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Full Length Research Paper

Distribution of Heavy Metals in Organs of Sheep and Goat Reared in Obuasi: A Gold Mining Town in Ghana

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Abstract

The aim of this study was to determine the concentration of metals in some organs of goat and sheep and assess the distribution of these metals in the sample tissues. Samples were digested with 60% nitric acid and concentrations of the heavy metals measured using atomic absorption spectrophotometer while the concentrations of Hg were measured with mercury analyzer. Concentrations of Zn, Cu were very high in the organs followed by Cr, Ni, Co, Pb, Cd, As and Hg. Total rank score assessment showed that liver, kidney and lung had accumulated high levels of metals while brain accumulated lowest. Mean Zn concentrations in all organs ranged between 24.88±11.22 in goat brain and 97.06±19.66 mg/kg in liver of goat. Mean Cu concentrations ranged between 7.96±1.20 (small intestine of sheep) and 106.63±111.24 mg/kg in liver of sheep. Cd concentration in liver and kidney in both species were above the EU set limit of 0.05 mg/kg. Concentrations of Co in liver, kidney and lungs of the two different animals did not vary significantly. As and Hg concentration were homogenous in all the organs of both animals and did not show any significant variation. Prolonged consumption of kidney, liver and lungs of goats and sheep having high concentrations of Zn Cu and Cd may lead to accumulation of these metals in humans and cause metal toxicity.

Keywords: Goat and sheep, Heavy metals, Mining, Obuasi, Total rank score.

INTRODUCTION

Environmental pollution is one of the problems that poses serious health threats to animals and humans worldwide. Pollution resulting from continuous and rapid growth in population, industrialization, transportation and its associated indiscriminate exploitation of natural resources has increased in recent years (Ihedioha and Okoye, 2012; Yabe et al., 2011). Widespread contamination of some ecosystems by heavy metals has frequently been reported in regions with long histories of mining and smelting, especially in the vicinity of nonferrous metal smelters (Navarro et al., 2008; Singh et al., 2005). The environmental concerns in mining areas is primarily related to the physical disturbance of surrounding landscape, spillage of mine tailings, dust emission and acid mine drainage transported into water bodies and farmlands. These contaminants are known to contain elevated levels of toxic metals and metalloids such as Pb, Cd, Hg and As (Tubaro et al., 2007). These metals and metalloids tend to bioaccumulate in the environment and biomagnify in food chains where their levels might reach toxic limits even when found in low concentrations in environmental samples (Caggiano et al., 2004). The risk associated with the exposure to metals present in food products has aroused widespread concern about human health. Therefore monitoring the levels of heavy metals in the food chain is of great importance for the well being of all life forms.

Serious health problems can develop as a result of excessive accumulation of these metals in the human body through dietary intakes (Oliver, 2007). Although some metals such as Zn, and Cu are essential at low concentrations, their excessive concentrations in food are of great concern because of their toxicity to

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humans and animals at relatively higher concentrations (Kabata-Pendias and Mukherjee, 2007). Pb, Hg and Cd are considered potential carcinogens and are associated with etiology of a number of diseases, especially cardiovascular, kidney, nervous system, blood as well as bone diseases (Jarup, 2003).

In most African countries, the reliance on pollution-prone technologies and inadequate controls on the discharge of pollutants from mining and other human activities have increased the chances and intensity metal pollution (Ihedioha and Okoye, 2012). Recent studies have shown that contamination of the environment and food with toxic metals has reached unprecedented levels over the past decade and that human exposure to toxic metals has become a major health risk on the continent (Yabe et al., 2010). This has been confirmed by the recent tragic Pb poisoning disaster in Nigeria, where more over160 children died after coming into contact with galena polluted ore obtained from gold mining site that was dumped in their compound (Blacksmith Institute, 2010; Yabe et al., 2010). The soil in the affected compound was reported to have Pb levels up to 23 times the maximum acceptable levels in soils set by USEPA.

Some studies have reported the incidence of heavy metals pollution in the Ghanaian environment. For example, Akoto et al., (2008), reported high levels of Pb and Cu in soils from Asafo Railway station in Kumasi; Antwi-Agyei et al., (2009) reported high levels of As in soils at Obuasi, the richest gold mine community in Ghana; Amonoo-Neizer et al., (1996) recorded high levels of Hg and As in soil, food crops, fish and plant samples from Obuasi and its environs indicating that the local environment is contaminated by mining and other human activities. Several other reports have shown the incidence of high levels of some heavy metals in water, soil and other environmental components (Asante et al., 2007; Golow et al., 1996).

Despite the high concentrations of heavy metals in some environmental samples from the Obuasi area, no studies have been conducted to determine metal contamination levels in domestic animals such as sheep and goats which scavenge freely in the area. The animals when exposed to toxic metals accumulate them in their organs such as liver and kidneys, which are considered delicacies in Ghana. Meat produced from these animals is a rich and convenient source of nutrients such as proteins and micronutrients.

The traditional system of management of livestock, free ranging, which involves animals taken from place to place in search for water and pasture, has remained the most practised in the country. Free ranged animals can pick toxicants such as heavy metals from the environment by feeding on fodder in the open or from waste dumps, drinking polluted water from drains and streams, and intake of atmospheric depositions especially from vehicular emission and fumes from open burning of wastes (Ihedioha and Okoye, 2012; Okoye and Ugwu, 2010). Food consumption had been identified as the major pathway of human exposure to pollutants, accounting for 90% compared to other ways of exposure such as inhalation and dermal contact (Zheng et al., 2007; Loutfy et al., 2006). Hence, accumulation of heavy metals in meat is of key concern due to food safety issues and potential health risks because heavy metals are toxic even at relatively low concentrations in nature (Akan et al., 2010; Santhi et al., 2008; McLaughlin et al., 1999).

