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# Heavy Metal Assessment in *Rattus argentiventer* (Rice-field Rats) from Tyo-Mu Districts in Makurdi Local Government of Benue State

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**Abstract**
Rice field rats (*Rattus argentiventer*) have provided supplementary protein for the human population within the proximity of the Tyo-Mu district of Makurdi, Benue State. This study aims to assess the concentration of heavy metals in the hairs of *Rattus argentiventer* in the Tyo-Mu district of Makurdi and its immediate neighborhood. Six random samples of the hair of *Rattus argentiventer* were sourced from the study area. The samples were digested, and concentrations of four heavy metals (Cu, Cd, Ni and Zn) were analyzed using the atomic absorption spectrophotometer (AAS) technique. The heavy metal concentrations in the hairs of the selected samples of *Rattus argentiventer* revealed that zinc has the highest mean concentration (mg/kg) of 0.841±0.270, followed by cadmium with 0.031±0.02, while nickel has the lowest concentration (mg/kg) of 0.023±0.02. Cadmium, nickel, and zinc were within the permissible limits (0.05, 12.0, and 50.0 mg/kg, respectively), as set by FAO/WHO. Copper metal was not detected. This study has shown for the first time that the rice field rats in the study area are safe from heavy metal contamination. However, close monitoring is required, and their future consumption should be checked for toxicological content.
**Keywords:** Concentration, Digestion, Heavy metals, *Ratus argentiventer,* Spectrophotometer

## Introduction

Several heavy metals have been found in air, water and soil samples resulting from diffused or point source pollution. This largely depends on components of parent materials in the soil or influence of anthropogenic antecedents lethal to humans. Heavy metals can become quite harmful by combining with different environmental elements, such as water, soil, and air resulting in lethal consequences within biotic components, especially when it is passed through the food chain. Environmental pollution, primarily caused by heavy metals, is a growing global issue influenced by factors like the greenhouse effect and eutrophication posing serious health risks due to their persistence, toxicity, and potential food chain incorporation [1]. According to Onakpa *et al.* [2], heavy metals are metals with atomic densities greater than 4 g/cm$^3$, or 5 times greater than water. Common metals include cadmium, chromium, cobalt, copper, lead, and zinc. These metals are natural components of the earth's crust and can enter biological tissues through food, water, and surface absorption. Some heavy metals are essential and required by the human body in trace amounts, but they can cause toxic effects when blood levels increase. Soil poisoning has increased globally due to anthropogenic activities affecting plants and medicines. Regulatory authorities are now concerned about food safety and other environmental factors related to heavy metal contamination [3, 4, 5, 6]. Tyo-mu is a Benue suburb very close to the state capital, Makurdi metropolis with averagely dense population whose main occupation is peasant agriculture, predominantly arable farming. This made the location of special interest.

The people of Benue particularly Makurdi consider *Rattus argentiventer* a delicious delicacy. Despite this, there has been very little scientific data on heavy metal presence in this species of rats. According to a recent World Atlas report, Makurdi is the most populated town in Benue State, with a population of 3003,77 [7]. It therefore becomes pertinent to document some health implications regarding the heavy metal contamination of this species within the area. Livestock production is a significant protein source for the Benue people, particularly in the Tyo-mu district in Makurdi. Rice-field rats, a significant food source for farmers and hunters, are also consumed by other carnivores and omnivores in the Benue area, posing a hazardous threat to humans and their environment [8]. Rattus *argentiventer* is the commonest rodent found in rice crops in Vietnam and it is an important pest of rice crops in other parts of Southeast

Asia including Malaysia and Indonesia. In Indonesia, it causes annual pre-harvest losses of around 17% [9, 10]. It is also the predominant rat species found as a major post-emergence and pre-harvest pest in agricultural farmlands within Makurdi and Nigeria, respectively. Assessing heavy metal accumulation in animals is crucial for public health as they pose a serious threat through their use in food, manure production, and medical testing. In this study, we report for the first time an assessment of the heavy metal level in the hair of *Rattus argentiventer* found within the Tyo-Mu, in Makurdi metropolis. This study is therefore aimed at assessing the heavy metal composition of *ratus argentiventer* Tyo-mu within Makurdi locality in Benue state.

