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Concentration of selected heavy metals in the hair, kidneys and livers of cattle and goats raised on in the oil and non – oil producing areas of Delta State

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Target Audience: Animal Scientists, ruminant farmers and consumers

Abstract

This study evaluated the levels of selected heavy metals namely: lead cadmium, mercury and chromium in the hair, kidneys and livers of cattle and goats reared on oil producing and non oil producing areas of Delta state, Nigeria. Samples of hair, kidneys and livers were collected from four purposively selected local government areas in four replicates, oven dried and digested with 20 mL of a 1:3 mixture of concentrated perchloric acid ($HClO_4$) and trioxonitrate (v) acid (HNO_3). A completely randomized design was used for the the study. Results showed that mean concentration (mg/kg) of lead in the hair (0.049) of cattle from the oil producing areas varied significantly from those of kidney (0.033) and liver (0.021). While mean lead concentration values showed non - significant variations in the organs obtained from cattle and goats in non oil-producing areas. Cadmium values (mg/kg) ranged from 0.010 to 0.045 in cattle and from 0.000 to 0.029 in goats with significant variations between the organs. Mean values of mercury concentration (mg/kg) in cattle were between 0.053 to 0.078 and 0.052 to 0.056 in goats from theoil producing areas. Mercury concentration in the organs of cattle in the non- oil producing areas varied significantly. Chromium concentration (mg/kg) of organs in cattle from the oil producing areas varied from 0.019 to 0.024 and 0.010 to 0.030 in the non -oil producing areas. Mean concentration in the hair, kidney and liver (0.010 - 0.046 mg/kg) of goats in both the oil producing areas and non - oil producing areas did not vary significantly. Also, in cattle, the effect of oil exploration was significant in the concentration of cadmium (0.016 vs 0.043) and chromium (0.016 vs 0.022) in the kidney as well as cadmium (0.010 vs 0.045), Hg (0.031 vs 0.053) and chromium (0.010 vs 0.019) in the liver. In goats, it was significant in the concentration of cadmium in the hair (0.000 vs 0.056) likewise mercury in the kidney (0.031 vs 0.055) of cattle as well as in the hair and liver of goats. Generally, the heavy metals were below or within the tolerable limits set by some regulatory bodies.

Keywords: Heavy metals, hair, organs, maximum tolerant.

Description of Problem

In Nigeria, ruminants are mostly free grazers and drink water from ditches, streams, rivers and other possible contaminated water sources. It was noted by (1) that most of the wastes from surrounding industries in Nigeria are either dumped on the roadsides or use as landfills while sewage is used for irrigation. However, ruminants graze along runways and other sites that might have been contaminated with toxic substances. According to (2) and (3) these toxic substances which are usually non-essential elements could be transferred through food chain to the animals and then to man. Therefore, it is possible that this eating habit of cattle and goats may lead to bioaccumulation of heavy metals in their organs and tissues where several detoxifications take place. These muscles and organs (including intestines)are sold in the market to the populace for consumption (4). Cadmium, lead, and arsenic are classified as heavy metals with strong toxic properties such as inducing multiple organ damage. Lead is widely distributed in all animal tissues, but its greatest concentrations are found in the bone, kidneys, liver, and muscles. According to the report of (5), lead is one of the major environmental pollutants, and its toxicity is one of the most frequently reported causes of acute poisoning in farm animals, especially cattle (6). Lead is poisonous to animals and is present in appreciable amounts in soils, sewage sludge and exhaust fumes (leaded gasoline). Lead exposure can also causes anaemia and increase in blood pressure, particularly in middle-aged and older people. Also, exposure to high lead levels can severely damage the brain and kidneys in adults or children and ultimately cause death (7).

Quantifying the transfer of cadmium from foods to mammalian target organs is a key to estimating the health risk from this exposure. For instance, the kidney is well known to be a major target organ of cadmium in animals and humans (8). Studies conducted on sheep and other ruminant animals indicated that absorbed cadmium bound to metallothioneins accumulates at greatest concentrations in the kidneys and liver (9). Also (10) reported that some heavy metals were detected in the tissues and organs of some of calves, and the most affected organs were the livers, kidneys and small intestines. Thus, exposure of ruminants to heavy metals are unavoidable though levels of exposure to most chemicals are usually low to induce any physiological effects, combination of pollutants can act additively to perturb multiple physiological systems (11).