This present study investigated concentrations of metals in different organs of free range goats and sheep reared within the Obuasi community and assessed the metal distribution in the organs of the animals.

MATERIALS AND METHODS

Fresh samples of liver, kidney, lung, heart, small intestines and brain of free ranged goats and sheep reared in Obuasi were collected from Obuasi slaughterhouse in May 2011. The samples were kept in labelled plastic bags and stored in cooler boxes before being transported to the laboratory and kept frozen till analysis.

The tissues samples of goats and sheep were dried in an oven at 105 ^{o}C for 24 h. Approximately 0.5 g of each sample was digested by adding 6 ml of 60% HNO_3 and 1 ml of 35% H_2O_2 (analytical grade, from Kanto Chemical Corp. Japan) to the sample in a digestion tube. Digestion tubes with contents were covered and put in microwave oven for extraction. The microwave unit was calibrated to a temperature of 200 ^{o}C and digestion was allowed for 25 minutes at 180 psi. After digestion, samples were cooled and filtered through ashless filter paper 5B (Advantec, Tokyo, Japan) into 10 ml screw-capped polypropylene tubes. 0.1 ml of lanthanum chloride (analytical grade 100 g/l) from WAKO Chemical Industries was added to the filtrate to prevent chemical, physical and ionization interference during metal analysis in the AAS (Atomic Absorption Spectrophotometer). The sample was made up to 10 ml using 2% HNO_3. A reagent blank was prepared by following the same procedure.

Concentrations of metals in the digested samples were determined with a flame/flameless atomic absorption spectrophotometer (AAS, Z-2010, Hitachi High-Technologies and Japan) equipped with a Zeeman graphite furnace. The instrument was calibrated using standard solutions of the respective metals to establish standard curves before metal analysis. Concentrations of Cu and Zn were determined by the flame method using acetylene gas as fuel, whereas concentrations of Pb, Cd, As, Ni, Cr, and Co were determined by the graphite furnace method using argon gas.

Recovery tests were performed for all the investigated metals in samples by spiking with aliquots of the metal standards and then carrying out digestion.

The solutions were then analyzed by AAS. The overall recovery rates (mean ± SD) of Co, Cr, Cu, Ni, Zn, Pb, As, Cd and Hg were 90±9.6, 95±3.9, 97±2.3, 88±3.3, 91±2.3, 90±8.1, 87±4.7, 92±2.6 and 94±4.2% respectively. The detection limits (µg/kg) of Cr, Co, Cu, Zn, Cd, Pb, Ni, As and Hg were 0.5, 0.5, 1.0, 1.0, 0.2, 1.0, 0.5, 2.0 and 0.02 respectively.

Total Hg concentration was determined in all the samples by using Mercury/ MA-3000 Mercury analyzer (Nippon Instrument Corporation, Tokyo, Japan) after calibration. Measurements were carried out on raw samples without any pre-treatment.

RESULTS AND DISCUSSION

Maximum, minimum, mean and standard deviation of heavy metals concentrations in the various organs of goats and sheep used in this study are listed in Table 1. Different organs of the same species were found to have different mean metal concentrations. Generally, organs were very rich in Zn and Cu followed by Cr, Ni, and Co which are considered micronutrients. But levels of Pb, Cd, As and Hg which are known to have no biochemical functions in animals and are toxic even at minute levels were low in all the organs.

Mean Zn concentrations in all organs ranged between 24.88±11.22 and 97.06±19.66 mg/kg in goat brain and liver respectively. Mean Cu concentrations as observed in the liver of sheep showed the highest concentration of 106.63±111.24 mg/kg and the lowest mean concentration of 7.96±1.20 mg/kg was recorded in the small intestine of sheep. The highest mean concentration of Pb was in the liver of sheep (0.2±0.2 mg/kg) and the least was below the detection limit which was observed in brain samples of the goat (Table 1). Hg was detected only in the liver and the kidney samples at very low mean concentrations ranging between 0.01±0.01 mg/kg in the liver of goat to 0.07±0.03 mg/kg in the kidney samples of sheep. Cd concentrations ranged from below detection limit in the brain and heart samples of both species to a maximum of 0.18±0.07 mg/kg in the kidney of sheep. The mean concentrations of As in the organs of both species ranged between 0.01±0.01 and 0.06±0.02 mg/kg. The highest mean As concentration was observed in the small intestines of sheep while the lowest value was found in the brain of goat. Nickel was detected in all the samples but was highest in the heart of goat with a mean concentration of 16.24±1.12 mg/kg. The highest mean concentrations of Co (0.51±0.29) and Cr (0.74±0.82) were found in the kidney of goat.

Organs were ranked according to their capacity to concentrate different metals by calculating the total rank score (TRS) for each organ (Swaileh, 2009; 2004). The liver of both species were ranked the richest in metals, while brain was the least in their ability to concentrate metals in the two animal groups investigated (Figure 1). According to the TRS, metal enrichment in the organs followed the order: liver > kidneys > lungs > small intestine > heart > brain. The liver and kidneys are target tissues for monitoring metal contamination in animals because both organs function in removing toxic metals from the body and therefore end up accumulating them (Abou-Arab 2001; Husain et al., 1996).

Metal concentrations in the same organ from the two animal groups were compared and statistically analysed using the analysis of variance (Table 1). Significant variation was observed for Co in liver, kidney and lung of the two animal groups analysed ($p<0.05$). Hearts of both animal groups were also found to differ significantly only in their mean Cu and Ni concentrations ($p≤0.05$). As, Cd and Hg concentrations were homogeneous in the all organs of both animals in which they were detected and showed no significant variation ($p<0.05$). Sheep liver contained higher amount of Cu than that of goat, but the difference was not significant ($p<0.05$). However, the other tissues (kidney, heart) contained significantly different level of Cu ($p<0.05$).