## Experimental

### *Materials*

Analytical grades ethanol, hydrogen peroxide (30 % $H_2O_2$), distilled water, and nitric acid (70% $HNO_3$) were used. Metal analysis was done using an Atomic Absorption Spectrophotometer, SP-IAA4530 (Mingsheng Building, No. 2117 Xinluo Street, High-tech).in department of Chemistry research laboratory, Benue State University.

### *Study Area*

Six samples of rice-field rats, *Rattus argentiventer*, were collected from random selling points districts in Tyo-Mu, Makurdi local government of Benue state (Figure 1). Makurdi is situated at latitude 7015' to 7045' North and Longitude 8015' to 8040' East and 104 meters elevation above the sea level [11]. Assessment of heavy metals in Rice-field Rats in Makurdi Metropolis is crucial to prevent food poisoning and produce pure biological species for medical trials and treatment procedures, as it reduces metal concentrations in their organs, tissues, and wastes [6].

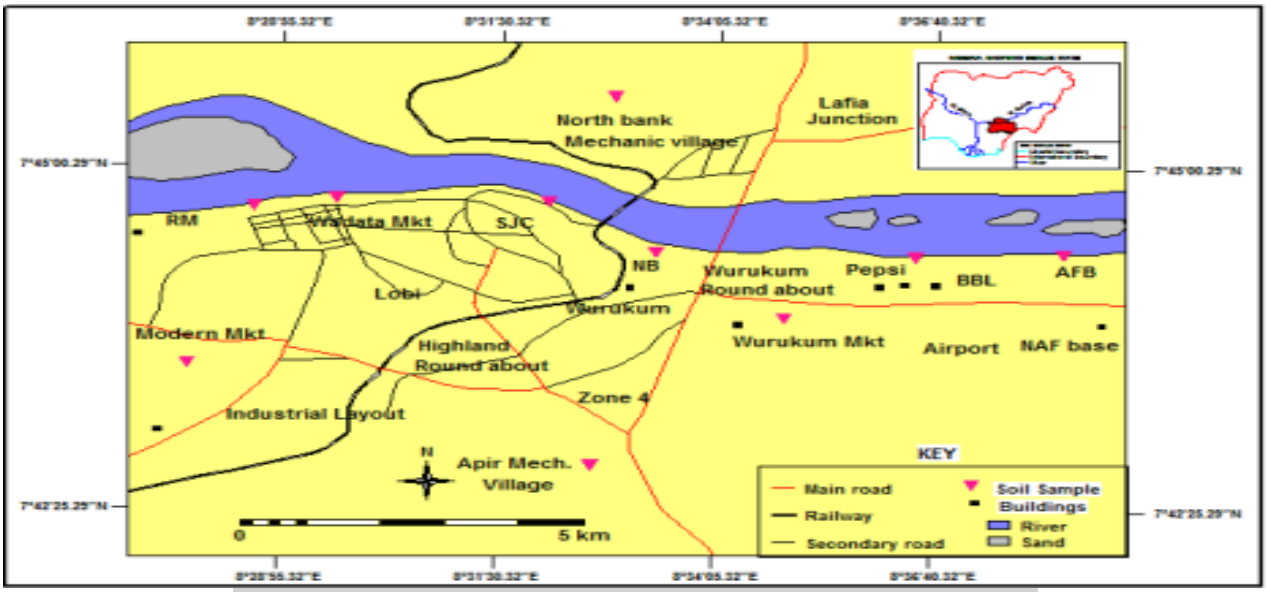


**Figure 1: Map of Makurdi showing the study areas, Tyo-Mu with a circle.**

### *Sampling and Pre-treatment*

The hair samples of *Rattus argentiventer* (**Figure 2)** were collected using sterile scissors. About 200-250 mg of the sample were obtained, then coded and stored. The stored samples were further cut into approximately 0.125 inches (0.3 cm) pieces and mixed to give a representative sub-sampling of the hair specimen. They were washed with distilled water and ethanol according to the recommendation of the International Atomic Energy Agency [12]. They were placed in crucibles and dried in the oven at 75 ± 5$^0$C for 25 minutes or until dried.

**Figure 2: Photo of *Rattus argentiventer* within the Makurdi rice mill (Photo credits:Wikimedia Creative Commons)**

***Sample Digestion for Metal Assay***

Sample preparation for heavy metal analysis was carried out using the acid digestion method. The acid digestion method includes digestion with nitric acid and hydrogen peroxide. They are all termed the "wet digestion technique"; This is quite different from the dry ashing technique, where the samples are heated in a muffle furnace, and the residual ash is dissolved in nitric acid ($HNO_3$) [13, 14, 15].

