dirty hands etc, thus making them susceptible to toxic metals poisoning. Furthermore, adults can also be exposed to similar threat through direct inhalation being the most common pathway by which toxic metals enter into our body.

Among all other natural resources, water is internationally regarded as the most fundamental and indispensable (Ashto and Seetal, 2002). Interest in water analysis is due to the enormous importance of water to all categories of living organisms. Water is necessary for healthy growth and development of man, animals and plants (Abulude et al, 2007). It plays an important role in the body intake of elements by humans. Both surface and underground waters, such as river water, sea water, pond water, well water, borehole water etc. are used directly for drinking or for agricultural purposes. Adequate and safe water supply is therefore a pre-requisite for significant socio-economic development of any community. Water quality is a term used to describe the physical, chemical and biological parameters of water and which affects its standard for specific usage (Diersing & Nancy 2009). Heavy metals levels in water is one of the important chemical parameters which must be monitored due to their toxicities. They enter into water supply through industrial and consumer wastes, or even from acidic rain that break down soils and release heavy metals into streams, rivers lakes and ground waters. The levels of these heavy metals in sediments and water may be traced to the bedrock from which the sediments were derived and/or through which the water flows (Ergin et al, 1991, Mantie et al, 1989). The knowledge of the current heavy metal levels in the soil of the sand filter bed of Dutsin-ma water treatment plant is important as it will guide academics and government to make rightful decisions and proffer adequate mitigating measures to protect the people of Dutsim-ma communities from being poisoned by heavy metals. There is therefore the ardent need to assess the levels of heavy metals in the sand filter bed so as to monitor its impact on the soil, plant and human health.

Heavy Metals Toxicities

Heavy metals are toxic to the environment, soil, air and water and invariably to plants, animals and humans. Their toxicities in each of these cases are discussed in the following sub-sections:

Toxic Effects of Heavy Metals on Soil

In the industrialized world especially, soil contamination by heavy metals is an important issue of concern (Hinojosa, et.al., 2004). The pollution of heavy metals causes not only in devastating effects on various plant quality and yield parameters but also causes serious changes in the size, composition and activity of the microbes in the soil (Yao, et.al., 2003). Heavy metals are therefore considered as one of the major soil contaminants. The negative consequences caused by heavy metals on soil biological and biochemical factors are well documented. The properties of soil such as organic matter, clay contents and pH greatly influences the extent to which metals affect biological and biochemical properties of soil (Speira, et.al., 1999). They indirectly affect then enzymatic activities of soil enzymatic by shifting the microbial community that synthesizes the (Chen, et.al., 2010) suggested that heavy metals causes decrease in the richness of bacterial species in the soil and relatively increase soil actinomycetes or even cause a decrease in both the biomass and diversity of the bacterial populations in contaminated soils. In the same vein, Karaca et al (Karaca, et.al., 2010) reported that the enzymatic activities in soils are influenced in different ways by different metals due to the different chemical affinities of the enzymes in the soil. (Ashraf and Ali, 2007) also reported that heavy metals pose toxic effects on soil microorganism which results in the change of the diversity, population size and overall microbial activity of the soil microbial communities. They also observed that Cr, Zn and Cd pollution influenced the metabolic processes of soil microbes in all cases. Generally, an increase in heavy metal concentration adversely affects soil microbial properties such as respiration rate, enzyme activity, which are very useful indicators of soil pollutions. However, in the case of soil contaminated with lead (Pb), slight variation was observed in the soil microbial profile.

