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A Survey of Heavy Metals Residues in Cattle and Goats Grazing at Duza Mining Field of Zamfara State-Nigeria

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Abstracts:
Background: *Heavy metals refer to any metallic element which has relatively high density and toxic even at low concentration. The epidemic of children deaths and other health difficulties in some rural areas of Zamfara State were traced to heavy metals poisoning resulting from crude gold mining in the area. Therefore, the present study was designed to assess the level of some selected heavy metals residues in the blood of cattle and goats grazing at Duza mining fields of Zamfara state.*
Materials and Methods: *Heavy metal residual concentrations of lead (Pb), cadmium (Cd), copper (Cu), iron (Fe), zinc (Zn) and chromium (Cr) in the blood of cattle and goats grazing at the selected mining field of Zamfara state was determined using atomic absorption spectrophotometer. Blood samples were collected via the jugular vein from fifty (50) each of cattle and goats.*
Results*: The mean values of the heavy metals in parts per million (ppm) were Pb (42.33±19.55 and 39.00± 21.99), Cd (1.92±0.99 and 0.72±0.34), Cu (2.75±1.0 and 3.99±1.14), Zn (14.48±2.07 and14.97±3.61), Fe (27.36±7.57 and 68.83±24.39) and Cr (3.13±2.83 and 48.62± 22.9) for cattle and goats, respectively. There was significant difference between the metal residue levels in cattle and goats ($P< 0.05$). Similarly, the results obtained shows that both species were susceptible to heavy metals bioaccumulation especially Pb and Fe. Heavy metals residues detected in the serum samples of cattle and goats in this study were higher than reference acceptable limits in both species.*
Conclusion*: Animals grazing at the study area could get exposed to heavy metals either through their pasture, water or direct inhalation of wind particles containing these heavy metals. Our findings indicated that the environment is polluted with heavy metals, and could be of great animal and public health implications.*
Key Word: *Heavy metals; Mining field; Toxicity; Cattle; Goats; Zamfara Nigeria*

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I. Introduction

The term "heavy metals" refers to any metallic element that has relatively high density and toxic or poisonous even at low concentration[1]. It is a collective term which applies to the group of metals and metalloids with atomic density greater than 4g /cm[32, 3, 4].The most important heavy metals include lead (Pb), cadmium (Cd), zinc (Zn), mercury (Hg), arsenic (As), silver (Ag) chromium (Cr), copper (Cu), iron (Fe), and the platinum group elements. Living organisms normally require some of these heavy metals up to certain limits for physiological processes and in case excess accumulation occurs it might lead to severe detrimental effects especially in humans and animals [4, 5].The epidemic of children deaths and other health difficulties in some rural areas of Zamfara State were traced to heavy metals poisoning resulting from crude gold mining in the area[6]. However the most important fact is that these heavy metals are harboured by the soil of the area, therefore, even if the mining activities are curtailed, there are still other ways through which the heavy metals get into the food chain and hence continue to affect the lives of the inhabitants of the area[7]. Once heavy metals contaminate the environment, they remain for years accumulating in humans and livestock[8]. Excessive exposure of elements such as cadmium, lead, arsenic, chromium and mercury is toxic to plants, animals and human beings [9]**.**These metals, for example cadmium is toxic to virtually every system in the animal body. Cadmium accumulated within the kidney and liver over long time [10]. It interacts with numbers of minerals mainly Zn, Fe, Cu and Se due to chemical similarities and competition for binding sites. It is also reported that Cd can affects calcium, phosphorous and bone metabolism [11]. Lead toxicity is frequently observed in farm animals, especially in those grazing on pasture in the vicinity of metallurgic complexes and also close to busy roads. Lead is associated with various forms of cancers [12], gout, renal hypertension [13] and damage to central nervous system [14]**.** Sometimes lead may affect the cardiovascular system in humans, can affect the intelligence quotient and can even lead to loss of hearing [15]. When copper is in excess, it binds to albumin forming a complex albumin-copper that is the active toxic fraction. Then it rapidly accumulates within red cells that cause oxidative damage and intravascular haemolysis [16]. An excess of Zn reduces the metabolism of phosphorus, causes anaemia and digestive disorders well as it antagonistic effects on iron and copper [17]. Therefore, the present study was designed to assess the level of some selected heavy metal residues in the blood of cattle and goats grazing at Duza mining fields of Zamfara state.