***Procedures for Nitric Acid ($HNO_3$) Digestion***

The hair samples of the *Rattus argentiventer* (0.107 g) were placed in a 50 mL crucible. Conc. $HNO_3$ (8 mL) was added after which the crucible was covered with the lid, placed on a heating mantle, and heated to a gentle boil. Hair samples were digested at 75-80 $^0$C for about 25 minutes or until the hair was completely digested and the solution looked clear and yellowish. The crucible was not allowed to go dry. When digestion was complete, the lid was removed and more $HNO_3$ was added to approximately 3mL, the crucible was then taken off the heating mantle and allowed to cool to room temperature inside the fume hood. 1 mL of 30 % $H_2O_2$ was added to each sample, the lid was replaced and heating resumed at the lower setting until the bubbling stopped. After this, the temperature was raised gradually to about 80 $^0$C, until the volume was reduced to about 2.5 mL. The content of each crucible was quantitatively transferred to a cleaned and dried 50mL volumetric flask. The digestion vessel was rinsed three times with 1.5 mL of distilled water and added to the 50 mL volumetric flask and was made up to the mark with distilled water. It was then transferred to a cleaned sample bottle, corked, labeled well, and stored in the refrigerator until it was ready to be analyzed. Blanks were also treated in the same manner without samples for each experiment. The procedure employed in this research work was adopted from the work of Onuwa *et al.* [16].

***Analysis of Metals in Samples Using Atomic Absorption Spectrophotometry (AAS)***

The Atomic Absorption Spectrophotometer (AAS) was used in the determination of the concentration of Cd, Cu, Ni, and Zn present in the *Rattus argentiventer*'s hair samples. AAS determinations were done by furnace AAS when the concentrations of the samples were high enough. As long as the flame results were above the detection limit, both techniques gave the same result. The analysis was carried out using respective cathode lamps under standard instrumental conditions, all the spectroscopic measurements of the standard metal solutions as well as the sample solutions were done at their respective wavelengths of maximum absorption, $\lambda_{max}$.

***Quality Assurance and Statistical Treatment of Analytical Data***

The Samples of *Rattus argentiventers*' hairs collected were washed thoroughly with distilled water to avoid contamination. All the glass wares were pre-washed and cleaned with distilled water. The nitric acid used in this experiment was of analytical grade. Reagent blank determinations were used to correct errors. The accuracy of the instrumental methods and analytical procedures was checked by duplications of the samples, as well as using the independent reference standard solutions. Mean and standard deviations were calculated using statistical tools.

## Results and Discussion

Calibration Curves of Heavy metals in Hairs of *Rattus argentiventer* (Rice-field Rats) in Tyo-Mu settlement are shown in Figures 3-6.

