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Heavy Metal and Trace Mineral Profile in Blood and Hair of Cattle Reared Around Industrial Effluent Contaminated Area

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ABSTRACT

Blood and hair samples were collected from seventy adult cattle reared in villages located near the industrial effluent contaminated River adjoining Meerut. Based on the distance of the villages from the river, they were divided into three areas viz. area 1 (villages located on the river bank), area 2 (villages within 1km distance from the river) and area 3 (villages more than 2 km from the river). Samples collected from cattle reared in rural locality away from the river were used as control. The mean lead (Pb) and cadmium (Cd) levels of blood and hair in the animals of area 1 and area 2 were significantly higher ($P<0.05$) as compared to control animals. The mean Pb and Cd levels of animals of area 3 were not significantly different from control values. Significantly low ($P<0.05$) copper and iron concentration in blood and hair were recorded in the animals from area1 and area 2 as compared to area 3 and control animals. Blood and hair zinc levels were not significantly different among animals of different areas. The blood cadmium level had significant negative correlation with blood copper($r=-0.379$, $p<0.01$) and iron($r=-0.395$, $p<0.01$). The blood lead levels had significant negative correlation with blood iron ($r= -0.138$, $p< 0.05$) and hair copper ($r= -0.178$, $p< 0.05$) and iron ($r= -0.302$, $p< 0.05$). The blood cadmium level had significant negative correlation with hair copper ($r=-0.377$, $p< 0.01$) and iron ($r= -0.482$, $p<0.01$). The study concludes that blood lead and cadmium influenced the concentration of trace minerals in the blood and hair.

Keywords: Cattle, Hair, Heavy metal, Industrial pollution, Trace mineral

Use of industrial effluents and domestic sewage water in the agriculture land for irrigation gradually increases the toxic metals in the soil which are taken up by plants and subsequently transferred into the food chain. Heavy metals like lead and cadmium are the major toxic metals posing threat to animal and human health (Rajaganapathy *et al.,* 2011). In the local studies carried out around industrial effluent contaminated Kali River adjoining Meerut city, high levels of heavy metals in the water, agricultural soil and vegetables have been reported (Kumar *et al*., 2014; Kulshreshtha *et al*., 2015; Maurya and Malik, 2016). Heavy metals are accumulated in the fodder grown on contaminated soil. Chronic intake of smaller quantities of toxic metals through contaminated fodder leads to their accumulation in different parts of animal body and is manifested by loss of appetite, anaemia and reproductive problems (Kotwal *et al*., 2005; Reis *et al*., 2010). The effects of heavy metal pollutants like lead and cadmium have also been found to affect mineral concentration in animal body (Reis *et al.,* 2010). Tissue specific changes in distribution of iron, zinc, copper, cobalt and manganese have been reported in cattle and rats after experimental administration of lead and cadmium (Patra and Swarup, 1998; Oishi *et al.,* 2000). As minerals are required for growth, production and reproduction in animals, knowledge on trace minerals and toxic metal concentration in cattle reared in polluted locality is required for assessing their effects on animal health. Hair contain sulphydryl group that can bind lead and cadmium for a longer period. Thus, long term exposure to heavy metals can be diagnosed by hair analysis (Chojnacka *et al*., 2012). Therefore, the present work was undertaken to study heavy metal and trace minerals profile in blood and hair from cattle reared around industrial effluent contaminated area.

MATERIALS AND METHODS

Animals, sampling and processing

Respective blood and hair samples were collected from seventy adult cattle reared in the study area at least for preceding 3 years. Samples were collected from villages located near the industrial effluent contaminated Kali River adjoining Meerut city, Uttar Pradesh, India. Based on the distance of the villages from the river, they were divided into three areas viz. area 1(villages located on the river bank), area 2 (villages within 1km distance from the river) and area 3 (villages more than 2 km from the river). Samples collected from cattle reared in rural locality away from the river were used as control for comparison. Blood samples were collected in nitric acid-washed heparinized glass vials and hair samples in separate plastic bags for further processing in the lab. The hair samples were washed in deionized water to remove dust and superficial contamination. This was followed by sequential washing with acetone, distilled water and acetone. 1 g of washed hair samples and 5 ml whole blood were wet digested separately, with nitric and perchloric acid mixture (Kolmer *et al.,* 1951). Two to three blank samples containing distilled water instead of bio sample were run simultaneously with each batch of the digestion.

