Concentration of some heavy metals in the hair, kidney and liver of cattle and goats in the oil and non-oil producing areas of Ondo State

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Abstract

Pollutions due to anthropogenic sources have made some animals possible carriers of certain toxic substances which could have detrimental effects on humans. In this study, the concentrations of lead (Pb), cadmium (Cd), mercury (Hg) and chromium (Cr) in the hair, kidney and liver of cattle and goats in the oil producing areas (OPA) and none oil producing areas (NOPA) of Ondo state, Nigeria, were evaluated. Hair, kidney and liver samples were collected from four purposely selected Local Government Areas in Ondo state in replicates, dried and digested using a 1:3 mixture of concentrated perchloric acid (HClO_4) and trioxonitrate (v) acid (HNO_3). Data collected were analyzed completely randomized design (CRD) and significant means were separated using Duncan multiple range test. Lead concentration (mg/kg) were not significantly different in the organs of cattle (mean = 0.076) and goats (mean = 0.043) in the OPA but varied significantly in the NOPA with highest values in the hair of cattle (0.081) and kidney of goat (0.056). Oil exploration effect was only significant in Pb deposition in the kidney. Cadmium values (mg/kg) ranged from 0.009 to 0.031 in cattle and from 0.010 to 0.020 in goats with no significant variation. However, oil exploration showed significant effect in the Cd deposition in the kidney of cattle. Mean values of mercury concentration (mg/kg) in cattle were between 0.022 to 0.054 and 0.029 to 0.039 in goats from the OPA. In the NOPA, Hg concentration did not vary significantly in the organs of cattle but showed significant variation in the organs of goats with values ranging from 0.016 – 0.046 mg/kg. Chromium concentration (mg/kg) varied between 0.004 to 0.020 in cattle and 0.005 to 0.025 in goats with no significant variation.

Conclusively, all the heavy metal concentrations obtained from analysis of the hair, kidney and liver from both the oil producing and the non – oil producing areas were below permissible limits reported by some regulatory bodies.

Keywords: Heavy metals, cadmium, lead, chromium, mercury, permissible limits

Introduction

Animal proteins have very high biological value and make a complete protein in the presence of essential amino acids (Bastin, 2007). However, the current state of the environment as a result of pollution due to anthropogenic sources such as commercial fertilizers, liming materials, agrochemicals and other materials used as soil

amendment, irrigation water and atmospheric decomposition (Senessi *et al.*, 1999) which are known to contain high levels of toxic metals and metalloids such as lead (Pb), cadmium (Cd), mercury (Hg) and arsenic (As) has made these animals possible carriers of some toxic substances, especially hairs, kidneys and livers which are sites of reception, purification and

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elimination. These animals especially ruminants which are mostly free grazing are exposed to environmental pollutants which are released into the air, soil and surface water as a result of unguided dumping, deliberate application and accidental discharge of industrial and agricultural effluents (Ogbuagu *et al.*, 2005). They are also exposed to waste products from vehicles that ply highways, emissions from exhaust pipes of automobile engine; pollutants from indiscriminate exploitation of natural resources, coal burning etc, which contributes cadmium, arsenic, mercury etc to the surroundings (Hammond and Bellies, 1980).

Toxic metals can be defined as heavy metals which are neither essential nor have beneficial effect. On the contrary, they display severe toxicological symptoms at low levels and are also defined as metals with specific weight more than 5 g/cm³ (Akan *et al.*, 2010). The level of these heavy metals in the environment and subsequently in the diet of man (both plant and animal sources) is very significant to the health of man. High concentration of these heavy metals above the threshold limits is as a result of bioaccumulation, which can severely affect the proper functioning of some important tissues, organs and systems of the body, thereby leading to various illnesses and sometimes death. This study was therefore undertaken in order to determine the levels of concentration of some of these metals (Cd, Pb, Cr, and Hg) in the hairs, livers and kidneys of cattle and goats in some areas in Ondo state.

Materials and methods

Study location

This study was carried out in four purposely selected (4) local government areas (LGA's) in Ondo state. Three from the oil

producing areas (OPA) namely Ilaje, Okitipupa, Odigbo and the fourth, Akure, which is a none / less oil producing area (NOPA).

Sample collection

Samples of hair, liver and kidney were collected from a total of thirty-two (32) animals (sixteen cattle and sixteen goats) the study area. The hair samples were collected by means of a scalpel into sample bottles. The animals were sacrificed in the abattoir and the liver and kidney samples were collected, put in bags and kept in the refrigerator pending the time for analysis. A total of ninety- six (96) samples were analyzed for cadmium, lead, chromium and mercury concentrations.