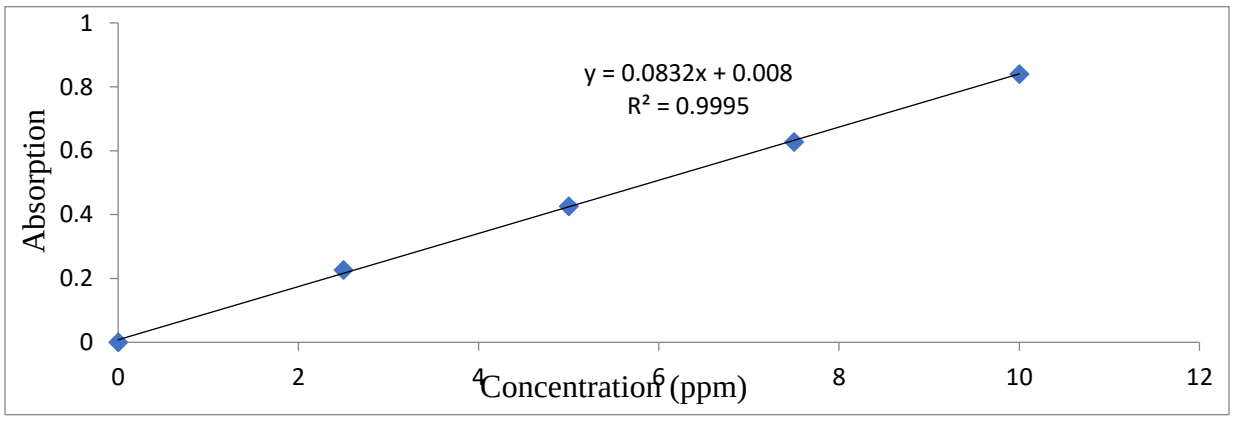

**Figure 3: Calibration Curve of Copper in hair samples of *Rattus argentiventer* in Tyo-Mu District**

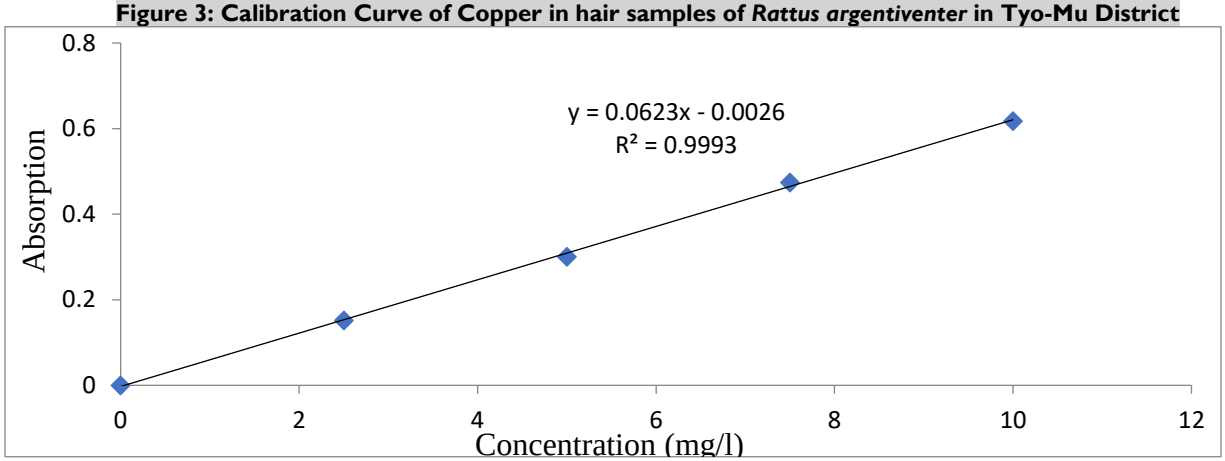


**Figure 4: Calibration Curve of Cadmium in hair samples of *Rattus argentiventer* in Tyo-Mu District**

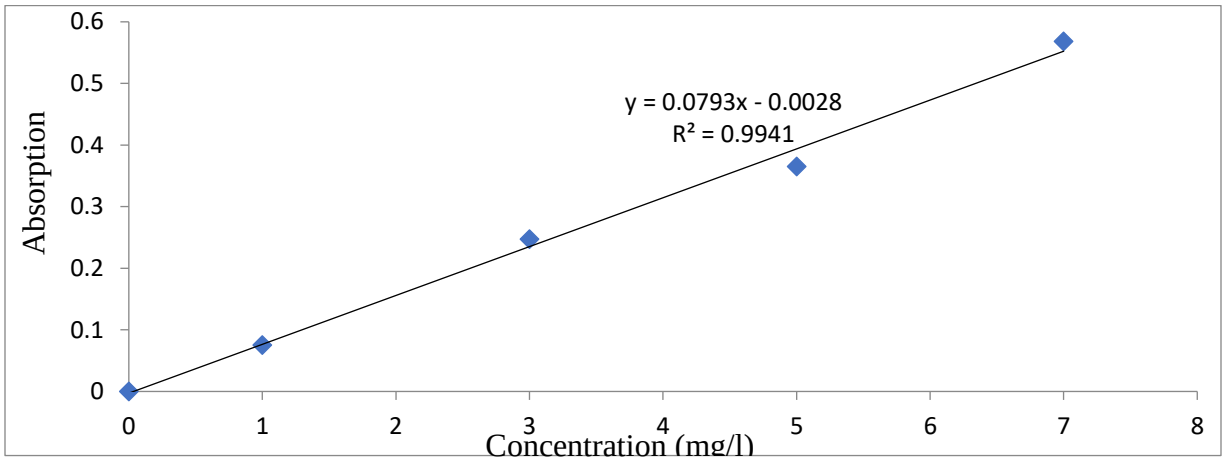


**Figure 5: Calibration Curve of Nickel in hair samples of *Rattus argentiventer* in Tyo-Mu District**

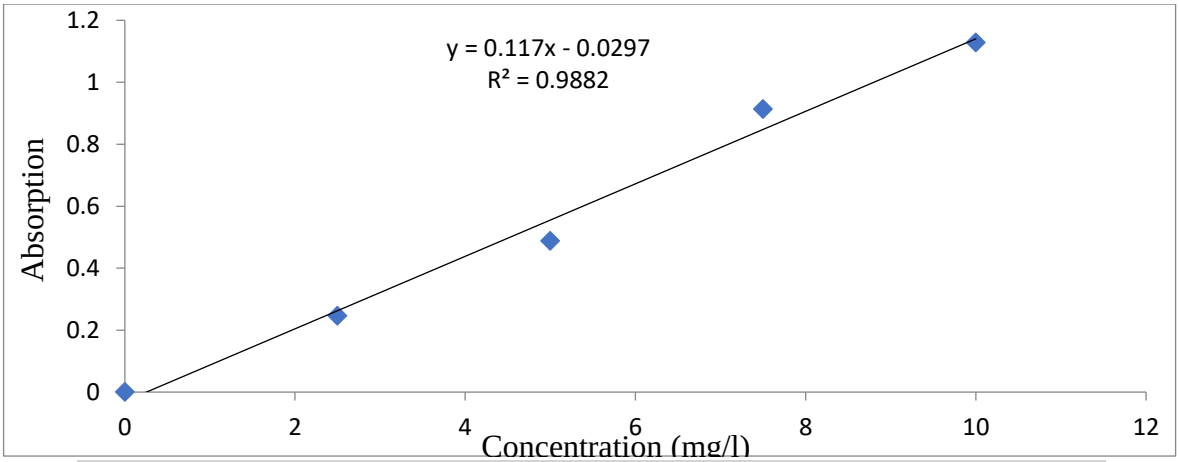


**Figure 6: Calibration Curve of Zinc in hair samples of *Rattus argentiventer* in Tyo-Mu District**

***Heavy Metals Concentration in Hairs of Rattus argentiventer***

The concentration (mg/kg) of heavy metals (Cd, Cu, Ni, and Zn) in individual sample using the Atomic Absorption Spectrophotometer, are shown in Table 1.

**Table 1: Concentration (mg/kg) of Heavy Metals in Hairs of *Rattus Argentiventer* (Rice-Field Rats) in Tyo-Mu District**

| Sample ID | Cu | Cd | Ni | Zn |
|---|---|---|---|---|
| Rh1 | BD | 0.058 | 0.056 | 1.224 |
| Rh2 | BD | BD | 0.008 | 0.575 |
| Rh3 | BD | BD | 0.008 | 1.068 |
