Research Journal of Environmental Sciences

ISSN 1819-3412

Academic
Journals Inc.

www.academicjournals.com

Research Journal of Environmental Sciences 5 (3): 288-294, 2011
ISSN 1819-3412 / DOI: 10.3923/rjes.2011.288.294

Assessment of Heavy Metal Concentrations in the Liver of Cattle at Slaughter during Three Different Seasons

[1]D.O. Nwude, [2]P.A.C. Okoye and [1]J.O. Babayemi
[1]Department of Chemical Sciences, Bells University of Technology, Ota, Ogun State, Nigeria
[2]Department of Pure and Industrial Chemistry, Nnamdi Azikwe University, Awka, Anambra State, Nigeria

Corresponding Author: J.O. Babayemi, Department of Chemical Sciences, Bells University of Technology, Ota, Ogun State, Nigeria Tel: +2348060709930

ABSTRACT

The investigation was carried out to assess the level of accumulation of heavy metals in the liver of cattle at slaughter during three different seasons: on-set of rainy season (April-July, 2004), peak of rainy season (July-October, 2004) and dry season (January-April, 2005), to identify the season of probable highest accumulation, the most and the least accumulated metals, which might give some clue to any variation in seasonal heavy metal pollution. Pollution is one of the major environmental problems requiring attention globally. As a result of this global problem, contaminations of various sources of food for humans have been reported. Possible markers of environmental pollution have been sought for a proper evaluation of pollutants level and monitoring. Pollutant metals of environmental concern, including lead, cadmium, zinc, cobalt, copper and iron were studied in this investigation. Liver samples were collected from cows at slaughter at Awka abattoir; the samples were digested with phosphoric acid and analyzed for the heavy metals using atomic absorption spectrophotometer, model Shimadzu AA-6800. During the three seasons, Zn was bioaccumulated most (3.00 B 14.40 mg kg^{-1}), followed by Pb (0.09 B 7.32 mg kg^{-1}) and the least being Cd (0.001 B 0.03 mg kg^{-1}). Statistical analysis showed a good correlation between the levels of Pb and Co, Pb and Zn and between Co and Zn, implying that cattle liver accumulations of Pb and Co are functions of Co and/or Zn levels in the liver. It could also be inferred that heavy metal bioaccumulation by cattle is affected by season.

Key words: Lead, cadmium, cobalt, zinc, copper, liver

INTRODUCTION

Environmental pollutants 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). Industrial and urban activities generate metal wastes which pollute soils, leading to the accumulation of toxic metals in the soils, transferred to plants and consequently into animals (Swarup *et al*., 2006). Application of pig and poultry manure which contain Cu and Zn at higher concentrations on agricultural lands as fertilizer could also result in metal pollution of agricultural lands (Poulsen, 1998) which may have an eventual effect on the grazing cattle. Through the polluted water sources, the aquatic animals and agricultural livestock have been infected with pathogenic microorganisms and as well accumulate chemical pollutants. The heavy metals and organic pollutants could have a detrimental effect on aquatic and farmland

animals (Van de Merwe *et al.*, 2010). If agricultural lands are close to highways, aerial deposition of metal-containing particulates from automobile exhausts could occur and eventual uptake by crops (Garcia and Millan, 1998). Medvedev (1995) inferred some indications of industrial pollution in the forest ecosystems by determining the concentrations of cadmium, lead and sulphur in the tissues of wild, forest reindeer from North-West Russia. In the determination of the levels of some heavy metals in urban run-off sediments in Ilorin and Lagos, Nigeria, by Adekola *et al.* (2002), very high concentrations of Zn, Fe and Cd were found in the urban sediment from these cities. Miranda *et al.* (2005) studied the effects of moderate pollution on toxic and trace metal levels in calves from a polluted area of northern Spain; Cd and Pb contents in the liver were moderately and significantly higher in calves from industrialized area. In the findings of Atayese *et al.* (2008) for Lagos environment, *Amaranthus* grown along major highways accumulated Pb and Cd at concentrations above the normal limit for plants, suggesting pollution by aerial deposition. Asonye *et al.* (2007) reported the concentrations of Pb, Cr, Cd, Fe, Zn, Mn and Cu in water samples of rivers, streams and waterways in southern Nigeria, exceeding the guidelines of WHO. Kpee *et al.* (2009) evaluated seasonal variation of Cd, Ni, Cu and Pb pollution in catfish, sediment and water samples from Ipo stream in Ikwere district of Rivers state, Nigeria. In this study, we made attempt to evaluate metal pollution by studying the levels in the liver of cattle at different seasons.