Sample preparation

The liver and kidney samples were weighed and oven dried at 100°C to constant weight. They were milled and kept in airtight containers pending chemical analysis. The hair samples were also packaged for laboratory analysis.

Chemical analysis

Analysis of the concentration of heavy metals under investigation was done using the standard procedure of AOAC (2005). One gram (1g) of the dried ground liver and kidney samples were weighed into a 250mL conical flasks. 20mL of mixture of concentrated perchloric acid (HClO₄) and trioxonitrate (v) acid (HNO₃) in a ratio 1:3 was added. The mixtures were heated on an electric burner, till crystal clear solutions were obtained. The clear solutions were allowed to cool. 5mL of 20% HCl were added to the solutions and properly stirred, filtered into a 100mL volumetric flasks and made up to mark with distilled water. The digests were analyzed for lead, cadmium, chromium and mercury in a UNICAM series 969 Atomic Absorption Spectrophotometer (AAS).

Statistical analysis

Data collected were subjected to analysis of variance (ANOVA) using the software of SAS in a completely randomized block design (CRD) and significant means were separated using Duncan Multiple Range Test (SAS, 2004).

Results

Table 1 presents the concentration of the heavy metals in the hair, kidney and liver of cattle. Concentration (mg/kg) of lead (Pb) did not vary significantly (0.060 – 0.100) in the hair and organs in the oil producing areas (OPA), but was significantly higher (0.081) in the hair of cattle in the non – oil producing areas (NOPA). Location effect

was only noticed in Pb concentration of the kidney and was significantly higher in the OPA. Cadmium concentration in organs both in the OPA (0.009 – 0.015 mg/kg) and NOPA (0.016 – 0.031 mg/kg) were not significantly different. There was a significant effect of location on the Cd concentration of the kidney. The concentration of Hg in the hair, kidney and liver showed no significant variation (0.022 – 0.054 mg/kg) in both the OPA and NOPA. Similarly, there was no significant difference in the Cr concentration (0.004 – 0.020 mg/kg) of the hair and organs studied. Location effect was also not significant for the Cr concentration.

Table 1: Effect of oil exploration, on the concentration of heavy metals (mg/kg) in some organs of cattle in Ondo state

Heavy metal	Activity (Act.)	Organs (Org.)			SEM	Org.	Act.	Org.*Act.
		Hair	Kidney	Liver				
Pb	OPA	0.068 ^a _A	0.060 ^a _A	0.100 ^a _A	0.022	0.7410	0.4885	0.7095
	NOPA	0.081 ^a _A	0.031 ^b _B	0.031 ^b _A	0.002			
	LSD	0.019	0.019	0.027				
Cd	OPA	0.015 ^a _A	0.010 ^a _B	0.009 ^a _A	0.004	0.5704	0.0500	0.6852
	NOPA	0.025 ^a _A	0.031 ^a _A	0.016 ^a _A	0.003			
	LSD	0.044	0.017	0.015				
Hg	OPA	0.051 ^a _A	0.054 ^a _A	0.022 ^b _A	0.005	0.0101	0.7325	0.5662
	NOPA	0.045 ^a _A	0.042 ^a _A	0.031 ^a _A	0.005			
	LSD	0.042	0.033	0.022				
Cr	OPA	0.008 ^a _A	0.004 ^a _A	0.005 ^a _A	0.002	0.4060	0.0351	0.8919
	NOPA	0.020 ^a _A	0.010 ^a _A	0.016 ^a _A	0.002			
	LSD	0.025	0.001	0.017				

^{abAB} = Means with common superscripts (a, b) along the row or with common subscripts (A, B) along the column for the respective heavy metals are not significantly different ($P > 0.05$); OPA = oil producing area; NOPA = non - oil producing area

Table 2 shows the concentration of the studied heavy metals in the hair, kidney and liver of goats. The concentration of lead (Pb) in the hair and organs of goats in the OPA (0.033 – 0.054 mg/kg), showed no significant difference. However, Pb concentration in the kidney of goats in NOPA was significantly highest (0.056 mg/kg). No significant differences were

observed for Cd and Cr concentration in the hair and organs of goats found in both the OPA and NOPA. Mercury concentration in the hair and kidney of goats in the NOPA, were significantly higher than that of liver. In addition, location effect showed no significant differences for all the metals studied. Lead concentration in the hair, kidney and liver of cattle in both areas

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showed significant difference in the kidney samples alone. However, in comparing the concentration of lead in the hair, kidney and liver of goats in the oil producing and non-oil producing areas, there were no significant differences ($P > 0.05$) in the hair, kidney and liver samples.