| Rh4 | BD | 0.019 | 0.033 | 0.680 |
| Rh5 | BD | 0.021 | 0.019 | 0.914 |
| Rh6 | BD | 0.027 | 0.014 | 0.586 |

BD = Below Detection Limit, Rh=Rat's hair

**Table 2: Mean concentration (mg/kg) of selected heavy metals in the hair samples of *Rattus argentiventer* in Tyo-Mu district**

| Heavy metals | Cd | Ni | Zn |
|---|---|---|---|
| Mean | 0.031±0.02 | 0.023±0.02 | 0.841±0.27 |

**Table 3: Calibration curve parameters (y = ax + b)**

| Heavy Metal | a | b | $R^2$ |
|---|---|---|---|
| Cd | 0.062 | -0.002 | 0.999 |
| Cu | 0.083 | 0.008 | 0.999 |
| Ni | 0.079 | -0.002 | 0.994 |
| Zn | 0.117 | -0.029 | 0.988 |

## Discussion

***Copper***

**Table 1** shows the concentration (mg/kg) of Heavy Metals in Hairs of *Rattus Argentiventer* (Rice-Field Rats) in Tyo-Mu District for all the individual samples. Total copper metal was analyzed at wavelength of 324.4 nm. Calibration curve for Cu is shown in Figure 3. Copper metal was not detected in all the *Rattus argentiventer* (Rice-field rats) samples; it was below detection limit. The detection limit of the instrument was 0.004 mg/L.

