# Assessment of Heavy Metals in Human Scalp Hair

Kabiru Bashir Ahmad[1]*, Ansar Bilyamin Adam[2], Idris Abdullahi Bilkisu[3], Falalu Shu aibu Umar[4], Alwan Hashim Kahtan[5]

Department of Chemistry, Federal University Lokoja, Kogi, Nigeria[1, 3]
Department of Chemical Sciences, Federal University Wukari[2]
Department of Chemistry Bayero University, Kano[4]
Aliko Dangote University of Science and Technology, Wudil, Kano, Nigeria[5]
***Corresponding author:** *kabiru.ahmad@fulokoja.edu.ng.*

## Abstract

*Heavy metal in the hair causes degenerative neurologic diseases, skin cancer. The presence and concentration of heavy metals (Chromium, Cadmium and lead) in samples of human scalp hair of some representative persons in Aliko Dangote University of Science and Technology (ADUST) Wudil, Kano, Nigeria were investigated. The heavy metals were analyzed using Atomic Absorption Spectroscopy (AAS). To get the samples ready for analysis, a hot plate digestion method is used. Nitric acid and sulfuric acid were used to break down organic substances in the sample during digestion. A flame atomic absorption spectrometer was used to evaluate the digested samples and determine the heavy metal amounts present. For every metal, the limit of detection (LOD) and limit of quantification (LOQ) were established together with a linear range of concentrations. The results revealed that the human scalp hair samples contained 0.08 mg/L of Chromium, 0.02 mg/L Cadmium and 0.06 mg/L Lead*

**Keywords*:*** Human scalp hair, Heavy metals, Atomic absorption spectroscopy, limid of detection, limit of quantification

# Évaluation des métaux lourds dans les cheveux du cuir chevelu humain

## Résumé

Les métaux lourds présents dans les cheveux provoquent des maladies neurologiques dégénératives et des cancers de la peau. La présence et la concentration de métaux lourds (chrome, cadmium et plomb) dans des échantillons de cheveux humains de certaines personnes représentatives d'Aliko Dangote University of Science and Technology (ADUST) à Wudil, Kano, Nigeria ont été étudiées. Les métaux lourds ont été analysés par spectroscopie d'absorption atomique (SAA). Pour préparer les échantillons à l'analyse, une méthode de digestion sur plaque chauffante est utilisée. L'acide nitrique et l'acide sulfurique ont été utilisés pour décomposer les substances organiques présentes dans l'échantillon pendant la digestion. Un spectromètre d'absorption atomique à flamme a été utilisé pour évaluer les échantillons digérés et déterminer les quantités de métaux lourds présentes. Pour chaque métal, la limite de détection (LDD) et la limite de quantification (LDQ) ont été établies ainsi qu'une plage linéaire de concentrations. Les résultats ont révélé que les échantillons de cheveux du cuir chevelu humain contenaient 0,08 mg/L de chrome, 0,02 mg/L de cadmium et 0,06 mg/L de plomb.

**Mots-clés**: Cheveux du cuir chevelu humain, Métaux lourds, Spectroscopie d'absorption atomique, limite de détection, limite de quantification

يسبب المعدن الثقيل في الشعر أمراضًا عصبية تنكسية وسرطان الجلد وجود المعادن الثقيلة وتركيزها (الكروم والكادميوم والرصاص) في عينات من شعر فروة الرأس البشري لبعض الأشخاص الممثلين في جامعة أليكو دانغوتي للعلوم والتكنولوجيا، ووديل، كانو، نيجيريا تم تحليل المعادن الثقيلة باستخدام التحليل الطيفي للامتصاص الذري للحصول على العينات جاهزة للتحليل، يتم استخدام طريقة هضم الصفائح الساخنة. تم استخدام حمض النتريك وحمض الكبريتيك لتحطيم المواد العضوية في العينة أثناء الهضم تم استخدام مطياف الامتصاص الذري للهب لتقييم العينات المهضومة وتحديد الكميات المعدنية الثقيلة الموجودة تم تحديد حد الكشف والحد من القياس الكمي معًا مع نطاق خطي من التركيزات. وكشفت النتائج أن عينات شعر فروة الرأس البشرية 0.08 ملغم/لتر من الكروم و0.02 ملغم/لتر من الكادميوم و0.06 ملغم/لتر من الرصاص

## Introduction

Heavy metal refers to any metallic chemical element that has a relatively high density and is toxic or poisonous at high concentration. Heavy metals are also natural compounds of the earth's crust that cannot be degraded or destroyed. As trace elements, some heavy metals (e.g. Copper, Selenium, and Zinc) are essential to maintain the metabolism of the human body. However, at higher concentrations they can lead to poisoning.