Delta state is a major oil producing state and ranked second to Rivers state in Nigeria. The state supplies about 35% of Nigeria crude oil and some considerable amount of natural gas (12). It shares the common boundaries with Edo, Bayelsa and Anambra states. The state plays host to one of the three refineries in the country and many other petrochemical subsidiaries. As such, routine effluent discharge in the immediate environment is not in doubt (12). This study was undertaken to determine the concentration of selected metals (Cd, Pb, Cr, and Hg) in the hairs, livers and kidneys of cattle and goats raised in Delta state - located in the Niger-Delta area where there are plenty of industrial activities with the release of some heavy metals (pollutants).

Materials and Methods

Study area

The study was carried out in four Local Government Areas (LGAs) namely, Ughelli, Warri, Sapele and Oshimilli (Asaba) LGAs of Delta state. Delta state is located on Latitude 5° 40N and 5° 43N and Longitude 6º 34E and 6° 38E (12). Hair, kidney and liver from cattle and goats were sampled from the locations for some heavy metal analysis. The heavy metals considered in this study were Lead (Pb), Mercury (Hg), Cadmium (Cd) and Chromium (Cr).

Animals and experimental design

The four LGAs were purposely selected to include Ughelli, Warri, Sapele from the oil producing area (OPA) and Oshimilli (Asaba) from the non-oil producing area (NOPA). The experimental design used for the study was completely randomized design. Thirty-two animals comprising sixteen each of cattle and goats were sampled from the four LGAs in which three had oil exploration activity and one did not.

Sixteen each of cattle and goats with records of at least three (3) months in the study area were randomly selected per LGA for collection of hair, liver and kidney samples. The hair samples were collected by means of a scalpel into sample bottles. The animals were slaughtered in the abattoir and the liver and kidney samples were collected, put in bags and transported in ice boxes to the refrigerator where they were kept pending the time for analysis. A total of ninety-six (96) samples were analyzed for cadmium, lead, chromium and mercury concentrations during this study.

Sample preparation

The liver and kidney samples were weighed and oven dried at 100^0 C for 24 hrs and then to a constant weight. They were milled and kept in air tight containers for chemical analysis. The hair samples were also oven dried and also kept in air containers for laboratory analysis.

Chemical analysis

Analysis for the concentration of heavy metals under investigation was done using the standard procedure of (13). One gram (1g) each of the dried and milled samples of liver, kidney and hair samples were weighed into kjeldhal flasks and digested using 20 mL of mixture of concentrated perchloric acid ($HClO_{4)}$ and trioxonitrate (v) acid (HNO_3) in a ratio 1:3. The digests were washed into 100 mL volumetric flask and concentrations of Pb, Cd, Cr and Hg were read in a UNICAM series 969 Atomic Absorption Spectrophotometer (AAS) (UK).

Statistical analysis

Data collected were subjected to analysis of variance (ANOVA) using the statistical software of (14) in a completely randomized design and significant means were separated using Duncan multiple range test.

Results

Table 1 presents the concentration of Lead (Pb), Cadmium (Cd), Mercury (Hg) and Chromium (Cr) in the hair, kidney and liver of cattle. Lead concentration (mg/kg) in the hair (0.049) varied significantly ($P < 0.05$) from those in the kidney (0.033) and liver (0.021) of cattle found in oil producing areas (OPA). While in the non – oil producing areas (NOPA), no significant differences ($P > 0.05$) existed in the Pb content of the organs. Cd concentration was significantly ($P < 0.05$) highest (0.045 mg/kg) in the liver of cattle found in the OPA. However, in the NOPA, Cd concentration was highest in the hair. The concentration of mercury was highest in the hair of cattle in both the OPA and NOPA, though not significantly different ($P< 0.05$) from the Hg concentration in the organs in the OPA. In the NOPA, Cr concentration was significantly highest in the hair (0.030 mg/kg) and non - significant variations ($P > 0.05$) were observed among the organs in the OPA. Location effect was noticed in the deposition of Pb, Cd, Hg and Cr in the kidney and liver. In most cases, comparisons between the concentrations of the heavy metals in the OPA and NOPA revealed significantly higher values in the OPA than the NOPA except for Pb.