Toxicity of Heavy Metals on Plants

Some heavy metals like As, Cd, Hg, Pb or Se are not essential for plants growth, as they do not perform any known physiological function in plants. However, others such as Co, Cu, Fe, Mn, Mo, Ni and Zn are essential and are thererfore required for normal growth and metabolism of plants, but they can easily cause poisoning when their concentrations are above the optimal values (Garrido, et.al., 2002; Rascio and izzo, 2011). Composts wastes are sometimes used to improve agricultural yield without regard to the possible negative effects. But considering the edible parts of the plants in most vegetable species, there is that risk of transferring the heavy metals from soil to humans and that is a matter of concern (Jardao, et.al., 2006). The uptake of heavy metals by plants and their subsequent accumulation along the food chain causes serious threat to animal and human health (Sprynskyy, et.al., 2007). The absorption metals by plant roots is one of the main routes through which heavy metals enter into the food chain (Jardao, et.al., 2007). This absorption and accumulation of heavy metals into plant tissues depend on many factors including temperature, moisture, organic matter, pH and nutrient availability in the soil. It also depends on the type of plant species and the efficiency of different plants in metals absorption is evaluated by either plant uptake or by soil to plant transfer factors of the metals (Khan, et.al., 2008). Heavy metals are potentially toxic to plants and phytotoxicity for plants causes issues such as chlorosis, weak plant growth, yield reduction, and may sometimes be accompanied by reduced nutrient uptake, disorders of plant metabolism and lower plants ability to fix molecular nitrogen in leguminous plants (Guala, et.al.,2010). High Pb concentration can cause a gradual delay in seed germination may be as a result of prolonged incubation of the seeds due to attempts to neutralize the toxic effects of lead by some other mechanisms e. g. leaching, chelation, metal binding and/or accumulation by soil microorganisms (Ashraf and Ali, 2007).

Toxic Effects of Heavy Metals on Aquatic Environment

Heavy metals are not subject to bacterial degradation and therefore remain permanently in the marine environment (Woo, et.al., 2009). Thus, they are highly persistent, toxic in trace amounts, and are potentially capable of inducing severe oxidative stress in aquatic organisms. Moreover, water contamination with heavy metals can cause devastating effects on the ecological balance of aquatic environment, resulting in the diversity of aquatic organisms becoming limited with increasing contamination (Ayandiran, et.al,, 2009). Heavy metals in aquatic environment are generally bound to particulate matter, which eventually settle down and become incorporated into sediments. Surface sediment therefore serve as the most important reservoir or sink of metals and other contaminants in aquatic environments. Because significant fraction of the trace metals in aquatic environment is associated with the bottom sediments, environmental degradation by metals can occur even in areas where water quality criteria are not exceeded, yet organisms in or near the sediments are adversely affected (Guirriera, 1998). Once heavy metals are accumulated in an aquatic organism, they can be transferred through the upper classes of the food chain. Carnivores at the top of the food Chain including humans, gets most of their heavy metal burden from the aquatic ecosystem through their food, especially where fishes are present, there exist that potential for considerable biomagnifications (Ayandiran, et.al., 2009). Contaminants in aquatic systems, including heavy metals, stimulate the production of reactive oxygen species (ROS) that can cause damage to fishes and other aquatic organisms (Woo, et.al., 2006). Fish being a commodity of potential public health concern can be contaminated with a range of environmentally persistent chsemicals, heavy metals being major culprits. Consumption of fishes containing high levels of heavy metals is a matter of concern because chronic exposure to heavy metals can cause serious health problems (Soliman, 2006). Mercury (Hg) happens to be one of the most important water pollutants due to its effect on marine organisms and its' being potentially hazardous to humans. Methylmercury, an organo-mercury compound formed in aquatic sediments by the bacterial methylation of organic mercury, is a very toxic chemical compound. In fact, nearly all of the mercury in fish muscles occurs as Methylmercury (Soliman, 2006). Transport of metals in fishes occurs through the blood where the metal ions are usually bound to proteins. There are five potential routes for a pollutant to get into a fish including through the food particles, non-food particles, gills, by oral consumption of water and through the skin. If the pollutants are converted into some other products by the liver, they may be stored there or excreted in the bile or passed back into the blood streams for possible excretion by the gills or kidneys, or stored in fat, an extra hepatic tissue (Ayandiran, et.al., 2009).

Toxicity of Heavy Metals on Human Health

The absorption of heavy metals by plants from soils at high concentrations may bring about a great health risk due to food-chain implications. The consumption of food crops contaminated with heavy metals is a route for human exposure via the food-chain. The cultivation of such crops in contaminated soil represents a serious potential risk since their vegetal tissues are capable of accumulating large amounts of heavy metals (Jardao, et.al., 2006). The heavy metals become toxic particularly when they are not metabolized by the body and get accumulated in the soft tissues (Sobha, et.al., 2007). Chronic levels of ingested toxic metals pose undesirable impacts on humans and the associated harmful impacts becomes prominent only after a very long time (several years) of exposure (Khan, et.al., 2008).

