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ANALYSIS OF HEAVY METALS CONCENTRATION IN HUMAN HAIRS OF SELECTED STUDENTS OF AKANU IBIAM FEDERAL POLYTECHNIC, UNWANA

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Abstract
The study was on the analysis of heavy metals (Mn, Fe, Cu, Zn, Cd, Pb & Cr) in human hairs in Akanu Ibiam Federal Polytechnic, Unwana. The investigation was done using Atomic Absorption Spectrophotometer. The results of the replicate analysis were compared with the Provisional Maximum Tolerable Daily Intake (PMTDI) recommended by FAO/WHO and were compared with the literature. The values showed the following mean concentrations of heavy metals in mg/Kg of Sample A was Mn 0.67±0.03, Fe 1.54±0.02, Cu 0.34±0.03, Zn 1.42±0.02, Cd 0.08±0.01, Pb 0.62+0.02 and Cr 0.83±0.03 and Sample B Mn 0.63±0.03, Fe 1.74±0.03, Cu 0.28±0.01, Zn 1.47±0.01, Cd 0.06±0.02, Pb 0.84+0.03 and Cr 0.79±0.02. The results showed the presence of all the metals analyzed in various amount in the samples. The presence of these heavy metals in the human hairs could be as a result of environmental factor and feeding habits. Heavy metals in any concentration are toxic and could have a deleterious effect in human beings.
Keywords: Analysis, Heavy Metals, Human Hairs, Environment, Toxic

Introduction

The word “heavy metal” has been defined in a variety of ways in literature. Heavy metals are often assumed to be highly toxic or damaging in the environment (Duffus, 2002). Heavy metals have the greatest potential to cause harm on account of their extensive use and their toxicities stem from some of their combined or elemental forms and their widespread distribution in the environment (Baird & Cann, 2012). In scientific terms, a heavy metal is any material that has alkaline oxides, may develop compounds along with non-metals without interacting with each other, can exchange places with hydrogen ions in acids, as well as is capable of becoming an electron donor. In terms of physical properties, it is any substance that can transfer electricity and heat efficiently and can be converted into metal plates as well as wire, has a metallic color, and is solid under ordinary conditions. However, in terms of their impacts, any metal that is harmful to any living organism in any situation can be referred to as a heavy metal, despite the way it is defined Gastan, (2018). Metals are generally classified as either physiologically necessary or unnecessary. They are referred to as xenobiotics, or alien elements, such as aluminum (Al), cadmium (Cd), mercury (Hg), tin (Sn), as well as lead (Pb), among other non-essential metals, possess no known biological purpose and become more harmful at higher concentrations. Some essential metals, such as nickel (Ni), cobalt (Co) zinc (Zn), Molybdenum (Mo), chromium (Cr). Copper (Cu), as well as iron (Fe), have a proven biological role but can be harmful at excessive doses or in metabolic shortages could have a detrimental influence on health, while an elevated level of that metal can have negative effects. In fish, heavy metals such as lead, cadmium, zinc, copper, as well as tin are most frequently discovered in fish, these elements have been investigated to be the cause of copper, chromium, zinc, lead, mercury, as well as cadmium Pakranakis *et al*. 2015) in living organisms are required in trace amount. Organisms can be harmed by an excess of metals (Inayat *et al*. 2024).

Copper (Cu), Selenium (Se) manganese (Mn), magnesium (Mg), and zinc (Zn) play important roles in human biochemical processes and their deficiency and excess have serious impacts on human health (ATSOR 2020). Determination of biological samples is useful for nutritional assessment and for the identification and

monitoring of environmental and occupational exposures, as well as in the diagnosis and monitoring of diseases.

Nordberg (2020) submitted that the determination of trace elements in hairs provides several advantages over blood and urine testing, including the easy collection, transportation, and handling of samples. The need for no special storage conditions in high concentration of elements, non-invasive procedure, longer retrospective time frame (months) representation and lower costs (WHO 2010) and inductively coupled plasma-mass spectrometry (ICP-MS) is suggested to be the most suitable analytical technique for ultra-trace multi-element analysis, with high sensitivity and ability to measure a large range of concentrations (Boezen, 2013). Various digestion methods have been reported, such as wet acid, dry ash, and micro wave acid digestion which can be appropriately modified. Each method has its own advantages and disadvantages According to Bass *et al.* microwave digestion is the most appropriate method for standardization. However, it requires an expensive microwave digester (Zeng 2013) and it has relatively low productivity.