Table 1: Concentration of heavy metals (mg/kg) in organs of cattle raised in the oil producing areas (OPA) and non – oil producing areas (NOPA) of Delta State

		Organs (Org.)				Significance		
Heavy metal	Activity (Act.)	Hair	Kidney	Liver	SEM	Org.	Act.	Org*Act.
Pb	OPA	0.049_A^a	0.033_B^b	0.021_B^b	0.003			
	NOPA	0.066_A^a	0.072_A^a	0.062_A^a	0.002	0.0073	< 0.001	0.1792
	LSD	0.022	0.028	0.024				
Cd	OPA	0.020_A^b	0.043_A^a	0.045_A^a	0.003			
	NOPA	0.030_A^a	0.016_B^b	0.010_B^b	0.002	0.0631	0.0068	0.0107
	LSD	0.024	0.023	0.026				
Hg	OPA	0.078_A^a	0.071_A^{ab}	0.053_A^b	0.004			
	NOPA	0.045_A^a	0.041_A^{ab}	0.031_B^b	0.002	0.0365	0.0016	0.8557
	LSD	0.026	0.044	0.022				
Cr	OPA	0.024_A^a	0.022_A^a	0.019_A^a	0.005			
	NOPA	0.030_A^a	0.016_B^b	0.010_B^b	0.002	0.6568	0.7401	0.7474
	LSD	0.042	0.037	0.032				

Means with common superscripts (a, b) along the row (organ) or with common subscripts (A, B) along the column (activity) for respective heavy metals are not significantly different (P > 0.05)

Table 2 shows the concentration of the studied heavy metals in the hair, kidney and liver of goats in Delta State. The concentration of lead (0.026 – 0.059 mg/kg) and cadmium (0.000 – 0.029 mg/kg) in the hair and organs of goats in the OPA (0.033 – 0.054 mg/kg) varied significantly,while those of Hg and Cr concentrations in the same location showed no significant variation. The Pb (0.031 – 0.056 mg/kg) and Hg (0.052 – 0.056 mg/kg) concentration of the organs of goats in NOPA followed a similar trend of non – significance, while Cr and Cd concentration in the hairs of goats were significantly highest in the NOPA. In addition, location effect showed no significant differences for all the metals studied, except for Hg in the kidney and Cd in the hair. Lead concentration in the hair, kidneys and livers of cattle in both areas showed significant difference in the kidney and liver samples. However, in comparing the concentration of lead in the hair (0.059 vs 0.056 mg/kg), kidney (0.040 vs 0.031 mg/kg) and liver (0.026 vs 0.031 mg/kg) of goats in the oil producing and non- oil producing areas, there were no significant differences (P > 0.05) in the values obtained.

Table 2: Concentration of heavy metals (mg/kg) in organs of goats raised in the oil producing areas (OPA) and non – oil producing areas (NOPA) of Delta State

		Organs				Significance		
Heavy metal	**Activity**	**Hair**	**Kidney**	**Liver**	**SEM**	**Org.**	**Act.**	**Org.*Act.**
Pb	OPA	0.059_{A}^{a}	0.040_{A}^{b}	0.026_{A}^{b}	0.002	0.0001	0.6398	0.5918
	NOPA	0.056_{A}^{a}	0.031_{A}^{a}	0.031_{A}^{a}	0.006			
	LSD	0.027	0.025	0.016				
Cd	OPA	0.000_{B}^{b}	0.029_{A}^{a}	0.028_{A}^{a}	0.004	0.0655	0.5165	0.1104
	NOPA	0.020_{A}^{a}	0.010_{A}^{b}	0.010_{A}^{b}	0.000			
	LSD	0.000	0.042	0.042				
Hg	OPA	0.056_{A}^{a}	0.055_{A}^{a}	0.052_{A}^{a}	0.003	0.7754	0.0061	0.7898
	NOPA	0.040_{A}^{a}	0.031_{B}^{a}	0.035_{A}^{a}	0.002			
	LSD	0.020	0.015	0.036				
Cr	OPA	0.015_{A}^{a}	0.012_{A}^{a}	0.012_{A}^{a}	0.005	0.5333	0.1347	0.4387
	NOPA	0.046_{A}^{a}	0.020_{A}^{b}	0.010_{A}^{b}	0.003			
	LSD	0.044	0.034	0.035				

Means with common superscripts (a, b) along the row (organ) or with common subscripts (A, B) along the column (activity) for respective heavy metals are not significantly different ($P > 0.05$)