The toxicities of some of the common heavy metals are as follows:

Cadmium (Cd) is a well-known toxic heavy metal whose specific gravity is 8.65 times greater than that of water. The target organs for Cd toxicity are the liver, placenta, kidneys, lungs, brain and bones (Sobha, et.al., 2007). Depending on the severity of exposure to cadmium, the symptoms of its toxicity include abdominal cramps, dyspnea, nausea, vomiting, and muscular weakness. However, severe exposure may cause pulmonary odema and death. Pulmonary effects such as emphysema, bronchiolitis and alveolitis and renal effects occurs following subchronic inhalation exposure to cadmium metal and/or its compounds (Duruibe, et.al., 2007). The Itai-itai disease in Japan was as a result of human exposure to cadmium and so brought the dangers of environmental Cd to the attention of the entire world. Cd has also been associated to a larger or lesser extent with many other clinical conditions including osteoporosis, proteinuria cataract formation in the eyes, anosmia, cardiac failure, various cancers, cerebrovascular infraction and emphysema. Yet, it has been difficult to establish obvious links of environmental Cd exposures with morbidity and mortality rates (Lalor, 2008).

Zinc (Zn) is considered as a trace element needed by humans for proper functioning of the body and is relatively non-toxic, especially when taken orally. However, excess amount of zinc in the body can cause system dysfunctions that may result in impairment of growth and reproduction. The clinical signs of zinc toxicity as reported by different people are liver failure, kidney failure anemia, vomiting, diarrhea, bloody urine and icterus (yellow mucus membrane) (Duruibe, et.al., 2007).

Copper (Cu), which is an essential element in mammalian nutrition function as a component of metalloenzymes where it serves as an electron donor or acceptor. Exposure to high levels of Cu can cause a number of adverse health effects. Human exposure to Cu occurs primarily through the consumption of copper contaminated food and drinking water. Some members of the population may be more prone to the adverse effects of high Cu intake due to occupational exposure, genetic predisposition or disease. However, acute Cu toxicity is generally linked to accidental ingestion; however (Stern, et.al., 2007). Excessive intake of Cu by humans may lead to severe hepatic and renal damage, central nervous system irritation followed by depression, mucosal irritation and corrosion and widespread capillary damage. Severe gastrointestinal irritation and possible necrotic changes in the liver and kidney may also occur.

The toxicities caused by Nickel (Ni) exposure vary from skin irritation to damage to the lungs, nervous system, and mucous membranes (Argun, et.al., 2007).

Lead (Pb) exposures cause physiological and neurological toxicity to humans. Acute Pb poisoning may lead to the dysfunction of the kidney, reproductive system, liver and brain damage that may eventually result to sickness and death (Odum, 2000). Lead very toxic even at extremely low concentrations (Kezemipour, et.al., 2008). A notably very serious effect of lead poisoning is the teratogenic effect. Lead poisoning also induces inhibition of the haemoglobin synthesis in the cardiovascular system and acute and chronic damage to the central nervous system (CNS) and peripheral nervous system (PNS). Other chronic effects lead toxicity include anemia, fatigue, gastrointestinal problems and anoxia. Lead causes difficulties in pregnancy, elevate blood pressure and cause muscle and joint pains (Odum,2000). Further effects of lead poisoning include damage to the gastrointestinal tract (GIT) and urinary tract resulting in bloody urine, neurological disorder and severe or permanent brain damage. Inorganic forms of lead, typically affect the CNS, PNS, GIT and other biosystems while the organic forms predominantly affect the CNS. Lead has serious effects on children; particularly in the age range of 2-3 years by causing poor development of the grey matter of the brain, which results in poor intelligence quotient (IQ). Absorption of lead in the body is enhanced when there is Ca and Zn deficiencies (Duruibe, et.al., 2007).

Chromium (Cr) is a persistent element in the environment and exists in the form of either Cr (III) or Cr (VI). Chromium (VI) being a strong oxidizing agent is toxic to plants and animals. It is corrosive, soluble in alkaline and mild acidic solutions, highly toxic and potentially carcinogenic. Chromium is the 10th most abundant element in the earth's crust (Shaffer, etal., 2001; Jeyasingh and Philip, 2009; Huang, et.al., 2010). The toxicity of Cr (VI) is due to its ability to diffuse through cell membranes and oxidize biological molecules (Shaffer, et.al., 2001). .