Figure 2 shows the distribution of metals in liver and kidney of goats and sheep samples by box-and-whisker plots. The rectangular part of the plot extended from the lower quartile to the upper quartile, covering the central part of each parameter. The central lines within each box show the location of the medians of each parameter. The whickers extend from the box to the maximum and minimum values of each parameter. Cr in the kidney and lungs of both animals recorded the most extended whiskers. The kidney of the goats also showed extended whiskerswhile sheep liver samples had extended whiskers for Cu.

Of all detectable toxic metals, Cd in liver and kidney of sheep and goat were higher than the EU set limit of 0.05 mg/kg for Cd in meat (Anonymous, 2005). The high levels of Cd concentrations in liver and kidney of goats and sheep are likely due to their special functions; liver as storage and metabolic organ and kidney as an excretory organ (Stoyke et al., 1995). There have also been suggestions that animals exposed to Cd accumulate it in their kidneys because of the presence of free protein-thiol groups which binds the heavy metals strongly to their structures. Pompe-Gotal and Crnic (2002) inferred that the excretory mechanism for such metals, which is based on low molecular compounds with –SH groups, was poorly developed in vertebrates and could not cope with high levels of such metal contaminations.

High Cd levels have been reported by Okoye and Ugwu (2010) in liver (0.35 mg/kg) and kidney (0.83 mg/kg) in goats from Nigeria, and were ascribed largely to atmospheric deposition and free range grazing. The mean concentrations of Cd in liver and kidney in this study was low when compared to 0.33 mg/kg reported in Lahore (Mariam et al., 2004) but higher than concentrations (0.009 and 0.006 mg/kg) in liver and

Table 1. Mean and Range of metal concentrations (mg/kg) in various organs of free range sheep and goat (n=10) near gold mine in Obuasi, Ghana

		Co	**Cr**	**Cu**	**Ni**	**Pb**	**As**	**Cd**	**Hg**	**Zn**
Sheep Liver	Average±SD	0.12±0.05	0.34±0.13	106.63±111.24	0.15±0.03	0.14±0.07	0.02±0.01	0.07±0.03	0.03±0.03	77.34±13.09
	Range(Med)	0.08-0.2(0.11)	0.22-0.55(0.29)	12.83-282.56(68.16)	0.11-0.18(0.16)	0.05-0.23(0.12)	0.01-0.04(0.02)	0.04-0.1(0.06)	ND-0.08(0.01)	62.24-91.13(76.82)
Goat Liver	Average±SD	0.38±0.17	0.33±0.17	40.09±24.52	0.19±0.03	0.04±0.02	0.02±0.01	0.06±0.03	0.01±0.01	97.06±19.66
	Range(Med)	0.23-0.61(0.30)	0.15-0.56(0.30)	12.22-72.81(46.29)	0.14-0.21(0.19)	0.02-0.07(0.04)	0.0-0.03(0.02)	0.03-0.12(0.05)	0.01-0.03(0.01)	73.06-118.00(102.81)
	ANOVA (*p* value)	0.011*	0.967	0.228	0.066	0.017*	0.641	0.572	0.338	0.099
Sheep kidney	Average±SD	0.11±0.02	0.59±0.51	11.72±0.94	0.29±0.05	0.18±0.07	0.03±0.03	0.18±0.07	0.07±0.03	74.91±9.07
	Range(Med)	0.09-0.14(0.10)	0.17-1.28(0.45)	10.88-12.86(11.56)	0.23-0.34(0.29)	0.14-0.29(0.15)	0.0-0.07(0.03)	0.1-0.27(0.17)	0.04-0.1(0.07)	66.0-83.57(75.03)
Goat kidney	Average±SD	0.51±0.29	0.74±0.82	14.40±1.80	0.63±0.17	0.13±0.04	0.03±0.02	0.15±0.03	0.07±0.02	86.21±3.86
	Range(Med)	0.28-0.91(0.34)	0.16-2.14(0.33)	12.50-17.27(13.81)	0.37-0.85(0.66)	0.08-0.18(0.11)	0.01-0.07(0.04)	0.11-0.19(0.16)	0.05-0.09(0.08)	80.45-90.00(85.830
	ANOVA (*p* value)	0.031*	0.751	0.031*	0.006*	0.180	0.832	0.480	0.920	0.038*
Sheep Lung	Average±SD	0.05±0.02	0.62±0.19	12.70±1.12	0.21±0.03	0.20±0.20	0.03±0.02	0.03±0.01	BDL	74.19±8.58
	Range(Med)	0.03-0.09(0.04)	0.41-0.77(12.08)	11.79-14.29(12.08)	0.17-0.24(0.20)	0.05-0.53(0.15)	ND-0.06(0.02)	0.01-0.04(0.04)	BDL)	59.64-82.17(77.08)
Goat Lung	Average±SD	0.12±0.07	0.36±0.11	12.60±0.98	0.22±0.20	0.09±0.05	0.03±0.12	0.02±0.01	BDL	64.77±7.20
	Range(Med)	0.07-0.23(0.09)	0.26-0.54(0.32)	11.43-13.81(12.5)	0.00-0.42(0.26)	0.04-0.17(0.08)	0.02-0.04(0.03)	0.01-0.04(0.02)	BDL	53.33-70.5(67.14)
	ANOVA (*p* value)	0.043*	0.028*	0.880	0.915	0.279	0.862	0.226	-	0.097
Sheep Brain	Average±SD	0.03±0.01	0.39±0.20	16.25±13.64	0.16±0.07	0.13±0.17	0.02±0.02	BDL	BDL	42.48±15.73
	Range(Med)	0.02-0.04(0.02)	0.09-0.60(0.37)	8.29-40.40(10.54)	0.1-0.25(0.11)	0.03-0.44(0.07)	ND-0.04(0.02)	BDL	BDL	26.45-67.20(42.16)
Goat Brain	Average±SD	0.07±0.06	0.21±0.26	11.32±9.16	0.05±0.03	BDL	0.01±0.01	BDL	BDL	24.88±11.22
	Range(Med)	0.02-0.18(0.05)	0.01-0.59(0.05)	5.47-27.42(7.72)	0.02-0.10(0.050	BDL	BDL 0.02(0.01)	BDL	BDL	14.4-40.0(21.81)
	ANOVA (*p* value)	0.162	0.264	0.522	0.023*	0.119	0.380	-	-	0.076
Sheep S. Intestine	Average±SD	0.05±0.02	1.63±1.70	7.96±1.20	0.34±0.05	0.16±0.11	0.06±0.02	0.03±0.01	BDL	80.08±6.64
	Range(Med)	0.03-0.07(0.06)	0.32-4.50(1.11)	7.14-10.0(7.37)	0.26-0.39(0.33)	0.04-0.27(0.17)	0.03-0.08(0.06)	0.03-0.04(0.03)	BDL	71.58-87.62(77.62)
Goat S. Intestine	Average±SD	0.13±0.11	0.23±0.09	8.44±2.84	0.21±0.21	BDL	0.04±0.01	0.004±0.01	BDL	60.30±33.84
	Range(Med)	0.01-0.30(0.11)	0.13-0.36(0.23)	4.55-12.5(8.42)	0.05-0.58(0.15)	BDL	0.03-0.05(0.040	BDL -0.02	BDL	nd-80.42(73.68)
	ANOVA (*p* value)	0.178	0.104	0.733	0.257	0.009*	0.123	0.000	-	0.236