Comparing the locations, Cd concentrations in the hair and liver samples of cattle were significantly different from

the concentration in the kidney samples while in goats, the hair, kidney and liver samples from the oil and non-oil producing areas also showed no significant variations ($P > 0.05$).

In goats, no significant differences existed in the mercury and chromium concentrations among the hair, kidney and liver samples from the oil and non-oil producing areas.

Table 2: Effect of oil exploration, on the concentration of heavy metals in the hair and some organs of goat in Ondo State

Heavy metal	Activity (Act.)	Organs (Org.)			±SEM	Org.	Act.	Act.*Org.
		Hair	Kidney	Liver				
Pb	OPA	0.054 ^a _A	0.041 ^a _A	0.033 ^a _A	0.006	0.3632	0.4861	0.2388
	NOPA	0.025 ^b _A	0.056 ^a _A	0.026 ^b _A	0.004			
	LSD	0.043	0.027	0.055				
Cd	OPA	0.020 ^a _A	0.015 ^a _A	0.010 ^a _A	0.003	0.3875	0.7794	0.9180
	NOPA	0.015 ^a _A	0.015 ^a _A	0.010 ^a _A	0.003			
	LSD	0.031	0.024	0.017				
Hg	OPA	0.035 ^a _A	0.039 ^a _A	0.029 ^a _A	0.003	0.0055	0.8845	0.0960
	NOPA	0.040 ^a _A	0.046 ^a _A	0.016 ^b _A	0.005			
	LSD	0.015	0.019	0.015				
Cr	OPA	0.007 ^a _A	0.005 ^a _A	0.005 ^a _A	0.002	0.5145	0.0132	0.4290
	NOPA	0.025 ^a _A	0.010 ^a _A	0.016 ^a _A	0.003			
	LSD	0.020	0.016	0.017				

^{abAB} = Means with common superscripts (a, b) along the row or with common subscripts (A, B) along the column for respective heavy metals are not significantly different ($P > 0.05$). ; OPA = oil producing area; NOPA = non - oil producing area

In the oil producing area, the highest mean Pb concentration in cattle was recorded in the liver, though not significantly different from those in the kidney and hair. While in goats, no significant differences existed between the mean concentrations in the hair and organs in the oil producing areas. In the non- oil producing areas, Pb concentration in the hair was significantly highest. Lead concentration in the hair, kidney and liver of cattle in both areas showed significant difference in the kidney samples alone. However, in comparing the concentration of lead in the hair, kidney and liver of goats in the oil producing and non- oil producing areas, there were no significant differences ($P > 0.05$) in the hair, kidney and liver

samples.

Comparing the locations, Cd concentrations in the hair and liver samples of cattle were significantly different from the concentration in the kidney samples while in goats, the hair, kidney and liver samples from the oil and non-oil producing areas also showed no significant variations ($P > 0.05$).

In cattle and goats, no significant differences existed in the mercury and chromium concentrations among the hair, kidney and liver samples from the oil and non-oil producing areas.

Discussion

The mean Pb concentration obtained during

this study showed that lead contamination was not based alone on oil activities in an area, but also on pollution from vehicular, as higher mean Pb concentration were recorded for non- oil producing areas than for oil producing areas. In addition, the results of this study were in line with the findings of *Abou – Donia (2008) who reported 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 the* Pb concentrations in different animals. *Nwude et al. (2010) also reported hair Pb concentration of 0.09 mg/kg in cattle at slaughter during three different seasons. The Pb concentration values obtained during this study were lower than the maximum tolerable level of 1mg/kg (ANZFA, 2010).*

Although, Concentration of cadmium has been reported to be higher in the air of industrial cities (*Friberg et al., 1971*), thus providing a possible environmental hazard. Cadmium concentration in the hair of cattle in this study was higher in the non-oil exploration areas, though not significantly different from oil areas. But in goats, there were significant differences between Cd concentration in the goats' hair from oil producing areas and non-oil producing areas. This showed that Cd concentration sources were not only based on the degree of oil exploration in an area but also on environmental factors, resulting from its use in industries and as a contaminant in phosphate fertilizers and sewage sludge (*Friberg et al., 1971*). The results obtained from this study were lower than the maximum tolerable level of 0.5 mg/kg (NRC, 2005).