Mercury (Hg) is another risk factor. Mercury is a toxic element and has no known function in human biochemistry and physiology. Inorganic forms of mercury causes such disorders as spontaneous abortion, congenital malformation and gastrointestinal problems (like corrosive esophagitis and hematochezia). Toxic effects of its organic forms, including monomethyl and dimenthylmecury causes erethism (an abnormal irritation or sensitivity of an organ or body part to stimulation), acrodynia (Pink disease, which is characterized by rashes and desquamation of the hands and feet). Others are gingivitis, stomatitis, neurological disorders, total damage to the brain and CNS and are as well associated with congenital malformation (Duruibe, et.al., 2007).

Arsenic (As) is also an important metallic toxicant that exists in different chemical forms like mercury and lead. Arsenic toxicity symptoms thus, depend on the chemical form ingested. It can coagulate protein, can form complexes with coenzymes and can as well inhibit the production of adenosine triphosphate (ATP) during respiration. It is a possible carcinogenic in compounds of all its oxidation states. High level of exposure to arsenic can easily cause death. Arsenic toxicity also presents a certain disorder similar to, and often confused with Guillain-Barre syndr-ome, which is an anti-immune disorder that occurs when the body's immune system mistakenly attacks part of the PNS, resulting in nerve inflammation that causes weakness of the muscle (Duruibe, et.al., 2007).

Sand Filters and Water Treatment

Water is the basic commodity needed for the survival of all living organisms most especially humans; hence the provision of clean water for human consumption is an important of global concern today. Different localities have different water problems and water resources. Thus, one solution is grossly inadequate all communities. In local communities for instance, the water is often supplied from a nearby lake or from ground water source and so it becomes necessary that the water must be treated to enhance its quality and make it fit for human consumption.

The rapid rate gravity filter (Sand filter) is usually the most common technology used in the treatment of such surface water supplies. The filter consists of a structure which houses the unit, the filter media, an under-drain system, a surface washer, and a waste disposal system. The filter area is normally divided into at least two separate compartments to allow for operational flexibility. Some pre-treatment processes of the raw water, such as sedimentation, aeration are usually needed before the raw water is subjected to the sand filtration processes. Thus, the sand filter gradually gets saturated with water contaminants and therefore, it is necessary toxic contaminants such as heavy metal levels in the filter must be constantly monitored to prevent the consumers from being poisoned.

A simplified diagram of a conventional gravity sand filter is presented in figure 1 with the arrangement of different soil particles as they should be in the filter demonstrated in bottles in figure 2.

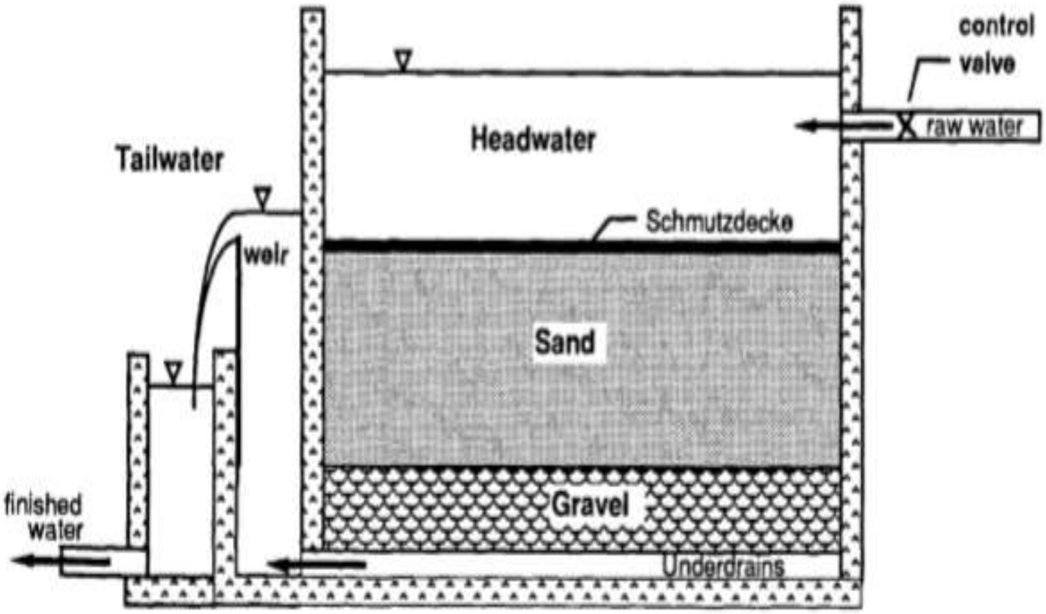

Figure 1: Showing a common design of a sand filter bed

Figure 2: Showing the different levels of the filter bed

Materials and Methods

The following are the methodologies adopted in conducting the research:

Sample Collection and Treatment

The soil samples used in this research were collected from the filtration unit of Dutsin-ma water treatment plant. Three soil samples A, B and C were collected from the plants' filter bed as follows:

Sample A: Sample collected from the surface of the filter bed,
Sample B: Sample collected from the mid-point (middle) of the filter bed, and,
Sample C: Sample collected from the bottom of the filter bed.