Table 1. Continue

Sheep Heart	Average±SD	0.01±0.01	0.25±0.16	11.09±3.04	0.32±0.09	0.17±0.04	0.02±0.01	BDL	BDL	44.87±12.46
	Range(Med)	ND-0.03(0.01)	0.11-0.47(0.22)	7.42-14.72(11.11)	0.24-0.43(0.30)	0.13-0.23(0.16)	0.01-0.03(0.02)	BDL	BDL	28.23-58.33(46.47)
Goat Heart	Average±SD	0.19±0.17	0.33±0.27	16.24±1.12	0.08±0.12	BDL	0.02±0.01	BDL	BDL	57.58±4.97
	Range(Med)	0.06-0.48(0.11)	0.07-0.64(0.20)	15.0-17.78(16.29)	0.02-0.30(0.02)	BDL	0.01-0.03(0.02)	BDL	BDL	53.21-65.19(54.81)
	ANOVA (*p* value)	0.072	0.636	0.009*	0.016*	0.000	1.000	-	-	0.073

BDL = below detection limit
∗ indicate significant value ($p<0.05$)

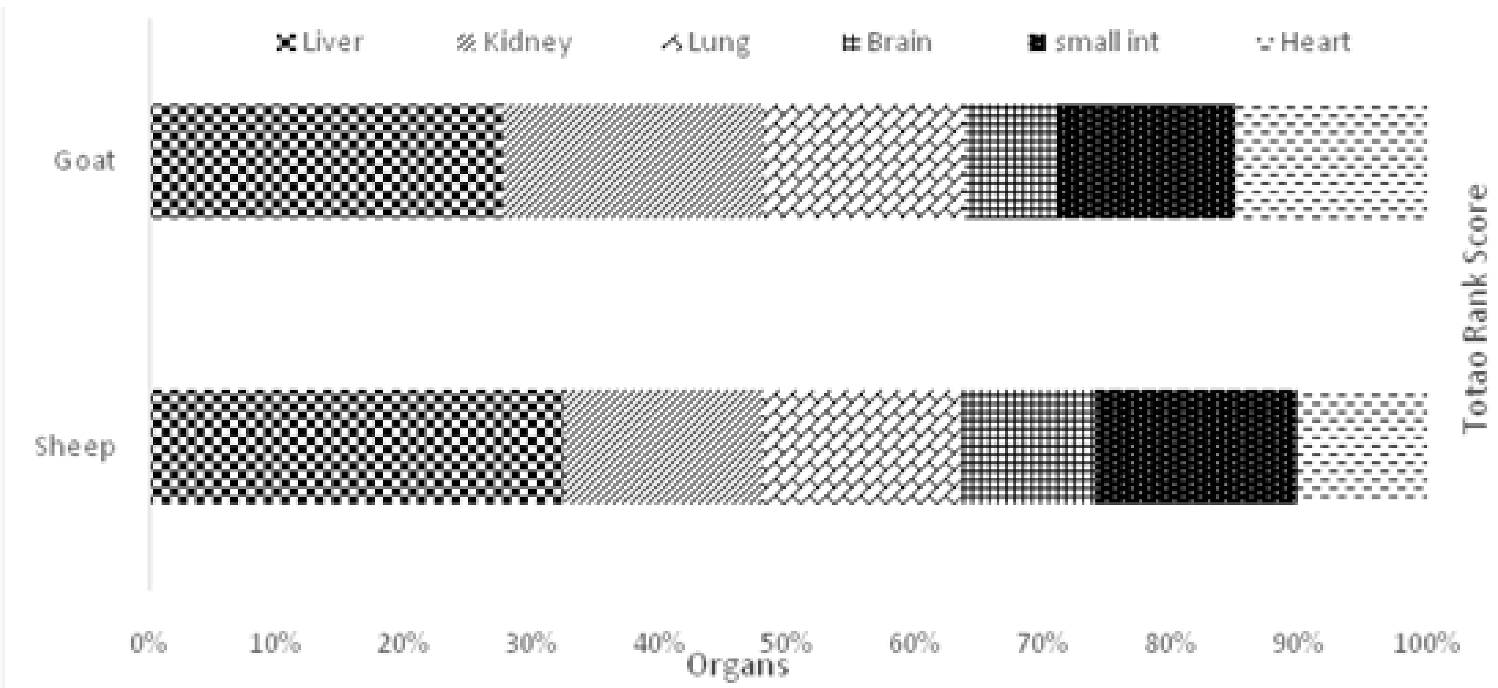

Figure 1. Total rank score of metals in organs of free range sheep and goat from the Obuasi townships

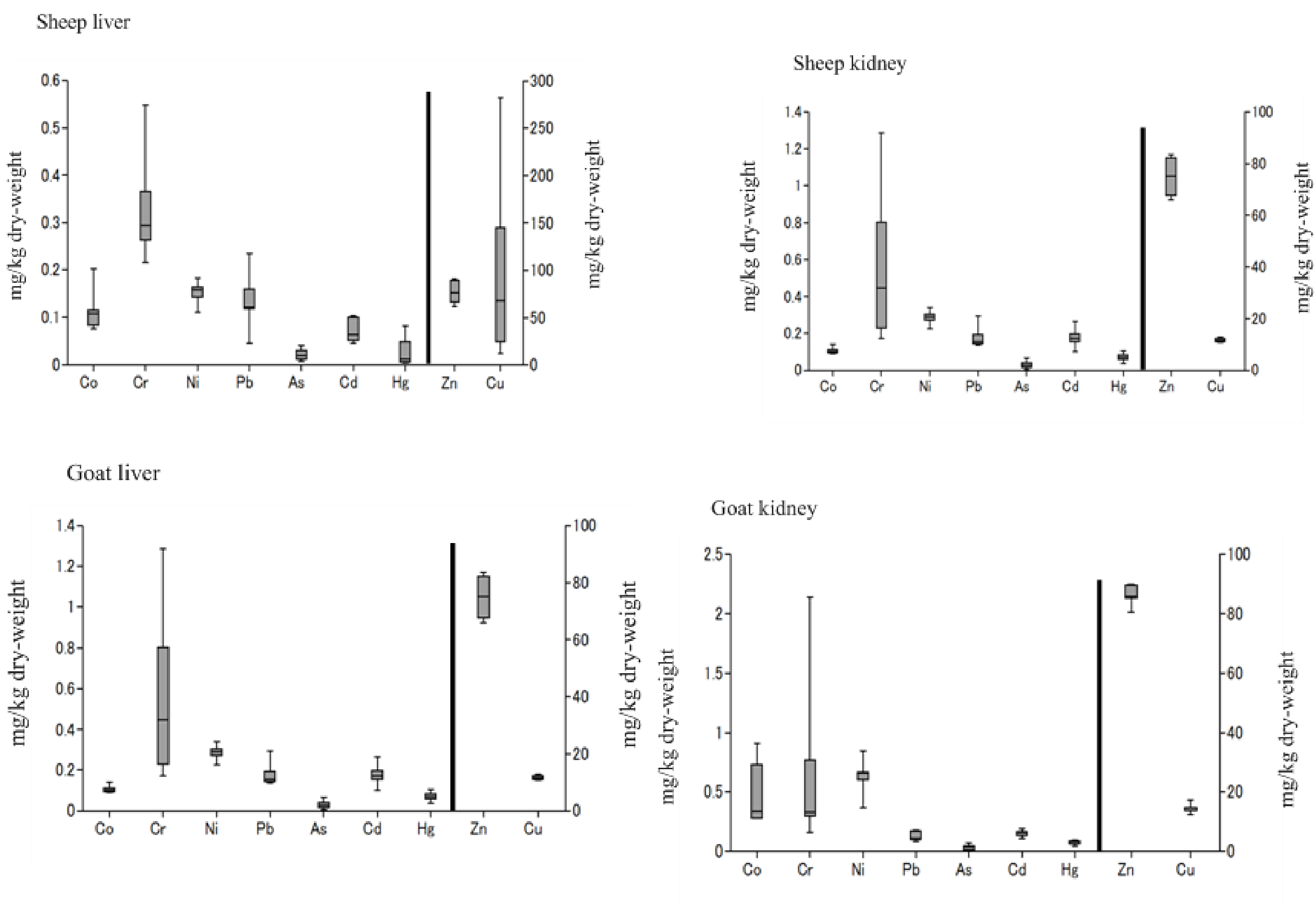

Figure 2. Box-whiskers graphics showing the distribution of heavy metals in liver and kidney of goats and sheep samples

kidney respectively of sheep from Kenya (Oyaro et al., 2007). These findings imply that some consumers in Obuasi are exposed to high concentrations of this toxic metal in offal of backyard sheep and goat, which are allowed to roam and scavenge for food to reduce the cost of production and provide an inexpensive source of protein.

When compared to results of similar studies from other countries (Table 2), metal levels reported in the present study seem to be comparable to or less than those reported in organs of animals from other sites. Results of Liu (2003) for metal levels in the organs of sheep sampled from contaminated sites in China are clearly higher than those found in our study. Levels of Cd and Pb in liver and kidney of sheep and goat from our study are comparable to those reported by Husain et al. (1996) from Kuwait (Table 2).