Cattle are raised in the northern part of Nigeria; while some graze from northern part through to southern part, others are transported to every other part of the country for human consumption as meat. The cattle are allowed to feed on grasses in the surroundings and drink water from any nearby streams and stagnant water. It has been an established fact that non-essential elements could be transferred through food chains (Rogival *et al.*, 2007; Ma *et al.*, 2007). It is therefore possible that this eating habit of cattle may lead to bioaccumulation of heavy metals in the liver where several detoxifications take place.

Sometimes, liver is used as a constituent of animal feed. And due to its good iron content, human consumption of animal liver has increased over the years in this part of the world. The importance of meat and milk derived from cattle as sources of protein for humans brings about the need to ensure that these protein sources do not contain harmful substances capable of causing health problems to humans. Exposure to Pb may result in human breast lesions (Siddiqui *et al.*, 2006). Accumulation of higher concentrations of heavy metals could predispose animals to illness (Harper *et al.*, 2007) and toxic heavy metals could cause alterations of immune system in diverse animals (Lapierre *et al.*, 1999). Therefore, the global environmental health concern calls for research to determine the pollutant levels, especially metals, in aquatic and terrestrial animals, since humans depend mainly on such animals for their protein. Exposure to pollutants runs through the food chain and humans at the receiving end stand at risk (Abbas *et al.*, 2006). Humans are exposed to metal pollutants in surface water by consumption of contaminated aquatic organisms (Mackey, 1991). These among others, have prompted this investigation of metals concentrations in the liver of cattle. Pollutant metals of environmental concern include Pb. Cd, Zn, Co, Cu and Fe; hence, these are studied in this investigation. This study aims at assessing the level of liver accumulation of the heavy metals in different seasons; the most and the least bioaccumulated metals and the season of highest bioaccumulation which may give a clue to any variation in seasonal heavy metal pollution.

MATERIALS AND METHODS

Sample collection: Liver samples were collected from Awka abattoir from five different cows at slaughter during the three different seasons of the year: on-set of rainy season (April-July, 2004), peak of rainy season (July-October, 2004) and dry season (January-April, 2005); the samples were stored in refrigerator, waiting the time of extraction and analysis of the metals.

Digestion and analysis: Ten gram of each liver sample was placed in conical flasks; 5 mL of phosphoric acid were added, heated on a heating mantle for about an hour, until heated to dryness; 100 mL of distilled water were added and thoroughly shaken. It was filtered into a 100 mL standard flask and the filtrate was made up to mark with distilled water. Aliquots of this were analyzed for Pb, Cd, Co, Zn, Cu and Fe using atomic absorption spectrophotometer, model Shimadzu AA-6800.

Statistical analysis: Correlations were made between the concentrations of one metal and the other to establish any possible relationships in the accumulation of the metals in the kidney, using the RSQ worksheet function.

RESULTS AND DISCUSSION

Table 1 shows the levels of heavy metals in the liver of cattle at the on-set of rainy season and the values ranged from 2.20-7.32 mg kg^{-1}, Pb; 0.01-0.02 mg kg^{-1}, Cd; 0.05-1.10 mg kg^{-1}, Co; 6.50-14.4 mg kg^{-1}, Zn and 0.04-0.10 mg kg^{-1}, Cu. At the peak of rainy season (Table 2), the values ranged from 0.35-1.33 mg kg^{-1}, Pb; 0.001-0.01 mg kg^{-1}; Cd; 0.07-1.04 mg kg^{-1}; Co; 3.00-3.18 mg kg^{-1}, Zn; 0.03-1.34 mg kg^{-1}, Cu and 0.73-1.20 mg kg^{-1}, Fe. The levels during the dry season are presented in Table 3: 0.09-1.49 mg kg^{-1}, Pb; 0.01-0.03 mg kg^{-1}, Cd; 0.20-0.25 mg kg^{-1}, Co; 3.72-4.12 mg kg^{-1}, Zn; 0.79-2.20 mg kg^{-1} Cu and 0.60-1.06 mg kg^{-1}, Fe. Table 4 shows the results obtained by other researchers to compare with the results in this study. Average concentrations in the three seasons were 1.97 mg kg^{-1}, Pb; 0.01, Cd; 0.46 mg kg^{-1}, Co; 5.82 mg kg^{-1}, Zn; 0.64 mg kg^{-1}, Cu and 0.85 mg kg^{-1}, Fe; illustrated by Fig. 1. The results of correlations (correlation coefficients, R^2): 0.11, Pb/Cd; 0.799, Pb/Co; 0.837, Pb/Zn; 0.0429, Pb/Cu; 0.3767, Cd/Co;