The mercury and chromium concentration values obtained in this study were lower than the maximum tolerable level of 2 mg/kg for mercury and 0.1 mg/kg for chromium (NRC, 2005). Mercury and

Chromium concentrations in cattle were not significantly different from that in goats, thus showing an even distribution of these heavy metals deposited in the atmosphere in the state.

Considering the mean concentration of Lead, Cadmium, Mercury and Chromium Concentrations in the kidney and liver of cattle and goats in Ondo State, the lead concentration values were lower than the maximum tolerable level of 1 mg/kg (ANZFA, 2010). The values are in agreement with 0.05, 0.04 and 0.01 mg/kg reported by *Tahvonon and Kumpulainen (1994)* in cattle muscle in Slovenia, Poland and Finland respectively. Also, *Abou Donia (2008) reported Pb values of 0.109 ± 0.01 and 0.198 ± 0.05 mg/kg in liver and kidney of cattle found in areas of high traffic in a study on the Pb concentrations in different animal muscles and consumable organs at specific localities in Cairo. Moreso, Khan et al. (1995), reported for goats in Alabama the liver and kidney Pb concentration of 1.11 and 1.09 ppm respectively while Salisbury et al. (1991) reported 0.08 ppm in the liver and 0.10 ppm in the kidney of Canadian slaughtered sheep and lambs. These values are similar to those obtained during this study, except for the values reported by Khan et al. (1995) which were higher.*

Cadmium concentration values obtained in the kidney of cattle and goats in this study were lower than the maximum tolerable limit for cadmium in the kidney (1 mg/kg) and in the liver (0.5 mg/kg) reported by *Vos et al. (1991)*. However, these values are in consonance with the suggestions of *Miranda et al. (2005)*, that kidney and liver samples obtained from calves in industrialized areas have higher Cd concentration in their liver and kidney (0.030 mg/kg and 0.161 mg/kg respectively) compared with those from rural areas (0.023 mg/kg and 0.096 mg/kg

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respectively). Also, Salisbury *et al.* (1991) reported Cd levels of 0.06 ppm in the liver and 0.17 ppm in the kidneys of Canadian slaughtered sheep and lambs. The values reported for this study is lower than those reported by Falandyz (1991) that the concentration of Cd, in Polish slaughtered sheep liver (0.56 ppm), and kidney (0.250 ppm). Carlton and Henderson (1977) reported that toxic heavy metals (Hg, Cd, and Pb) are concentrated mostly in the kidneys and livers of animals. The values recorded for this study are similar to those given by Tahvonen and Kumpulainen (1994) for cattle liver; in Finland (0.061 mg/kg); Sweden (0.070 mg/kg) and Holland (0.105 mg/kg). These reports are in line with the result of this study, where the kidney and liver had the highest concentration of these heavy metals with the exception of lead concentration in the hair of cattle and goats.

The mercury concentration values obtained for this study are below the maximum tolerable level of 2mg/kg (NRC, 2005). Ayyadurai and Krishnasamy (1986) reported Hg concentrations of 0.094 and 0.014 ppm in the kidney and liver of slaughtered goats in India. This is in line with the results obtained for this study. Salisbury *et al.* (1991) reported Hg levels of 0.02 ppm, in livers and 0.03ppm, in kidneys of Canadian slaughtered sheep and lambs. Falandyz (1991) also reported that the concentration of Hg, in slaughtered sheep livers was 0.002ppm while 0.12ppm was reported in the kidney.

Kidney and liver Cr concentrations obtained in the oil and non oil producing areas were lower than 0.43 ± 0.10 $\mu\text{g/g}$ for liver and 0.27 ± 0.04 $\mu\text{g/g}$ for kidney reported by Akan *et al.* (2010). In addition, Iwegbue (2010) also reported higher mean values of 3.62 mg/kg in the liver and 3.63 mg/kg in the kidney of cattle. The values obtained in this study are below the

maximum tolerable limit of 0.1 mg/kg for chromium (NRC, 2005)

Conclusion

The study showed that concentrations of some heavy metals were higher in the oil producing areas than in the non oil producing areas. In some cases, as with lead and cadmium, concentration was higher in the non oil producing areas than in the oil producing areas, showing that their presence is not only based on industrial pollutants, but also on some anthropogenic sources. However, values obtained were below the maximum tolerable limit set by some regulatory bodies.