Pollution caused by heavy metal has become a serious health concern in recent years. Continuous exposure to low levels of heavy metals may result in bioaccumulation and health deterioration in humans (Mishra et al., 2019). Toxic heavy metals of greatest concern are Cadmium (Cd), Chromium (Cr), Lead (Pd) and Mercury (Hg). Exposure to these metals is a continuous daily process, especially at the place of work, in portable water, in food and in the air (Goyer et al., 1995). Moreover, metals can enter an organism via the air, water, food or pharmaceuticals applied through skin and the respiratory tract (Sardar et al., 2013). Afterwards, they are transported and distributed through blood into organs (i.e. Liver, Kidney) and removed from the organism through the following excretory pathways: sweat, hair, urine and feces (Apostoli, 2002). The levels of metals in the human bodies can be determined by analyzing human fluids. Fluids such as blood and urine are often considered the best specimens for evaluation of undue exposure to heavy metals, but the results reflect a transient situation (Goullé et al., 2005). Other materials such as scalp hair clippings can be used as biomonitors because human hair is an excretory system for trace metals and can act as an accumulating tissue. Therefore, the metal content in human hair can reflect the body status over a long period, including exposure to metals in time (Apostoli, 2002). Besides, the concentration of metals in human hair may be 10-fold higher than the amount found in blood or urine (Mortada *et al.,* 2002). The high affinity of hair to metals is mainly due to the presence of cysteine, which makes up approximately 14% of human hair (Chojnacka *et al.,* 2005).

Exposure to toxic heavy metals is generally classified as acute (14 days or less); intermediate (15-354days); and chronic, (more than 365days). Additionally, acute toxicity is usually from a sudden or unexpected exposure to a high level of heavy metal as a result of careless handling,

inadequate safety precautions or an accidental spill or release of toxic material in the laboratories, industrial, or transport environment

Chronic toxicity results from repeated or continuous exposure, leading to an accumulation of toxic substance in the body (Jaishankar et al., 2014). Chronic exposure may result from contaminated food, air, water or dust, living near a hazardous waste site; spending time in areas with deteriorating lead paint; maternal transfer in the womb; or from participating in hobbies that use lead paint or solder. Chronic exposure may occur in the home, school or workplace (Sarigiannis, 2017).

## Materials and methods

### *Sample Collection*

Scalp hair samples were collected from 10 persons of Aliko Dangote University of Science and Technology (ADUST) Wudil, Kano, Nigeria. Samples were collected from each person immediately after barbing the hair from the University barbing saloon and put in plastic bag containers. Each container was well-labeled using different colour tags for each person in order to prevent a mix-up. After collection, the samples were taken immediately to the laboratory for pretreatment and digestion.

### *Sample Pre treatment*

Each composite hair sample were immersed in 20 mL acetone for about 10 minutes with continuous stirring in an ultrasonic bath to remove grease, dust and organic impurities and followed by rinsing with distilled water and thereafter with acetone. The washed samples were independently placed in glass beakers and dried for a period of about 24 hours at 40$^{o}$C in a drying oven and weighed.

### *Sample Dissolution*

Pretreatment hair sample weighing 0.5 g (500 mg) was precisely measured and placed into a 50 mL volumetric flask. Five mL (5 mL) of concentrated Nitric Acid ($HNO_3$, 68%) was added at room temperature. The contents of a flask were heated to boiling in a fume cupboard and 1 mL Perchloric Acid [($HClO_4$, 72%)] was added and heated at 60-70 until dense white fumes appeared. The contents of the flask were cooled and then transferred to a 50 mL volumetric flask, made up to mark with 2% Nitric acid, and filtered through Whatman No. 42 filter paper into a labeled reagent bottle.. (Muhammad, *et al.,* 2023).

### *Preparation of reagent*

### *Preparation of 10 % Nitric acid*

147.06 mL concentrated nitric acid (ρ=1.4; 68% w/v) was accurately transferred into a 1000 mL Volumetric flask and made to mark with distilled water.