Although Cu and Zn are essential metals, their high concentrations in some organs of sheep and goats in Obuasi could pose significant health risks to consumers, as these metals can be toxic at high concentrations. In humans, consumption of excessive Cu (through diet) can result in liver and kidney damage as well as anaemia (ATSDR, 2004), whereas consumption of excess Zn in the diet can result in haematological effects such as anaemia and induction of Cu deficiency by hindering its absorption (ATSDR, 2005).

The positive correlation between Hg and Cd ($p<0.05$) in liver and kidneys of sheep could be attributed to metallothioneins (MTs), as Hg can also induce MT synthesis (Komsta-Szumska and Chmielnicka, 1983). Although mechanisms of their interactions are not clearly defined, interactions between toxic and essential metals may disrupt the metabolism of essential metals such as Zn and Cu. Metallothioneins binds tightly with toxic metals, reducing their availability within cells and therefore reducing their toxic potentials. The synthesis of MT which is induced by the presence of Cd causes great accumulation of Zn the tissues (Cherian and Goyer, 1978). Significant positive correlation were also recorded between Hg-Pb and Pb-Cd in the liver and kidney of the sheep ($p<0.05$) (Table 3 and 4).

Among essential metals, positive correlations were recorded between Cu-Zn, Co-Cr, in goat kidney ($p<0.05$) and sheep liver ($p<0.05$). The strong positive correlation between Cu and Zn concurred with reports in cattle (Nriagu et al., 2009; Blanco et al., 2006; Lopez et al., 2002) and in humans (Honda and Nogawa, 1987).

Table 2. Data on metal levels (mg/kg dry weight) in organs of sheep and goats from different regions of the world

Study/country	Animal	Organ	Cd	Pb	Cu
Liu (2003) China	Sheep (control)	Liver	0.49	0.72	120.6
		Kidneys	1.83	0.96	11.8
		Heart	0.3	1.54	15.7
		Lungs	0.61	1.45	10.6
		Muscles	0.17	0.86	5.9
	Sheep (contaminated)	Liver	7.92	15.3	248.1
		Kidneys	25.39	39.5	25.2
		Heart	0.38	4.3	28.8
		Lungs	3.02	4.35	23.2
		Muscles	0.62	1.85	8.0
Husain et al., (1996) Kuwait	Sheep	Liver	0.044	0.125	–
		Kidney	0.301	0.145	–
	Goat	Liver	0.047	0.13	–
		Kidney	0.442	0.427	–
Caggiano et al., (2005) Italy	Sheep	Liver	0.33	1.5	–
		Kidneys	6.71	2.0	–
		Muscles	0.16	1.6	–

Table 3. Spearman's rank correlation coefficient (r_s) for metal correlation in sheep liver

	Co	Cr	Cu	Ni	Pb	As	Cd	Hg	Zn
Co									
Cr	**0.7772**								
Cu	**0.9824**	**0.7683**							
Ni	-0.0768	0.3833	-0.0616						
Pb	-0.0803	0.0948	-0.2045	0.6318					
As	-0.5769	-0.1145	-0.4541	0.2899	-0.3671				
Cd	0.3234	0.5074	0.2302	**0.735**	**0.8865**	-0.4067			
Hg	0.0899	0.1975	0.0056	**0.7245**	**0.9411**	-0.3958	**0.9383**		
Zn	0.6174	**0.6674**	**0.7448**	0.1929	-0.4743	0.2259	-0.0348	-0.2155	

*bold values indicate significant differences between metals

Table 4. Spearman's rank correlation coefficient (r_s) for metal correlation in sheep kidney

	Co	Cr	Cu	Ni	Pb	As	Cd	Hg	Zn
Co									
Cr	**0.8083**								
Cu	0.3902	0.1034							
Ni	-0.142	0.4041	0.0090						
Pb	-0.2453	-0.3939	**0.7957**	0.1524					
As	-0.2043	0.4022	-0.2801	0.9561	-0.1125				
Cd	-**0.6502**	-**0.7726**	0.4341	0.0079	**0.8758**	-0.1619			
Hg	**-0.7667**	-**0.9221**	0.2122	-0.1704	**0.7095**	-0.2717	0.9580		
Zn	0.569	0.3796	**0.9584**	0.1643	**0.6443**	-0.1075	0.2010	-0.0538	

*bold values indicate significant differences between metals

Table 5. Spearman's rank correlation coefficient (r_s) for metal correlation in goat kidney

	Co	Cr	Cu	Ni	Pb	As	Cd	Hg	Zn
Co									
Cr	**0.7180**								
Cu	**-0.6504**	-0.2803							
Ni	-0.3381	**-0.8838**	-0.0866						
Pb	**0.9612**	0.5775	**-0.7755**	-0.1921					
As	0.4163	**0.8869**	0.1264	**-0.8978**	0.1885				
Cd	-0.0486	0.0198	-0.1014	0.1318	-0.1871	0.2229			
Hg	0.4483	-0.0489	-0.4204	0.2123	**0.6325**	-0.4277	**-0.7652**		
Zn	**-0.8529**	**-0.9116**	**0.6009**	**0.6321**	**-0.753**	**-0.7085**	-0.2263	-0.0124	

*bold values indicate significant differences between metals

Table 6. Spearman's rank correlation coefficient (r_s) for metal correlation in goat liver

	Co	Cr	Cu	Ni	Pb	As	Cd	Hg	Zn
Co									
Cr	**-0.7723**								
Cu	**0.7341**	-0.2421							
Ni	-0.5030	**0.7566**	-0.2367						
Pb	-0.1850	-0.2967	-0.4193	-0.7233					
As	-0.3672	-0.2494	**-0.7563**	-0.4542	**0.8866**				
Cd	-0.2762	0.4832	-0.3695	0.6647	-0.3321	-0.1184			
Hg	**0.7713**	-0.3837	**0.7460**	0.0828	**-0.7385**	**-0.7717**	-0.1255		
Zn	**0.6328**	-0.4615	0.273	-0.4379	0.1913	0.0244	0.2952	0.1635	