Table 1: Metal concentrations (mg kg^{-1}) in the liver of various cows (C_1.....C_5) at the on-set of rainy season (April-July)

Cows	Pb	Cd	Co	Zn	Cu	Fe
C_1	7.32±0.03	0.01±0.01	0.059±0.15	14.30±0.00	0.07±0.05	-
C_2	2.20±0.01	0.01±0.02	1.10±0.10	6.50±0.02	0.10±0.50	-
C_3	2.41±0.00	0.01±0.02	1.10±0.10	8.90±0.03	0.04±0.05	-
C_4	5.50±0.23	0.02±0.10	0.05±0.10	14.40±0.02	0.05±0.02	-
C_5	3.61±0.02	0.01±0.01	1.24±0.00	8.20±0.02	0.10±0.10	-

Table 2: Metal concentrations (mg kg^{-1}) in the liver of various cows (C_1.....C_5) at the peak of rainy season (July-October)

Cows	Pb	Cd	Co	Zn	Cu	Fe
C_1	0.35±0.14	0.001±0.00	0.07±0.27	3.18±0.03	1.34±0.04	1.20±0.10
C_2	1.33±0.23	0.01±0.07	0.60±0.20	3.00±0.05	0.03±0.04	1.20±0.05
C_3	1.03±0.01	0.004±0.02	0.30±0.01	3.00±0.05	0.10±1.00	0.73±0.10
C_4	1.40±0.02	0.004±0.13	1.04±0.02	3.04±0.02	0.40±0.10	0.73±0.02
C_5	1.53±0.01	0.01±0.00	0.20±0.20	3.01±0.02	0.80±0.03	0.90±0.06

Table 3: Metal concentrations (mg kg^{-1}) in the liver of various cows (C_1.....C_5) during the dry season (January-April)

Cows	Pb	Cd	Co	Zn	Cu	Fe
C_1	1.49±0.00	0.01±0.03	0.25±0.27	3.93±0.00	0.79±0.02	0.75±0.03
C_2	0.40±0.10	0.01±0.03	0.24±0.23	3.72±0.03	1.00±0.02	0.63±0.06
C_3	0.82±0.09	0.02±0.01	0.20±0.10	4.00±0.00	0.94±0.03	0.71±0.04
C_4	0.11±0.99	0.01±0.01	0.24±0.10	4.12±0.02	2.20±0.03	1.06±0.02
C_5	0.09±0.07	0.03±0.01	0.25±0.11	4.00±0.01	1.60±0.04	0.60±0.01

Table 4: Concentration of toxic metals and essential metals in the liver of calves/cattle/sheep

	Wet weight (µg kg^{-1})			Wet weight (mg kg^{-1})		
Environment	Pb	Cd	Co	Zn	Cu	Fe
[a]Industrial area	ND-411	3.39-131	-	19.2-64.6	1.86-137	47.4-255
[a]Rural area	ND-174	6.43-221	-	20.9-71.3	2.28-139	54.9-291
[b]Desa region	<DL-509	<DL-85.5	<DL-187	33.7-115	3.72-38	4.3-90.2
[c]Southern Nigeria	0.00-0.26*	0.03-0.13*	-	-	0.46-4.89	22.89-57.86
[d]Morocco**	-	2.9-7.1	-	95-161	76-156	-
[e]VNFMS	15.30±1.14*	7.92±2.36*	-	217.9±35.7	248.1±35.9	-