References

- Abou-Donia, M. A. 2008.** Lead Concentrations in Different Animals Muscles and consumable organs at specific localities in Cairo. *Global Veterinaria* 2 (5):280-284.
- Akan, J.C., Abdurrahman, F.I., Sodipo, O.A. 2010.** Distribution of Heavy metals in the liver, kidney, and meat of beef, mutton, caprine and chicken from Kasuwan Shanu market in Maiduguri metropolis, Borno State, Nigeria. *Research Journal of Applied Sciences, Engineering and Technology* 2(8):743-748.
- ANZFA. (Australia New Zealand Food Authority) 2010.** Wellington NZ 6036 May, 2010. Retrieved from URL: <http://www.anzfa.gov.au>
- AOAC. (Association of Official Analytical Chemists) 2005.** Official Methods of Analysis of the Association of Analytical Chemists International, 18th ed. Gathersburg, MD U.S.A Official methods, 2005.08.
- Ayyadurai, K. and Krishnasamy, V. 1986.**

- A study on concentration of copper, zinc and mercury in goat kidney and liver samples. *J. Food Sci. Technol.*, 23:332–334.
- Bastin, S. 2007.** Nutrition value of meat: Co-op. Ext. Service. University of Kentucky – College of Agric. UK. Pp 1-3
- Carlton, W. W. and Henderson, W. 1977.** Trace elements in human and animal nutrition 4th ed by Underwood. E.J, Academic Press, New York. P 5.
- Falandyz, J. 1991.** Manganese, copper, zinc, iron, cadmium, mercury, and lead in muscle meat, liver, and kidneys of poultry, rabbit, and sheep slaughter in the northern part of Poland, 1987. *Food Add Contam* 8:71-83.
- Friberg, L., Piscator, M and Nordberg, G. 1971.** *Cadmium in the environment*. The Chemical Rubber Co. Press. Cleveland, Ohio.
- Hammond, P.B. and Bellies, R.P. 1980.** *Metals*. In: Casarrett and Doulls toxicology. The Basic Science of Poisons. 2ed. Macmillan New York. p 409-467
- Iwegbue, C.M.A. 2010.** Heavy metal composition of livers and kidneys of cattle from Southern Nigeria. *Vet.arhiv*. 78, 401-410
- Khan, A.T., Diffay, B.C, Datiri, B.C., Forester, D.M., Thompson, S.J. and Mielke, H.W. 1995.** Heavy Metals in Livers and Kidneys of Goats in Alabama. *Bull. Environ. Contam. Toxicol.* 55: 568- 573
- Miranda, M., Lopez-Alonso, M., Castillo, C., Hernandez J. and Benedito, J. L. 2005.** Effects of moderate pollution on toxic and trace metal levels in calves from a polluted area of Northern Spain. *Environ. Int.*, 31:543-548.
- NRC, 2005.** *National Research Council. Mineral Tolerances of Animals*. 2nd rev.ed. Washington DC. The National Academies Press
- Nwude, D.O., Okoye, P.A.C. and Babayemi, J.O. 2010.** Heavy metal level in animal muscle tissue. A case study of Nigeria raised cattle. *Res. J. Appl. Sci.* 5: 146–150
- Ogbuagu, J.O., Nnodu, C.K. and Okoye, P.A.C. 2005.** Ground water contamination in some residential areas of Anambra State. *Nigeria. J. Applied Sci.*, 8:5062-5074.
- Salisbury, C.D.C., Chan, W. and Saschenbrecker, P. W. 1991.** Multi-element concentrations in liver and kidney tissues from five species of Canadian slaughtered animals. *J Assoc. of Anal. Chem.* 74: 587-591
- Senessi, G. S., Baldassare, G., Senessi, N and Radina, B. 1999.** Trace Element Inputs into Soils by Anthropogenic Activities and Implications for human health. *Chemosphere* 39: 343-377.
- SAS. (Statistical Analytical Systems). 2004.** User guide: Statistics. SAS Institute, Cary, NC.
- Tahvonen, R., and Kumpulainen, J. 1994.** Lead and cadmium, content in pork, beef and chicken and in pig and cow liver in Finland. *Food Add. Contam.* 11, 415-419.
- Vos, G., Lammers, H., Delft, W. V. and Van, C. 1991.** Arsenic, cadmium, lead and mercury in meat, livers and kidneys of sheep slaughtered in the Netherlands. *Zeitschrift Leben. Unter Forsh.* 187, 1-7.

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