*bold values indicate significant differences between metals

Although both Cu and Zn can bind to MT, displacement of Cu from MT by Zn has been reported in experimental studies (Evans et al., 1970). The effect of this interaction has also been demonstrated in ruminants, in which high dietary Zn levels induce Cu deficiency (Mills and Dalgarno, 1972). Therefore, the interaction between Cu and Zn in our study has the potential to affect Cu metabolism. Other significant correlations were also recorded between Ni-Cr, Zn-Co and Cu-Hg in the liver of the goats samples (Table 6). Significant but negative correlations were also observed between Cu-Co, Pb-Cu As-Ni in the kidney of the goat as presented in Table 5.

CONCLUSION

Sheep and goat reared freely within in Obuasi township accumulate higher concentrations of Zn, Cu and Cd in their kidney and liver tissues. Statistical analysis of the results showed no significant differences in metal concentrations in kidney and liver of the two animals groups. These two organs were also found to concentrate more metals than the other organs that were considered in this study.

Prolonged consumption of high concentrations of Zn, Cu and Cd in sheep and goat offal may lead to accumulation of these metals in the human body and cause metal toxicity. There is a clear need to avoid consumption of contaminated offals from these animals. There is also the need to restrict sheep and goat from roaming and scavenging for food. Continuous monitoring of Zn, Cu and Cd residues in the liver and kidneys of sheep and goat raised within the Obuasi municipality is recommended in the interest of human consumers.

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REFERENCES

Abou-Arab AAK (2001). Heavy metal contents in Egyptian meat and the role of detergent washing on their levels. Food Chem Toxicol; 39, pp. 593-599.

Akan JC, Abdulrahman FI, Sodipo OA, Chiroma YA (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. Res J App Sci, Engin and Tech; 2(8), pp. 743-748.

Akoto O, Ephraim JH, Darko G (2008). Heavy Metals Pollution in Surface Soils in the Vicinity of Abundant Railway Servicing Workshop in Kumasi, Ghana. Int. J. Environ. Res; 2(4): pp. 359-364.

Amonoo-Neizer EH, Nyamah D, Bakiamoh SB (1996) Mercury and arsenic pollution in soil and biological samples around the mining town of Obuasi, Ghana. Water, Air, and Soil Pollut; 91(3-4), pp. 363-373.

Anonymous (2005). Commission Regulation (EC) NO: 78/2005 of 16 January 2005 amending Regulation EC No: 466/2001 as regards heavy metals. Off J L 16/43. pp. 43-45.

Antwi-Agyei P, Hogarh JN, Foli G (2009).Trace elements contamination of soils around gold mine tailings dams at Obuasi, Ghana. Afr J Envirol Sci and Tech; 3(11), pp. 353-359.

Asante KA, Agusa T, Subramanian A, Ansa-Asare OD, Biney CA, Tanabe S (2007). Contamination status of arsenic and other trace elements in drinking water and residents from Tarkwa, a historic mining township in Ghana. Chemosphere; 66, pp. 1513-1522.

ATSDR (Agency for Toxic Substances and Disease Registry). (2004).Toxicological profile for copper (CAS 7440-50-8). U.S. Department of Health and Human Services, Atlanta, GA.

ATSDR (Agency for Toxic Substances and Disease Registry). (2005). Toxicological profile for zinc (CAS 7440-66-6). U.S. Department of Health and Human Services, Atlanta, GA.

Blacksmith Institute (2010). Papers and annual reports. New York, NY, USA. http://www.worstpolluted.org/files/FileUpload/files/2010/; WWPP-Report-2010-Top-Six-Toxic-Threats-Web.pdf. (assessed 14-04 – 11).

Blanco-Penedo I, Cruz JM, Lo´pez-Alonso M, Miranda M, Castillo C, Herna´ndez J, Benedito JL (2006). Influence of copper status on the accumulation of toxic and essential metals in cattle. Environ Int; 32, pp. 901-906.

Caggiano R, Macchiato MF, Ragosta M (2004) Heavy metals in ryegrass species versus metal concentrations in atmospheric particulates in an industrial area of southern Italy. Environ Monit Assess; 102(1-3), pp. 67-84.

Cherian MG, Goyer RA (1987). metallothioneins and their role in the metabolism and toxicity of metals. Life Sci; 23(1, 2) pp. 1-9.

Evans GW, Majors PF, Cornatzer WE (1970). Mechanism for cadmium and zinc antagonism of copper metabolism. Biochem Biophys Res Commun; 40, pp. 1142-1148.

Golow AA, Schlueter A, Amihere-Mensah S, Granson HLK, Tetteh MS (1996). Distribution of Arsenic and Sulphate in the Vicinity of Ashanti Goldmine at Obuasi, Ghana. Bull. Environ. Contam. Toxicol; 56, pp. 703-710.

Honda R, Nogawa K (1987). Cadmium, zinc and copper relationships in kidney and liver of humans exposed to environmental cadmium. Arch Toxicol; 59, pp. 437-440.

Husain A, Al-Rashdan A, Al-Awadhi A, Mahgoub B, Al-Amiri H (1996). Toxic metals in food products originating from locally reared animals in Kuwait. Bull Environ Contam Toxicol; 57, pp. 549-555.

Ihedioha, JN, and Okoye, COB (2012). Cadmium and Lead Levels in Muscle and Edible Offal of Cow Reared in Nigeria. Bull Environ Contam Toxicol; 88, pp. 422-427.