Discussion

Lead concentration (mg/kg) of cattle in oil producing areas was highest in the hair, (0.049) and was significantly different from those in the kidney and liver. This is in line with the findings of (15) that concentration of lead was much greater in the hair than in other tissues, when a survey on lead and cadmium levels in different tissues of pigs in Hungary was carried out. This could be due to the accumulation of lead on the hair of the animals' overtime, and the greater saturation of binding sites of lead in the hair (16). In addition, higher lead concentration in the hair could be as a result of the abundance of cysteine residues, the sulfhydryl group. This might probably bind with divalent cations such as lead and cadmium, resulting in their deposition in the hair for a long time (17 and 18). The concentration of Pb in the kidney and liver were significantly higher in the non-oil producing than the oil producing area of Delta State. In goats, the values of lead obtained were however, higher than the mean lead concentration values of 0.005 mg/kg and 0.001 mg/kg for liver and kidney respectively reported by (19). The results of this study also showed that lead pollution may not only be a function of industrial activities but also from vehicular emissions and agricultural activities. This however is in consonance with the reports of (20) that cars emit colloidal lead and uncombusted lead (Pb) particulates, containing tetra-akyl lead, motor oil, cadmium from tyres and zinc, chromium and others from wear of moving metallic parts in a car . The high Pb values obtained in the NOPA during this study were in line with the findings of (21) who reported that Pb values of 0.061 and 0.109 mg/kg in liver and kidney of cattle collected from areas of high traffic in a study on Pb concentrations in different animals. In addition, a researcher (22) reported similar Pb values of 0.08 ppm in livers and 0.10 ppm in kidneys of Canadian slaughtered sheep and lambs. The highest mean lead concentration values obtained during this study were lower than the permissible limit of 0.5 mg/kg for kidney and liver as stated by (23). In cattle, Cd concentration of hair samples from the oil and non-oil producing areas were not significantly different. Cadmium concentrations obtained were found to be lower than those reported by (24) for calves from polluted areas of Northern Spain. However, similar values though lower, were reported by (25) for cattle liver; in Finland (0.061 mg/kg); in Sweden (0.070 mg/kg) and in Holland (0.105 mg/kg). However, values obtained were within the 0.07 – 3.08 mg/kg mean concentration range reported by (26). The results obtained in the study were lower than the maximum tolerable level of 0.5 mg/kg cadmium in the liver (27) and 1 mg/kg in the kidney (28).

The mean concentration of mercury (Hg) in hair (0.078 mg/kg) and from oil producing and non oil producing areas showed significant differences from that ine liver (0.053 mg/kg). During this study, Hg values obtained in the kidney and liver were similar to Hg levels of 0.02 ppm, in livers and 0.03 ppm, in kidneys of Canadian slaughtered sheep and lambs reported by (22) as well as the 0.094 and 0.014 ppm in the kidney and liver respectively for Indian slaughtered goats reported by (29). The mercury concentration values obtained were below the maximum tolerant level of 2 mg/kg (27).

In the non-oil producing areas, Cr concentration in the hair was significantly higher than those in the kidney and liver. The Cr concentration in goats showed no significant variation in both areas. Mean concentration values obtained during this study varied between 0.019 – 0.024 mg/kg and 0.010 – 0.030 mg/kg for cattle in the oil producing and non- oil producing areas respectively, while concentration values in goats varied between 0.012 - 0.015 mg/kg in oil producing and 0.010 -0.046 mg/kg in the non oil producing areas. The values were lower than the highest mean concentration value of 1.22±0.21 mg/g reported by (30) in caprine liver after a study on distribution of heavy metals in the liver, kidney and meat of beef, mutton, caprine and chicken from kasuwan shanu market. Similar values (0.040 mg/kg ± 0.027 mg/kg for kidneys and 0.046 ± 0.030 mg/kg for livers) were also reported by (31) for goats slaughtered at Atakpa Abattoir, Calabar South, Cross River State, Nigeria. The values obtained during this study were lower than the maximum tolerable limit of 0.1 mg/kg (27).

Conclusion and Applications

1. The results obtained from this study showed that mean concentrations of heavy metals in the hair of cattle from the non oil producing areas and oil producing areas were not significant
2. There were significant variations in lead, cadmium, mercury and chromium concentrations of the liver as well as in the kidney but not in Hg concentrations between the oil producing areas and non oil producing.
3. Mean concentration values obtained for all the samples were below the maximum tolerant limit set by some regulatory bodies.

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