[a]Miranda *et al.* (2005); [b]Blanco-Penedo *et al.* (2006); [c]Iwegbue (2008); [d]Sedki *et al.* (2003); [e]Liu (2003); <DL: Below detection limit; ND: Not detected; VNFMS: Vicinity of non-ferrous metal smelters; *mg kg^{-1}; **µg g^{-1};

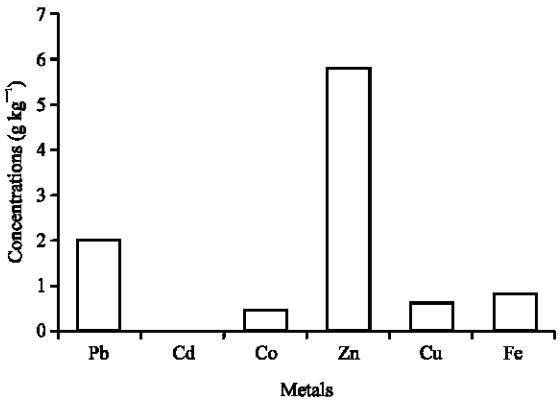

Fig. 1: Metal accumulation in the liver of cattle: aggregate of the three seasons

0.3628, Cd/Zn; 0.1964, Cd/Cu; 0.29, Zn/Cu; 0.9243, Co/Zn and 0.1904, Co/Cu; are presented in Fig. 2. Figure 3 shows average concentrations of the metals at each of the three seasons: on-set (X), peak (Y) and dry (Z).

Pb accumulation was highest at the on-set of rainy season; higher at the peak of rainy season and least during the dry season. Cd level at the on-set of rainy season and dry season show a similar pattern, but slightly different at the peak of rainy season. The higher values for the two seasons with similar pattern may that Cd was accumulated more at the on-set of rainy season and during the dry season than at the peak of rainy season. The accumulation of Co was higher both at the peak of rainy season and during the dry season than at the on-set of rainy season. Zn level was highest at the on-set of rainy season and lowest at the peak of rainy season. Cu level was highest during dry season and lowest at the on-set of rainy season. The levels of Fe at the peak of rainy season and during the dry season were similar.