The samples were placed in separate plastic containers already washed with de-ionised distilled water and rinsed with 10% Trioxonitrate(v) acid solution and then taken to chemistry laboratory where they were dried in an oven and kept in desiccators until needed.

Soil Digestion and Determination of Heavy metals

One gram (1.0g) of the soil sample was placed into a 250 cm^3 conical flask and 15 cm^3 of aqua-regia (HNO_3 : HCl mixture in the ratio 1:3 v/v) was added. The mixture was boiled on a hot plate at 90 ^oC for 2hrs with constant stirring using a magnetic stirrer. The digest was allowed to cool at room temperature and filtered through what man No40 filter paper in a 100 cm^3 volumetric flask. The filtrate was made up to mark with de-ionized distilled water (Olafisoye et al., 2013). The samples were then analyzed for Pb, Cd, Cr, Zn, Fe, Hg, As, Fe, Mn and Cu using Classical Atomic Absorption Spectrophotometer.

Statistical Analysis of Data

Mean metal levels in the filter bed were determined and used in calculating the Azuka Index (Ai) which determines the safe limits of each metal in the filter bed and the percentage variations for the metals using the expressions,

$$\textbf{Azuka index (Ai)} = \frac{\mathbf{Mch}}{\boldsymbol{Mcc}}$$

Where:

Ai = Azuka Safe Index for heavy metals;
Mch = heavy metal mean concentration in the filter bed;
Mcc = Heavy metal mean control concentration.
Interpretation: [If Ai < 1→ safe condition; Ai > 1→ Risky condition; Ai = 1 → moderate risk]

$$\%\mathbf{Variation} = \frac{\mathbf{H2 - H1}}{\boldsymbol{H2}}\mathbf{X100}$$

Where
H2 = Highest mean metal value in the filter bed;
H1 = Lowest mean metal value in the filter bed.

Results and Discussion

The results of heavy metal concentrations at the three different levels of the filter bed and the calculated of the Azuka index (Ai) as well as the percentage variations of the different heavy metals are presented in Table 1.

Table 1: Azuka index (Ai) and percentage variation of heavy metals in the sand filter

S/N	Element	Upper (ppm)	Middle (ppm)	Bottom (ppm)	Mean (ppm)	Control (ppm)	Variation (%)	Azu Index
1	**Cadmium**	**0.010**	**0.007**	**0.008**	**0.00833**	**0.007**	**20.00**	**1.19**
2	**Chromium**	**0.002**	**0.049**	**0.279**	**0.110**	**0.247**	**99.28**	**0.45**
3	**Cobalt**	**0.063**	**0.091**	**0.003**	**0.052**	**0.023**	**96.70**	**2.26**
4	**Copper**	**0.038**	**0.027**	**0.009**	**0.025**	**0.002**	**76.32**	**12.50**
5	**Iron**	**4.940**	**6.380**	**14.622**	**8.647**	**2.252**	**66.49**	**3.84**
6	**Lead**	**0.340**	**0.970**	**0.760**	**0.690**	**0.130**	**64.95**	**5.31**
7	**Manganese**	**0.570**	**0.605**	**0.744**	**1.919**	**0.490**	**27.42**	**3.92**
8	**Mercury**	**246.30**	**54.10**	**217.30**	**172.57**	**166.6**	**78.05**	**1.04**
9	**Nickel**	**0.034**	**0.034**	**0.028**	**0.032**	**0.008**	**17.65**	**4.00**
10	**Zinc**	**0.0992**	**0.0655**	**0.0416**	**0.069**	**0.1804**	**58.07**	**0.38**

Discussion

The results in Table1 shows the safe factor indices for the heavy metals studied as Cd(1.19), Cr(0.45). Co(2.26), Cu(12.50), Fe(3.84), Pb(5.31), Mn(3.92), Hg(1.04), Ni(4.00) and Zn(0.38). Only the values for Cr and Zn were within good safe limit (Ai < 1), all others were above the safe limits. The Ai values for Copper, Lead, Nickel, Manganese and Iron were extra ordinarily far above the safety limit of their presence in the filter bed. This point to the high level of heavy metals pollution, emanating from natural geologic factors (as indicated by levels of these metals in the control sample) and from anthropogenic activities around the water sources that supplies the treatment plant. The values were very alarming because heavy metals especially at such elevated levels could very dangerous to human health. High levels of Cu in the body may lead to severe hepatic and renal damage, central nervous system irritation and depression, mucosal irritation and corrosion and, widespread capillary damage. Copper can also cause severe gastrointestinal irritation and possible necrotic changes in the liver and kidney.