II. Materials and Methods

Study Area: Duza is one of the villages identified for mining activities in Zamfara state, Nigeria. The village is also called Tungar Daji situated in the north eastern part of Anka Local government, Zamfara State. It lies on longitude 6^0 4'E and latitude 11^0 54' N[18].

Sample Collection and Analysis: Fifty (50) blood samples each from cattle and goats were gently collected from jugular vein, blood (8 ml) samples were immediately transferred in to plain (without anticoagulant) transparent containers and the age (determined by dentition and history from client), sex and breeds of the animals used were noted. The samples were transported on ice packs to the Central Research Laboratory, Usmanu Danfodiyo University, Sokoto. Subsequently, samples were spanned at 3000rb/min for 5 minute to harvest the serum which was later stored at -4°C until required for analysis.

Wet Digestion of Blood Serum for Mineral Analysis: Serum samples from cattle and goats were used for mineral analysis through wet digestion method as described [19]. A 1 ml of serum was taken in to evaporation dish and 5ml of concentrated nitric acid (HNO_3) was added. The contents of the flask were evaporated on a steam bath to half way. The final volume was made to 30ml by adding distilled water. The digested samples were taken to National Research Institute for Chemical Technology, Zaria for mineral (heavy metals) analysis using atomic absorption spectrophotometric (AAS) analysis.

Heavy Metals Analysis: Heavy metals (Pb, Cd, Cr, Cu, Zn and Fe) residues in the digested blood serum were determined by AAS method. The concentrations of the various metals were determined by atomic absorption spectroscopy (AA-6800 SHIMADZU). Samples were aspirated into the flame through the air stream as fine mist, this passes in to the burner through mixing chamber, the air meet the fuel gas (acetylene) supplied to the burner at a given pressure and the mixture was burnt. The radiations from the resulting flame passes through a lense and finally through an optical filter which permits only the radiation characteristics of the element under investigation to pass through the photocell. The atoms held were irradiative with the light produced by the cathode lamp. These atoms held absorbs some of the incident radiation, and the amount absorbed is proportional to the concentration of the element in the sample in mg /l, then the output from the photocell was measured on a suitable digital readout system and was finally printed out via a printer. The respective actual concentration of each metal analyzed were multiplied by the dilution factor (30 ml) used during digestion.

***Statistical Analysis*:** Data were analyzed using statistical package for social sciences Version 22. The obtained values were presented as mean and standard deviation and result was analyzed using student's *t*-test (two tailed), $P < 0.05$ was considered significant.

III. Result

The mean heavy metal residues in the blood of cattle and goats grazing at Duza mining fields of Zamfara state is shown in Table 1.

Table no 1: Heavy metal residues in the blood of cattle and goats grazing Duza mining field of Zamfara state.

Heavy Metals	Reference level (ppm)	Cattle (ppm)	Goats (ppm)
Lead	0.05 - 0.25[2]	42.33 ± 19.55^a	39.00 ± 21.99^a
Cadmium	0.015 - 0.05**	1.92 ± 0.99^a	0.72 ± 0.34^b
Copper	0.7 - 1.3[1]	2.75±1.0	3.99±1.14
Zinc	0.015**	14.48 ± 2.07^a	14.97 ± 3.61^a
Iron	130*	27.36 ± 7.57^a	68.83 ± 24.39^b
Chromium	3*	3.13 ± 2.83^a	48.62 ± 22.9^b

Reference level [20 (1), 21 (2), 22**, 23*].Values with different superscript across the rows are statistically significant (P<0.05).

As demonstrated in Table 2, the sex of the animal has no statistical significance on the bioaccumulation of heavy metals in the study area. Similarly, heavy metal residues in the two age groups studied namely < 2 and ≥ 2 years, and < 1.5 and ≥ 1.5 years for cattle (Figure 1) and goats (Figure 2), respectively were not statistically significant.

Table no 2: Heavy metals residues according to the sex in cattle and goats grazing Duza mining field of Zamfara State.