Heavy metals are ubiquitous environmental pollutants that pose significant health risks to human populations due to their toxic nature and potential for bioaccumulation in the body. Human hairs have emerged as a non-invasive. Bio monitoring tool for assessing chronic exposure to heavy metals reflecting long-term accumulation levels that can provides valuable insights into environmental and occupational exposure risks.

Exposure of heavy metals resulting from different sources and activities may have deleterious effects on human health. Bio monitoring of heavy metal concentrations in human bodies have significant importance, as their amounts in biological samples (hair, nails, blood, saliva, and urine) can be utilized as a medium metal contamination index. The simplicity with which nails can be sampled transported and handled. And generally biological media, such as blood and urine make the nails to be more suitable and convenient tissues for monitoring localized exposure to toxic metals (Parizangeneh *et al*. 2014).

Hair is rich in proteins and contain keratins as cysteine resides, their roots are highly influenced by health status of the cells, whereas blood and other body fluids give transient concentrations human human hairs provide a continuous record of elemental concentration (Okoro *et al*. 2015), therefore this study poised to investigate the concentration of heavy metals in human hairs. Human hair is viewed to ascertain human health index.

The significance of the study lies in its contribution to understanding heavy metal exposure risks and heavy metal levels in human hairs; the study can also inform risk assessment, exposure prevention strategies, and public health interventions aimed at reducing heavy metal exposure and protecting human health. The study of human hairs are expected to provide valuable insights for environmental and occupational health management practices.

The determination of heavy metals in human hairs is crucial for assessing long term exposure risks and monitoring potential health effects associated with heavy metal contaminations. Human hairs serve as a reliable bio-marker for assessing chronic exposure to heavy metals, providing valuable information on individual exposure history and environmental risk factors that may impact human health.

This study aims to determine the concentrations of heavy metals in human hairs and evaluates the implications for environmental and occupational exposure assessment.

Materials and Methods

Methods

Sampling Area and Sample Collection

The students whose hairs were collected were volunteers and this was after the authorization of the Head of the Department who officially issued letter to that effect. The hair samples were collected from selected students of Akanu Ibiam Federal Polytechnic, Unwana. Samples were collected from the students with respect

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to sex and age. Finger nails were collected using sterilized stainless scissors cleaned with ethanol, a neutral solvent to remove external contaminants. The human hair samples collected were sealed in a plastic.

Washing of Hair Samples

The hair samples were scraped and cleaned of dust particles and were washed with non-ionic detergent (Triton x 100) following a standardized washing procedure. This was followed by soaking the hair samples in order to remove external contaminant, and finally the samples were rinsed five times with deionized water and dried in an oven at 110℃ and stored in a desiccator pending analysis.

Digestion of Hair Samples

A 50ml of each water sample was transferred into a 250ml conical flask containing 1g of dried hair sample and 3ml of a mixture of nitric (HNO_3) and per chloric acid ($HClO_4$) in the ratio of 3:1 was added the sample. The mixture was placed on a hot plate and digested down to 50ml. It was allowed to cool and filtered through a Whatman no.42 filter paper into a 50ml volumetric flask. The test samples filtrates were used for heavy metal analysis using Varian Spectra AA 55B Atomic Absorption Spectrophotometer appropriate cathode lamp.

AAS Technique

Atomic absorption spectrophotometry makes use of absorption spectrometry to assess the concentration of an analyte in a sample. It requires standard solutions to establish the relationship between measured absorbance and the analyte concentration, and relies on Beer-Lambert law. It is commonly used for determining the concentration of a particular metal element in a sample. In their elemental form, metals will absorb ultraviolet light and get excited. Each metal has a characteristic wavelength that will be absorbed. The AAS instrument looks for a particular metal by focusing a beam of UV light at a specific wavelength through a flame and into a detector. The sample of interest is aspirated into the flame. If that metal is present in the sample, it will absorb some of the light, thus reducing its intensity. The instrument measures the change in intensity. A computer data system converts the change in intensity into an absorbance.