### *Preparation of 2% Nitric Acid*

29.41 ml concentrated nitric acid (ρ=1.4; 68% w/v) was accurately transferred into a 1000 mL volumetric flask and made to mark with distilled water.

### *Preparation of 1000 mg/dm$^3$ Chromium solution*

5.658 g of potassium dichromate ($K_2Cr_2O_7$) was weighed and dissolved in a beaker containing 10 mL of 10 % nitric acid. The solution was transferred into a 1000 mL volumetric flask and made up to mark with distilled water.

### *Preparation of 100 mg/dm$^3$ Chromium solution*

10 mL of 1000 mg/dm$^3$ was pipetted into 100 mL Volumetric flask. The volume was made to mark with distilled water.

***Working standard concentrations of Chromium***

2, 4, 6, 8 and 10 mg/dm$^3$ Chromium solutions were prepared by dilution of 2, 4, 6, 8 and 10 mL of 100 mg/dm$^3$ chromium solution in separate 100 mL Volumetric flask (Zewge*et al.,* 2011).

***Preparation of 1000 mg/dm$^3$ Cadmium solution***

2.103 g cadmium nitrate $Cd(NO_3)_2$ was weighted and transferred into a beaker containing 10 ml of 10 % nitric acid. The solution was transferred into a 1000 ml volumetric flask and made up to mark with distilled water.

***Preparation of 100 mg/dm$^3$ Cadmium solution***

10 ml of 1000 mg/dm$^3$ cadmium solution was pipetted into a 100 mL volumetric flask. The volume was made to mark with distilled water.

***Preparation of working standard concentrations of cadmium***

2, 4, 6, 8, and 10 mg/dm$^3$ Cadmium solution were prepared by dilution of 2, 4, 6, 8 and 10 ml of 100 mg/dm$^3$ cadmium solution in separate 100 mL Volumetric flaks (Zewge *et al.,* 2011).

***Preparation of 1000 mg/dm$^3$ Lead solution***

1.599 g of $Pb(NO_3)_2$ was weighed and dissolved in a beaker containing 10 mL of 10 % nitric acid. The solution was transferred into a 1000 mL volumetric flask and made up to mark with distilled water.

***Preparation of 100 mg/dm$^3$ Lead solution***

10 ml of 1000 mg/dm$^3$ lead solution was pipetted into a 100 ml volumetric flask. The volume was made up to mark with distilled water.

***Preparation of working standard concentrations of Lead***

2, 4, 6, 8 and 10 mg/dm$^3$ Lead solutions were prepared by dilution of 2, 4, 6, 8 and 10 mL of 100 mg/dm$^3$ Lead solution in separate 100 mL Volumetric flasks (Zewge *et al.,* 2011).

***Sample Analysis***

The samples and blank were analyzed for Cr, Cd, and Pb using the BUCK Scientific 201VGR model Atomic Absorption Spectrophotometer (AAS). The spectrophotometer was calibrated using stock concentrations. Distilled water was used for sample preparation and stock standard solutions dilution. All samples were analyzed in triplicate, with mean metal concentrations within ±2%. The blank was regularly interjected after every five measurements to ensure AAS functioning. The analytical equipment underwent both inter-laboratory and intra-laboratory control tests.

**Results and discussion**

***Interpretation of results***

Concentration of heavy metals in human hair showed the distribution pattern for Chromium, cadmium and lead in human hair is shown in Tables 1 with a mean concentration of 0.0774 mg/L chromium, 0.0245 mg/L Cadmium and 0.0646 mg/L Lead. Sample F has the highest average Chromium concentration of 0.1190 mg/L. Sample I has the least average Chromium concentrations of 0.0446 mg/L, Sample I has the highest average Cadmium concentration of 0.0373 mg/L, while sample G has the lowest average Cadmium concentrations of 0.0124 mg/L. Sample I has the highest

average Lead concentration of 0.0.973 mg/L, while sample D and G has the lowest average Lead concentrations of 0.0354 mg/L.