***Cadmium***

The calibration curve is depicted in Figure 3. The analysis was performed at working wavelength of 228.9 nm and a bandwidth of 0.4 nm. Results in **Table 1** indicate that cadmium ranges from 0.019-0.058 mg/kg. Sample Rh1 has the highest concentration while Rh4 has the lowest concentration in the surveyed samples. Rh1 as a single value was slightly above the USDA acceptable limit. This explains variation between food contents of the rodents based on location activities, as hair metal content is a residual accumulation of that in their body tissues [16]. However, Chafik [17] reported concentration of cadmium in camel as 0.12 mg/kg, which is higher than all the values of cadmium obtained in this work.

The mean concentration (mg/kg) of Cd is 0.031 ± 0.02 (Table 2). This result indicates a value within the acceptable limit (0.05 mg/kg) of United States Development Agency [18]. The results obtained from this work is in agreement with that carried out by Makanjuola and Olakunle [19], who found that the concentration of cadmium in cassava samples (0.001 mg/kg) was also lower than the value obtained by USDA [18] and in this work, respectively. However, this result was lower than that obtained by Chafik [17] who reported a concentration of cadmium in beef, sheep, and camel to be 0.12 mg/kg, indicating a value of cadmium concentration that was higher than the USDA [18] permissible level of cadmium which is 0.05 mg/kg.

***Nickel***

Ni was detected by its cathode lamp at a wavelength of 213.9 nm. The calibration curve $R^2$ value of 0.988 is shown in Figure 5. Its concentration (mg/kg) ranges from 0.008-0.056, with samples Rh2, Rh3 having same values being the lowest while sample Rh1 has the highest individual concentration (**Table 1**). Nickel was detected in *Rattus argentiventer* from Tyo-Mu district Makurdi, Benue state. The samples had mean concentration (mg/kg) of 0.023 ± 0.02, which is below the

acceptable limit set by USDA [18] and some other international standards such as European Commission [20, 21], Food Standards Australia New Zealand [22] and [23]. These results show all nickel concentrations below the WHO permissible limit of 12.0 mg/kg [24], hence the hair samples of

*Rattus argentiventer* from Tyo-Mu district of Makurdi, Benue State indicates safety with regard to nickel poisoning within this period of time.

***Zinc***

Zinc was detected in all the samples of the Hairs of *Rattus argentiventer*. The calibration curve for Zn is shown in Figure 6, with $R^2$ value of 0.988. This indicates good linearity. The concentration of Zn (mg/kg) in individual samples is presented in Table 1. This ranges from 0.575-1.224 mg/kg. Samples Rh2 and Rh1 have the lowest and highest concentrations, respectively. Zn has the highest overall individual concentration as well as the highest mean concentrations in hair samples of *Rattus argentiventer* from locations under consideration. The mean concentration (mg/kg) of Zn in the hair samples was 0.841 ± 0.27. The concentrations of zinc detected were all below USDA's [18] permissible limit of 50 mg/kg for zinc. This indicates that consumers of *Rattus argentiventer* are not at risk of metal poisoning due to Zinc.

## Conclusion

In conclusion, the assessment of heavy metals in *Rattus argentiventer* from the Tyo-mu districts in Makurdi local government of Benue State reveals significant insights into environmental contamination and its potential impact on both wildlife and human health. Our study detected moderate levels of heavy metals such as cadmium, nickel and zinc as copper was not detected in the hair samples of rice-field rats, indicating considerable environmental content in these mammals, reflective of agricultural constituent of the areas. These findings underscore the need for environmental check and pollution control measures in the region to forestall future degeneration. The presence of these heavy metals does not only pose a potential risk to the health of the local rat population but also raises concerns for the broader ecosystem, including human communities that rely on these agricultural fields. Consuming crops grown in contaminated environmental media can lead to serious health challenges, as these metals are known to have long-term toxic effects. The study found that the mean metal concentration in hair samples of *Rattus argentiventer* in the Tyo-Mu district of Makurdi, Benue state was within permissible limits by WHO and FAO. This indicates that *Rattus argentiventer* hair samples are temporarily safe from heavy metal poisoning. Further analysis in other parts of *Rattus argentiventer*, such as skin, liver, and intestine, could help assess the health risk to meet the United Nations' 2030 sustainable development goals.

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