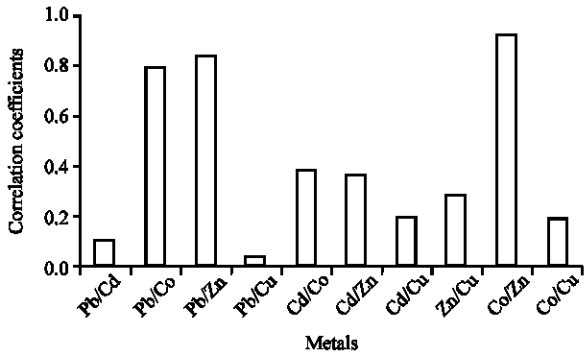

Fig. 2: Results of correlations between concentrations of the metals

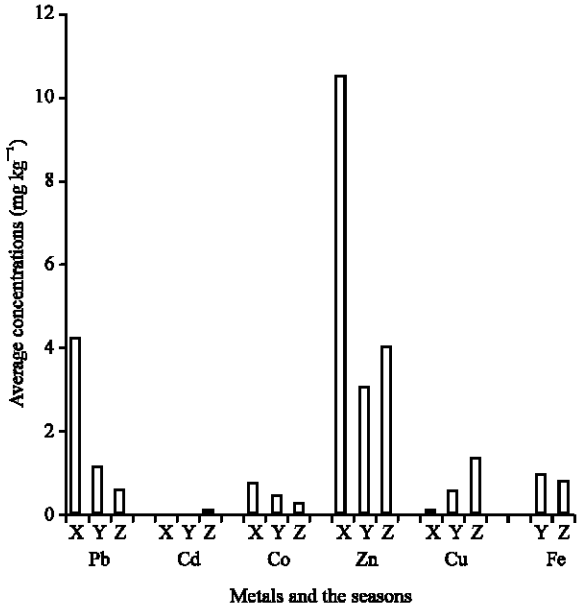

Fig. 3: Average concentrations of metals at seasons X, Y and Z

Iwegbue (2008) obtained 0.00-0.26 mg kg^{-1}, Pb; Liu (2003), 15.30±1.14 mg kg^{-1}; Miranda *et al.* (2005), ND-411 μg kg^{-1} for industrial area and ND-174 for rural area and Blanco-Penedo *et al.* (2006), DDL-509 μg kg^{-1}. In this study, 0.09-7.32 was observed. The level of Pb recorded in this study perfectly agrees with these references, except Liu (2003), where disparity exists. The level of Cd reported in the references ranged from 3.39-131 μg kg^{-1} for industrial area and 6.43-221 μg kg^{-1} for rural area (Miranda *et al.*, 2005); DDL-85.5 μg kg^{-1} (Blanco-Penedo *et al.*, 2006); 0.03-0.13 mg kg^{-1} (Iwegbue, 2008); 2.9-7.1 μg g^{-1} (Sedki *et al.*, 2003); 7.92±2.36 mg kg^{-1} (Liu, 2003) and 0.001-0.02 mg kg^{-1} (this study). Disparity only exists with that obtained by Liu (2003). The Zn level ranged from 19.2-64.6 mg kg^{-1} for industrial area and 20.9-71.3 mg kg^{-1} for rural area (Miranda *et al.*, 2005); 33.7-115 mg kg^{-1} (Blanco-Penedo *et al.*, 2006); 95-161 mg kg^{-1} (Sedki *et al.*, 2003); 217±35.7 mg kg^{-1} (Liu, 2003) and 3.00-14.40 mg kg^{-1} (this study). The Zn level observed in this study is less than those in the references, except that recorded for industrial area by Miranda *et al.* (2005), where the results are a bit closer. The levels of Cu as observed by other researchers ranged from 1.86-137 mg kg^{-1} for industrial area and 2.28-139 mg kg^{-1} for rural area

(Miranda *et al.*, 2005); 3.72-38 mg kg^{-1} (Blanco-Penedo *et al.*, 2006); 0.46-4.89 mg kg^{-1} (Iwegbue, 2008); 76-156 μg g^{-1} (Sedki *et al.*, 2003); 248.1±35.9 μg kg^{-1} (Liu, 2003) and 0.03-2.20 μg kg^{-1} (this study). While, there is agreement with the results recorded by Miranda *et al.* (2005) for industrial area and that by Iwegbue (2008), disparity exists with the others. The levels of Fe observed in this study are lower than those recorded in the references.

The results of correlations (correlation coefficients, R^2 are shown in Fig. 2. There was a good correlation between Pb and Co ($R^2 = 0.799$), between Pb and Zn ($R^2 = 0.837$) and between Co and Zn ($R^2 = 0.9243$). Others showed little or no correlations. One may infer that cattle liver accumulation of Pb was a function of Co and/or Zn levels and bioaccumulation of Co was a function of Zn. The observation was similar to that made by Blanco-Penedo *et al.* (2006) in which they observed a strong and significant correlation between Cu and Pb concentrations in the liver of cattle. However, further study may be necessary to establish these.

CONCLUSION

Bioaccumulation of heavy metals by cattle varies with seasons; hence, variation in bioaccumulation of heavy metals by cattle at different seasons could depict seasonal variation in environmental pollution by metals. Cattle liver is a potential target organ for accumulation of metals. Bioaccumulation of one metal in the liver of cattle could be a function of the level of concentration of the other.

REFERENCES

Abbas, S.T., S.M. Mehdi, M. Sarfraz and G. Hassan, 2006. Accumulation and bioavailability of heavy metals in soils and rice plants polluted with industrial wastewater. Caderno de Pesquisa série Biologia, 18: 29-48.

Adekola, F.A., O.A. Eletta and S.A. Attanda, 2002. Determination of the levels of some heavy metals in urban run-off sediments in Ilorin and Lagos, Nigeria. J. Applied Sci. Environ. Manage., 6: 23-26.

Asonye, C.C., N.P. Okolie, E.E. Okenwa and U.G. Iwuanyanwu, 2007. Some physico-chemical characteristics and heavy metal profiles of Nigerian rivers, streams and waterways. Afr. J. Biotechnol., 6: 617-624.