**Table 1: Concentration of Heavy Metals in Human hair**

| S/N | Sample | Age (yrs) | Cr (mg/L) | Cd (mg/L) | Pb (mg/L) |
|---|---|---|---|---|---|
| 1 | A | 27 | 0.0595 | 0.0207 | 0.0619 |
| 2 | B | 28 | 0.0744 | 0.0166 | 0.0531 |
| 3 | C | 25 | 0.0595 | 0.0249 | 0.0708 |
| 4 | D | 26 | 0.0893 | 0.0166 | 0.0354 |
| 5 | E | 30 | 0.0595 | 0.0332 | 0.0884 |
| 6 | F | 23 | 0.1190 | 0.0332 | 0.0796 |
| 7 | G | 25 | 0.0744 | 0.0124 | 0.0354 |
| 8 | H | 20 | 0.0893 | 0.0207 | 0.0531 |
| 9 | I | 32 | 0.0446 | 0.0373 | 0.0973 |
| 10 | J | 38 | 0.1042 | 0.0290 | 0.0708 |
| | | **Mean=** | 0.0774 | 0.0245 | 0.0646 |

***Discussion of the results***

The results were compared with the Permissible Limits (PL) and Provisional Maximum Tolerable Daily Intake (PMTDI) for Chromium (0.05 mg/L), Cadmium (0.05 mg/L) and Lead (0.1 mg/L) as set by World Health Organization (WHO). Cadmium and lead were within Permissible Limits (PL) while Chromium concentration was observed to be higher.

**Conclusion**

From the result of the studies it was concluded that concentration of Chromium in the samples of scalp hair were found to be higher than the minimum acceptable values provided by World Health Organization (WHO) and Provisional Maximum Tolerable Daily Intake (PMTDI).

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## APPENDIX 1

**APPENDIX 1:1 AAS Results for the Absorbance of Chromium in Human Scalp Hair**

| S/N | Code | First | Second | Third |
|---|---|---|---|---|
| 1 | A | 0.0010 | 0.0020 | 0.0010 |
| 2 | B | 0.0010 | 0.0020 | 0.0020 |
| 3 | C | 0.0010 | 0.0010 | 0.0020 |
| 4 | D | 0.0010 | 0.0030 | 0.0020 |
| 5 | E | 0.0020 | 0.0010 | 0.0010 |
| 6 | F | 0.0030 | 0.0030 | 0.0020 |
| 7 | G | 0.0010 | 0.0010 | 0.0030 |
| 8 | H | 0.0020 | 0.0020 | 0.0020 |
| 9 | I | 0.0010 | 0.0010 | 0.0010 |
| 10 | J | 0.0020 | 0.0020 | 0.0030 |

**APPENDIX 1:2 AAS Results for the Absorbance of Cadmium in Human Scalp Hair**

| S/N | Code | First | Second | Third |
|---|---|---|---|---|
| 1 | A | 0.0030 | 0.0010 | 0.0010 |
| 2 | B | 0.0010 | 0.0010 | 0.0020 |
| 3 | C | 0.0010 | 0.0020 | 0.0030 |
| 4 | D | 0.0010 | 0.0010 | 0.0020 |
| 5 | E | 0.0020 | 0.0020 | 0.0040 |
| 6 | F | 0.0020 | 0.0030 | 0.0030 |
| 7 | G | 0.0010 | 0.0010 | 0.0010 |
| 8 | H | 0.0010 | 0.0020 | 0.0020 |
| 9 | I | 0.0020 | 0.0040 | 0.0030 |
| 10 | J | 0.0040 | 0.0020 | 0.0010 |

**APPENDIX 1:3 AAS Results for the Absorbance of Lead in Human Scalp Hair**

| S/N | Code | First | Second | Third |
|---|---|---|---|---|
| 1 | A | 0.0020 | 0.0010 | 0.0040 |
| 2 | B | 0.0020 | 0.0030 | 0.0010 |
| 3 | C | 0.0030 | 0.0030 | 0.0020 |
| 4 | D | 0.0010 | 0.0020 | 0.0010 |
| 5 | E | 0.0030 | 0.0030 | 0.0040 |
| 6 | F | 0.0040 | 0.0020 | 0.0030 |
| 7 | G | 0.0020 | 0.0010 | 0.0010 |
| 8 | H | 0.0020 | 0.0010 | 0.0030 |
| 9 | I | 0.0040 | 0.0040 | 0.0030 |
| 10 | J | 0.0020 | 0.0020 | 0.0040 |