Järup L (2003). Hazards of heavy metal contamination. Br Med Bull; 68, pp. 167-82.

Jarup L (2003). Hazards of heavy metal contamination. Brit Med Bull; 68, pp. 167-82.

Kabata-Pendias A, Mukherjee AB (2007). Trace elements from soil to human. NewYork: Springer-Verlag.

Komsta-Szumska E, Chmielnicka J (1983). Effect of zinc, cadmium or copper on mercury distribution in rat tissues.Toxicol Lett; 17, pp. 349-354.

Liu ZP (2003). Lead poisoning combined with cadmium in sheep and horses in the vicinity of non-ferrous metal smelters. Sci Total Environ; 309, pp. 117-126.

Lopez-Alonso M, Benedito JL, Miranda M, Castillo C, Hernandez J, Shore RF (2002). Cattle as biomonitors of soil arsenic, copper and zinc concentrations in Galicia (NW Spain).Arch Environ Contam Toxicol; 43, pp. 103-108.

Loutfy N, Fuerhacker M, Tundo P, Raccanelli S, El Dien AG, Ahmed MT (2006.). Dietary intake of dioxins and dioxin-like PCBs, due to the consumption of dairy products, fish/seafood and meat from Ismailia city, Egypt. Sci Total Environ; 370, pp. 1-8.

Mariam I, Iqbal S, Nagra SA (2004). Distribution of some trace and macro minerals in beef, mutton and poultry. Int. J. Agric. Biol.; 6: pp. 816-820.

McLaughlin MJ, Parker DR, Clarke JM (1999). Metals and micronutrients food safety issues. Field Crops Res; 60, pp. 143-63.

Merian E (Ed.), (1991). Metals and Their Compounds in the Environment. Occurrence, Analysis, and Biological Relevance. VCH, Weinheim.

Mills CF, Dalgarno AC (1972). Copper and zinc status of ewes and lambs receiving increased dietary concentrations of cadmium. Nature; 239, 171-173.

Navarro MC, Perez-Sirvent C, Martinez-Sanchez MJ, Vidal J, Tovar PJ, Bech J (2008). Abandoned mine sites as a source of contamination by heavy metals: A case study in a semi-arid zone. J Geoche Explor; 96, pp. 183-9.

Nriagu J, Boughanen M, Linder A, Howe A, Grant C, Rattray R, Vutchkov M, Lalor G (2009). Levels of As, Cd, Pb, Cu, Se and Zn in bovine kidneys and livers in Jamaica. Ecotoxicol Environ Saf; 72, pp. 564-571.

Okoye COB, Ugwu JN (2010). Impact of environmental cadmium, lead, copper and zinc on quality of goat meat in nigeria. Bull. Chem. Soc. Ethiop; 24(1), pp. 133-138.

Okoye COB, Ugwu JN, Ibeto CN (2010). Characterisation of rural water resources for potable water supply in some parts of Southeastern Nigeria. J Chem Soc Nigeria; 35(1), pp. 83-87.

Oliver MA (2007). Soil and human health: a review. Eur J Soil Sci; 48, pp. 573-92.

Oyaro N, Ogendi J, Murago ENM, Gitonga E (2007). The contents of Pb, Cu, Zn and Cd in Nairobi, Kenya. J Food Agric Environ; 5(3-4), pp. 119-121.

Pompe-Gotal J, Crnic AP (2002). Cadmium in tissue of roe deer (Capreolus capreolus) in Croatia. Vet Arh; 72, pp. 303-310.

Santhi D, Balakrishnan V, Kalaikannan A, Radhakrishnan KT (2008). Presence of heavy metals in pork products in Chennai (India). Am. J. Food Technol; 3(3), pp. 192-199.

Singh AN, Zeng, DH, Chen FS (2005). Heavy metal concentrations in redeveloping soil of mine spoil under plantations of certain native woody species in dry tropical environment, India. J. Environ Sci; 1, pp. 168-74.

Stoyke M, Doberschutz KD, Lusky K (1995). Heavy metal contents (cadmium, lead and mercury) in selected feedstuff, organs and tissue in cattle found different sites of Brandenburg. Mengen Spureneler Arb; 15, pp. 269-276.

Swaileh KM, Hussein RM, Abu-Elhaj S (2004). Assessment of heavy metal contamination in roadside surface soil and vegetation from the West Bank. Arch Environ Contam Toxicol; 47(1), pp. 23-30.

Swaileh KM, Abdulkhaliq A, Hussein RM, Matani M (2009). Distribution of toxic metals in organs of local cattle, sheep, goat and poultry from the West Bank, Palestinian Authority Bulletin of Environmental Contamination and Toxicology; 83(2) pp. 265.

Tubaro A, Hungerford J (2007). Environmental toxicology. In Gupta RC, ed, Veterinary Toxicology: Basic and Clinical Principles. Academic, New York, NY, USA, pp 663-725.

Yabe J, Ishizuka M, Umemura T (2010). Current levels of heavy metal pollution in Africa. J Vet Med Sci; 72, pp. 1257-1263.

Yabe J, Nakayama SMM, Ikenaka Y, Muzandu K, Ishizuka M (2011). Uptake of lead, cadmium, and other metals in the liver and kidneys of cattle near a lead-zinc mine in Kabwe, Zambia. Environ Toxicol and Chem; 30(8), pp. 1892-1897.

Zheng N, Wang Q, Zhang X, Zheng D, Zhang Z, Zhang S (2007). Population health risk due to dietary intake of heavy metals in the industrial area of Huludao city, China. Sci Total Environ; 387, pp. 96-104

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