Similarly, lead poisoning can cause damages to the kidneys, liver, heart, brain, skeleton and the entire nervous system (Flora, et.al., 2006). Symptoms may come with headache, dullness, memory loss and being irritable (CDCP, 2003). Lead poisoning can also result in the disturbance of hemoglobin synthesis and anemia (Jarup, 2003) and children with chronic exposure to low levels of Lead may have their intelligence quotient (IQ lowered. Lead is also a carcinogenic substance in humans (Jarup, 2003).

Nickel is also another risk factor, Negative effects of nickel on human health may include dermatitis, allergy, organ diseases, and cancer of the respiratory system (Seilkop and Oller, 2003).

Iron, even though an essential element needed by plants and animals bodies, its Excess amounts in the body (more than 10 mg/kg) can lead to rapid increase in pulse rate and coagulation of blood in blood vessels, hypertension and drowsiness. Iron has also been accused of causing stains on clothes and imparting of a bitter taste.

Inspite of the important roles played by manganese in the formation of connective tissues, bones, blood clotting, carbohydrate metabolism, and calcium absorption and sugar regulation and its essential requirement in the normal brain and nerve formation (Jeffrey et al., 1992), low level of Mn in the body may result in development of dermatitis and elevated concentration of serum calcium and phosphorous. Accumulated levels in individuals with cirrhosis or liver failure may contribute to neurological disorders leading to Parkinson's disease, lung embolism and bronchitis. Again exposure of men to manganese for a long period may lead to impotency. When the central nervous system is attacked by Mn, it can cause damage which may result in permanent disability symptoms, such as languor; sleepiness; weakness; emotional disturbances; spastic gait; recurring leg champs; and paralysis. Hence, the values of the risk factor indices for these metals are really very disturbing because the entire Dutsin-ma community rely heavily on water treated by this plant for consumption and other domestic activities. Based on their risk indices, the metals form the following trend: Zn < Cr < Hg < Cd < Co < Mn < Fe < Ni < Pb < Cu. Thus, Cu pose the highest risk and Zn then least.

Another important consideration is on the values of the percentage variations of these metals within the filter bed. The values obtained indicated that all the metal levels varied widely except for Ni (17.65%), Cd (20.00%) and Mn (27.42%). All others have %variations exceeding 50 percent each. These values are further indicators of heavy metal pollution in the water treatment plant. The trend in percentage variation of the heavy metals was: Cd < Ni < Mn < Zn < Pb < Fe < Cu < Hg < Co < Cr. Chromium was the most widely varied metal while Cd was the least.

The results obtained in this research are consistent with those reported by Iyama, and Edori (2020), in the assessment of levels and safe factor index of heavy metals in soils around Diobu, Port Harcourt, Nigeria.

Conclusion and Recommendation

The results obtained showed that the safe factor indices of the heavy metals studied ranged from 0.38 – 12.50 with Zn having the least value (0.38) and Cu the highest value (12.50). However, of the ten metals studied, only Cr and Zn had safety factor values that were within good safety limit (Ai < 1), all other metals had values that exceeded the approved safety limits. Copper, Lead, Nickel, Manganese and Iron were observed to have Ai values that were extra ordinarily far above the safety limit of their presence in the filter bed. The percentage variations, of the metals obtained indicated that all the metal levels varied widely except for Ni (17.65%), Cd (20.00%) and Mn (27.42%). All others had %variations exceeding 50 percent each. Based on these results, it can concluded that there were high level heavy metals pollution activities emanating from natural geologic factors as well as anthropogenic activities around the water sources that supplies the treatment plant. Therefore, in view of the high values of the safe factor indices and %variation for some of the metals immediate heavy metal remediation especially in the filter bed and at the water reservoir to mitigate the heavy metal pollution of the water should be carried out.

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