Results

Table 1: The Standard Deviation of mean of the heavy metal concentration in Sample A in Human hair

Parameter	1st	2nd	3rd	Mean	Std Dev
Mn	0.68	0.62	0.7	0.67	0.03
Fe	1.52	1.54	1.56	1.54	0.02
Cu	0.22	0.28	0.22	0.24	0.03
Zn	1.4	1.46	1.42	1.43	0.02
Cd	0.08	0.1	0.07	0.08	0.01
Pb	0.6	0.65	0.62	0.62	0.02
Cr	0.81	0.81	0.86	0.83	0.02

Table 2: The Standard Deviation of mean of the heavy metal concentration in Sample B in Human hair

Parameter	1st	2nd	3rd	Mean	Std Dev
Mn	0.62	0.6	0.68	0.63	0.03
Fe	1.7	1.74	1.78	1.74	0.03
Cu	0.27	0.27	0.29	0.28	0.01
Zn	1.46	1.46	1.48	1.47	0.01
Cd	0.04	0.06	0.08	0.06	0.02
Pb	0.82	0.82	0.88	0.84	0.03
Cr	0.78	0.82	0.78	0.79	0.02

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Table 3: The Standard Deviation of mean of the heavy metal concentration in Sample A and Sample B in Human hair

Parameter	Sample A	Sample B
Mn	0.67±0.03	0.63±0.03
Fe	1.54±0.02	1.74±0.03
Cu	0.24±0.03	0.28±0.01
Zn	1.43±0.02	1.47±0.01
Cd	0.08±0.01	0.06±0.02
Pb	0.62±0.02	0.84±0.03
Cr	0.83±0.02	0.79±0.02

Discussion

The results as presented in Table 3 showed that the mean concentration of Mn in Sample A was 0.67±0.03mg/g and 0.74±0.03mg/g for Sample B. The results showed that the concentration of the heavy metal in Sample A was lower than the Concentration of Sample B. high levels of Mn in human hair can be a sign of toxicity which can cause serious health issues such as neurological symptoms like decreased memory and concentration, fatigue, headache, vertigo and loss of equilibrium. Deficiency of Manganese might cause bone demineralization and poor growth in children, skin rashes, air depigmentation, decreased serum, cholesterol and increased alkaline phosphate activity in man (Nelsen, 2012)

Table 3 showed that the mean concentration of Fe in Sample A was 1.74±0.02 mg/g and 1.75±0.03 for Sample B. From Figure 1, the concentration of Fe in Sample B was higher than that of Sample A. The values of Fe were above the WHO guideline. The high concentrations of Fe in the samples may be attributed to the environmental factor. Taking too much Fe can cause severe symptoms, including vomiting, diarrheal abdominal pain, liver damage and even death. A study done by Linus Pauling Institute, 20001 showed, Fe supplements can cause gastrointestinal irritation, nausea, vomiting, diarrhea, or constipation in some people, while a study by Solanki and others in 2014 showed that excess amount of iron can harm human body elements because of its toxicity and causes nausea, vomiting, abdominal pain, dyspepsia, constipation, pneumonia, asthma and vision problems.