Atayese, M.O., A.I. Eigbadon, K.A. Oluwa and J.K. Adeosun, 2008. Heavy metal contamination of *Amaranthus* grown along major highways in Lagos, Nigeria. Afr. Crop Sci. J., 16: 225-235.

Blanco-Penedo, I., J.M. Cruz, M. López-Alonso, M. Miranda and C. Castillo *et al.*, 2006. Influence of copper status on the accumulation of toxic and essential metals in cattle. Environ. Int., 32: 901-906.

Garcia, R. and E. Millan, 1998. Assessment of Cd, Pb and Zn contamination in roadside soils and grasses from Gipuzkoa (Spain). Chemosphere, 37: 1615-1625.

Harper, E.R., J.A. St. Ledger, J.A. Westberg, L. Mazzaro and T. Schmitt *et al.*, 2007. Tissue heavy metal concentrations of stranded California sea lions (*Zalophus californianus*) in Southern California. Environ. Pollut., 147: 677-682.

Iwegbue, C.M.A., 2008. Heavy metal composition of livers and kidneys of cattle from southern Nigeria. Vet. Arch., 78: 401-410.

Kpee, F., E. Ozioma and L. Ihunwo, 2009. Seasonal variation of Cd, NI, Cu and Pb in catfish, sediment and water samples from IPO stream in Ikwere district of Rivers state. J. Applied Sci. Environ. Manage., 13: 63-67.

Lapierre, P., S. De Guise, D.C. Muir, R. Norstrom, P. Beland and M. Fournier, 1999. Immune functions in the Fisher rat fed beluga whale (*Delphinapterus leucas*) blubber from the contaminated St. Lawrence estuary. Environ. Res., 80: S104-S112.

Liu, Z.P., 2003. Lead poisoning combined cadmium in sheep and horses in the vicinity of non-ferrous metal smelters. Sci. Total Environ., 309: 117-126.

Ma, H.W., M.L. Hung and P.C. Chen, 2007. A systemic health risk assessment for the chromium cycle in Taiwan. Environ. Int., 33: 206-218.

Mackey, C., 1991. Predicting the Environmental Portioning of Organic Contaminants and their Transfer to Biota. In: Organic Contaminants in the Environment, Jones, K.C. (Ed.). Elsevier Science Publ., New York.

Medvedev, N., 1995. Concentrations of cadmium, lead and sulphur in tissues of wild, forest reindeer from North-West Russia. Environ. Pollut., 90: 1-5.

Miranda, M., M. Lopez-Alonso, C. Castillo, J. Hernandez and J.L. Benedito, 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.

Ogbuagu, J.O., C.K. Nnodu and P.A.C. Okoye, 2005. Ground water contamination in some residential area of Anambra State, Nigeria. J. Applied Sci., 8: 5062-5074.

Poulsen, H.D., 1998. Zinc and copper as feed additives, growth factors or unwanted environmental factors. J. Anim. Feed Sci., 7: 135-142.

Rogival, D., J. Scheirs and R. Blust, 2007. Transfer and accumulation of metals in a soil-diet-wood mouse food chain along a metal pollution gradient. Environ. Pollut., 145: 516-528.

Sedki, A., N. Lekouch, S. Gamon and A. Pineau, 2003. Toxic and essential trace metals in muscle, liver and kidney of bovines from a polluted area of Morocco. Sci. Total Environ., 317: 201-205.

Siddiqui, M.K.J., Jyoti, S. Singh, P.K. Mehrotra, K. Sing and R. Sarangi, 2006. Comparison of some trace elements concentration in blood, tumor free breast and tumor tissues of women with benign and malignant breast lesions: An Indian study. Environ. Int., 32: 630-637.

Swarup, D., R.C. Patra, R. Naresh, P. Kumar, P. Shekhar and M. Baragangatharathilagar, 2006. Lowered blood copper and cobalt contents in goats reared around lead-zinc smelter. Small Ruminant Res., 63: 309-313.

Van de Merwe, J.P., M. Hodge, H.A. Olszowy, J.M. Whittier and S.Y. Lee, 2010. Using blood samples to estimate persistent organic pollutants and metals in green sea turtles (Chelonia mydas). Mar. Pollut. Bull., 60: 579-588.