Species	Sex	Metals Concentration in ppm					
		Pb	Cd	Cu	Zn	Fe	Cr
Cattle	Male	44.14±19.03[a]	1.82±0.93[a]	2.78±1.17[a]	14.35±2.04[a]	27.75±8.09[a]	3.38±3.04[a]
	Female	34.12±20.89[a]	2.37±1.17[a]	2.63±0.72[a]	15.05±2.22[a]	25.59±4.47[a]	2.01±1.04[a]
Goats	Male	34.82±27.74[a]	0.63±0.33[a]	3.99±1.33[a]	14.81±4.38[a]	68.38±24.48[a]	49.28±24.94[a]
	Female	40.32±20.12[a]	0.75±0.35[a]	3.99±1.09[a]	15.01±3.40[a]	68.98± 24.68[a]	48.41±22.58[a]

Values with different superscript across the rows are statistically significant ($P < 0.05$).

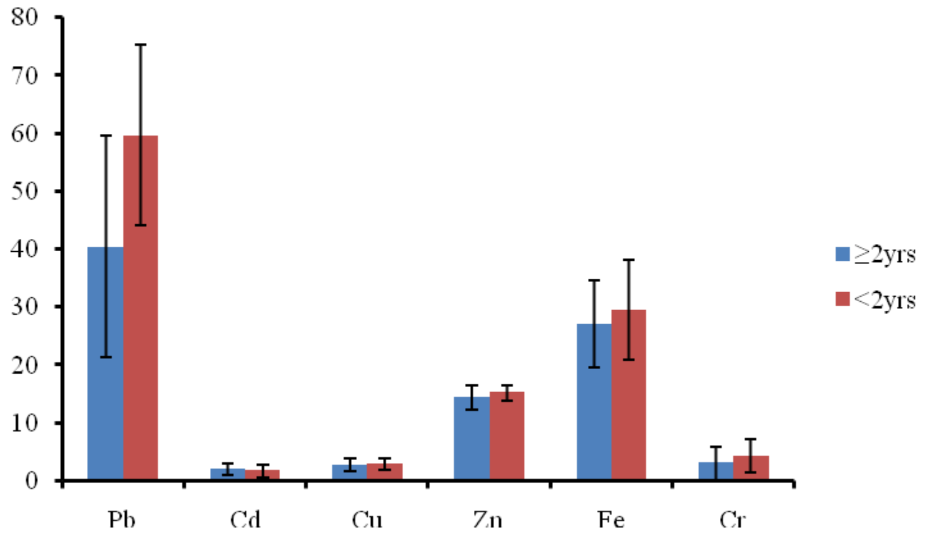

Figure no 1: Heavy metals concentration based on age in cattle grazing Duza mining field of Zamfara State.

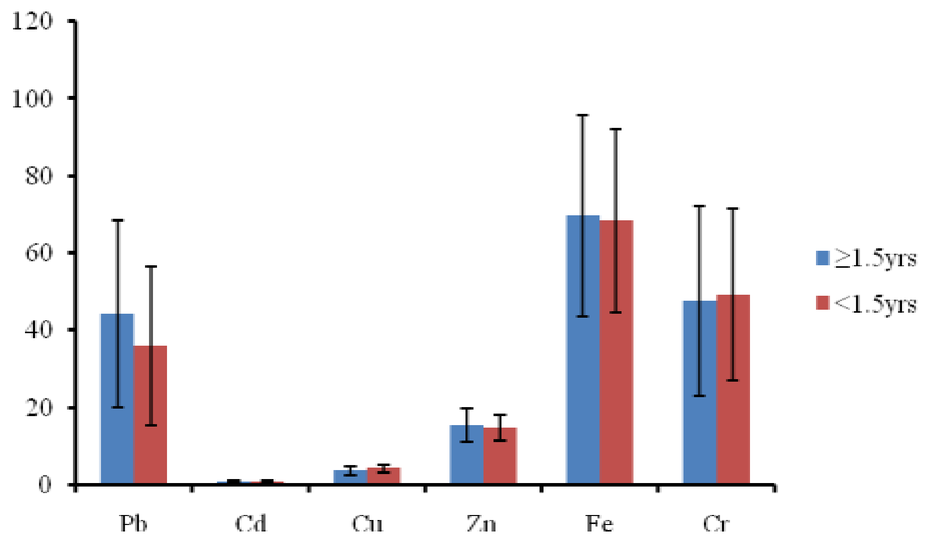

Figure no 2: Heavy metals concentration based on age in goats grazing Duza mining field of Zamfara state.