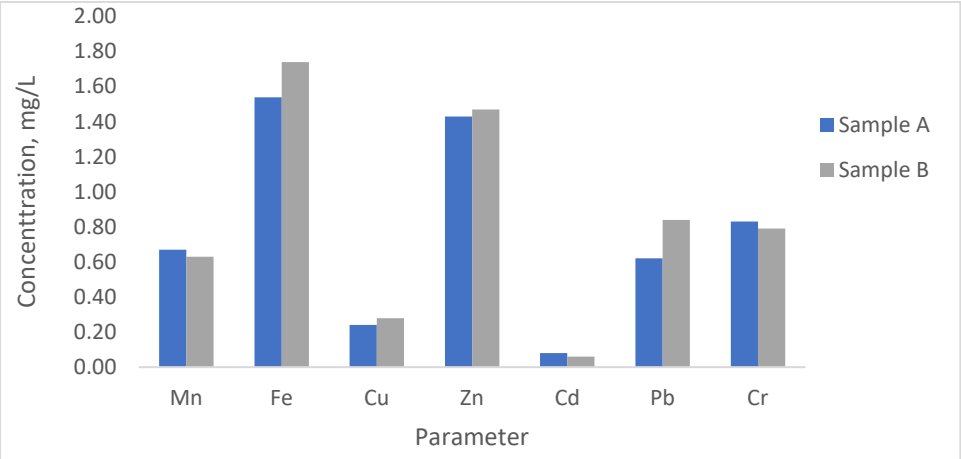


Figure 1: The Bar Chart showing the mean concentration of Heavy Metals in Human Hair

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The average concentrations of the selected heavy metals along with relevant standard deviation (SD) values are listed in Table 3. The mean concentration of Cu in Sample A was 0.33±0.06 mg/Kg while Sample B was 0.26±0.01 mg/Kg. Figure 1 showed that Sample B has lower concentration than Simple A. Dara and Umare (2010) reported that in low concentration, Cu may not be detrimental to human health but at higher concentration, it may cause stomach and internal distress. Cu according to Dara and Umare (2010) may cause Wilson's disease which is a rare genetic disorder characterized by excessive accumulation of copper in the body, particularly in the liver brain, and other vital organs.

From the results as shown in Table 3, the mean concentration of Zn in sample A was 1.52±0.01 while that of Sample B was 1.55±0.01mg/Kg. The results of the analysis showed that the mean concentration of Sample B was higher than Sample A. The results of the analysis were below the WHO (2011) permissible limit. . Zn, is considered to be essential and non-toxic and can have a deleterious health effects when in high concentration.

The mean concentration of Cd reported in Table 3 showed that Sample A was 0.07±0.01 while Sample B was 0.12±0.06±0.03 mg/Kg. Figure 1 showed that the mean concentration of sample A was higher than that of Sample B. Chojnacka *et al* (2005) and Senofonte *et al* (2000) reported a mean concentration of 0.114±0.14 mg/Kg and 0.23±0.55 mg/Kg, respectively. The findings were not in agreement with our findings as our submissions were lower. The values were higher than the WHO (2006) permissible limits and hence pose danger to the humans because of the accumulation in the body. Cadmium is generally present in the environment at low levels; however, however at higher concentration above WHO permissible limits Cd becomes harmful and contaminates the environment (WHO, 2019). Cadmium exerts toxic effects on the kidneys as well as the skeletal and respiratory systems. WHO (2019) classified it as a human carcinogen.

Table 3 showed that the mean concentration of Pb in Sample A was 0.85±0.02mg/Kg while sample B was 0.83±0.02. From Figure 1, Sample B has a higher mean concentration of Pb than that of sample A. The results of the finding was lower than the values submitted by Liang *et al* (2024). The difference in value could be as a result of the differences in geographical environment and dietary habits (Wang et al, 2005). Acute Pd poisoning in humans cause an anemia, fatigue and irritable severe dysfunction in the kidney, reproductive system, liver, and the brain and central nervous system (Bhatia, 2011).

Table 3 showed that the mean concentration of Cr in Sample A was 0.83±0.02mg/g while the mean concentration was 0.82±0.03mg/Kg. The concentration of Sample A was higher than Sample B. The values of the chromium concentration in the hair were higher than the value recommended by WHO (2006). Occupational exposure to chromium (VI) or chromium (III) in other chromium-related industries has been associated with respiratory effects, in addition to symptoms of labored breathing, dizziness, headache, weakness and nausea (WHO, 2006).

Conclusion

Analysis was carried out using AAS technique for Mn, Fe, Cu, Zn, Cd, Pb and Cr. There were indications of the presence of all the heavy metals analyzed in relatively large amounts with Zn having the highest mean concentrations between the two samples.

The presence of all the heavy metals under investigation is a clear indication of the environmental content of the heavy metals in the school environment and the poor feeding and drinking habits by the students.

Recommendations

i. Frequent test of the human hairs should be carried out as to ascertain the level of heavy metal accumulation in the human hair of the students in the school;
ii. Public enlightenment and education should be carried out by the government on the danger associated by heavy metals in the body.

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