IV. Discussion

The evaluation of heavy metals residues especially Pb in livestock is important for the assessment of the potential effects of pollutants on grazing animals and their consequence on humans through consumption of milk and meat [24]. The mean concentrations of Pb in cattle and goats were greater than reference blood Pb level of 0.05 - 0.25 and 0.05 in ppm for ruminant and humans, respectively[25, 26]. Similarly, the results were also higher than the blood Pb (0.144 ppm) level for cattle reared in polluted mining area as demonstrated by Leonidis and co-researchers [27]. Although, the results obtained were lower that the Pb concentration demonstrated previously [28]. In that study, the mean Pb levels were 57.6±50.05mg/kg and 77.6±20.8mg/kg in cattle and goats, respectively. Furthermore, in this study the mean heavy metal residue (e.g. Pb) was not statistically significant

(P>0.05) between species studied, i.e. cattle and goat. However, Pb concentration of 10 ppm in the liver or kidney is diagnostic in Pb poisoning in most animal species [21]. Lead toxicity can occur as a result of bio-accumulation in the body tissues and this varies with individual animal and the duration of exposure [29, 30]. The mean concentrations of Cd in cattle and goats were higher than the maximum allowed limit of 0.288 ppm [27].The level of Cd and Pb in the blood of cattle and goats might be responsible for some of the clinical signs such as loss of appetite, anemia, poor growth, abortions and teratogenic effects encountered by the animals in the area. Cd and Pb toxicities have been demonstrated to cause the aforementioned conditions [31, 32].

The mean concentrations of copper in cattle and goats were higher than the reference blood copper level of 0.7-1.3 ppm [20]. It was demonstrated that kidney level greater than 15 ppm is significant in acute copper toxicosis. Similarly, liver concentration greater than 150 ppm was found to be significant in sheep [21].The obtained values were also higher than reference values of 0.48±0.120 mg/L in cattle [33], therefore copper concentrations in cattle and goats could be inadequate to present clinical symptoms in this study. Furthermore, the Zn concentrations between cattle and goats were not significantly different. But, the obtained values in both species were higher than the blood Zn concentration obtained in male (2.80 mg/l) and female (2.22 mg/l) cattle as demonstrated by previous researchers [34]. Also, the median lethal dose (LD_{50}) of zinc salts in cases of acute toxicity has been reported to be 100 mg/kg. Similarly, diets containing high levels of zinc (> 2,000 ppm) have been reported to cause chronic zinc toxicity in large animals[35]**.** Thus, high exposure to Zn as shown in this survey constitutes a major health challenge to the livestock grazing in the study area. Moreover, Fe concentrations between cattle and goats were not significant; however, both species are vulnerable to Fe bioaccumulation. Iron concentration in cattle was higher than the reference values (4.04±0.710) in apparently healthy cattle [36]. Cattle and sheep have been killed by excessive dosing with ferric ammonium citrate and other iron preparations [37].Furthermore, the mean Cr concentration in goats was significant compared to the values obtained in cattle as well as the reference value reported [23]. Despite the lower concentration of Cr recorded in cattle, cumulative toxic effect could still occur over time. Wind erosion of the soil increases the chance for inhalation of Cr, hence chromium compounds could spread by rainwater through cracks in soil, asphalt roadways and masonry walls which ultimately forms chromium crystals on surface [38].

Based on our findings, animal sex has no statistical significance for heavy metals accumulation in the blood of both sexes studied. This could be that males and females are equally at risk of heavy metals bioaccumulation. Similarly, age and sex have been described as important sources of disparity in bioaccumulation of heavy metals [33]. Heavy metals can cause severe toxicity in various animal species affecting different organs. They can enter into water via drainage, direct inhalation of wind particles containing them, soil erosion and all forms of human activities. As the heavy metals concentrate more in the environment, they enter biogeochemical cycle, leading to toxicity and potential public health consequence [7].

V. Conclusion

The present study has demonstrated the vulnerability of cattle and goats to heavy metals toxicity. Most importantly, Pb and other heavy metals (Cd, Cu, Zn, Fe and Cr) could continuously contaminate the study area and thus exposing animals and humans to their bioaccumulation and consequence toxicity.

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