Analysis of toxic and trace minerals

The toxic heavy metals lead and cadmium and trace elements copper, zinc and iron concentrations in the digested samples were estimated using atomic absorption spectrophotometer (GBC Scientific) at the wave length of 217.0, 324.7, 240.7, 213.9, 248.3 with 6, 6, 7, 7, 5 mA current, respectively. The standards procured (Sisco Research Laboratory, Mumbai, India) for each element were used to calibrate the equipment. The values were expressed in µg/ml of blood and µg/g of hair.

Statistical analysis

The data were analyzed using one-way analysis of variance to find out the statistical difference among the mean values of a particular trace or toxic element in different areas. A parametric (Pearson) correlation between toxic heavy metal and trace element in blood and hair were analyzed using standard statistical methods (Snedecor and Cochran, 1994).

Table 1: Blood lead and cadmium concentration and trace mineral profile of cattle reared around industrial effluent contaminated area (Mean± S. E.)

	Parameter				
	Lead (µg/ml)	**Cadmium (µg/ml)**	**Copper (µg/ml)**	**Iron (µg/ml)**	**Zinc (µg/ml)**
Area1 (n=29)	0.44 ± 0.03^{a} (0.08-0.91)	1.01 ± 0.03^{a} (0.34-1.2)	1.11 ± 0.08^{a} (0.30-1.95)	82.03 ± 4.51^{a} (22.18-125.60)	1.80 ± 0.06^{a} (1.30-2.62)
Area 2 (n=15)	0.33 ± 0.02^{b} (0.10-0.51)	0.74 ± 0.04^{b} (0.56-1.0)	1.14 ± 0.07^{a} (0.62-1.60)	105.88 ± 3.52^{b} (79.58-122.20)	1.99 ± 0.17^{a} (1.05-3.72)
Area 3 (n=16)	0.13 ± 0.01^{c} (0.01-0.30)	0.34 ± 0.05^{c} (0.16-0.93)	1.62 ± 0.09^{b} (0.88-2.30)	123.70 ± 4.09^{c} (91.98- 152.24)	2.04 ± 0.12^{a} (1.28-2.97)
Control (n=10)	0.10 ± 0.02^{c} (0.03-0.24)	0.23 ± 0.02^{c} (0.13-0.32)	1.68 ± 0.16^{b} (1.20-2.80)	120.15 ± 3.58^{c} (90.64-159.62)	1.94 ± 0.13^{a} (1.33-2.60)

Values with different superscripts in a column differ significantly ($p<0.05$),

Figures in parenthesis indicate range

Area 1- villages located on the river bank, Area 2- villages within 1km distance from the river,

Area 3- villages more than 2 km distance from the river, Control- villages away from the river

RESULTS AND DISCUSSION

The present investigation was carried out to assess the heavy metal and trace mineral profile in blood and hair from cattle reared around industrial effluent contaminated area and to examine their effect on concentration of trace minerals like copper, zinc and iron in blood and hairs. Blood and hair lead and cadmium residue and trace mineral profile of cattle is given in table 1 and 2.

Levels of toxic metals in blood and hair

The mean Pb and Cd levels of blood and hair in the animals of area 1 and area 2 were significantly higher ($P<0.05$) as compared to control animals. The mean Pb and Cd levels of animals of area 3 were not significantly different from control values (Table 1 and 2). High levels of Pb and Cd in the soil, sediment and waste water of Kali river have been reported earlier also (Sharma and Shukla, 2013; Maurya and Malik, 2016). The disposal of untreated industrial effluents and domestic sewage from adjoining city in Kali River which is used for irrigation purpose by local villagers lead to higher concentrations of toxic pollutants in water, soil and feedstuffs. This might have resulted into increased levels of toxic heavy metals in the animal body through ingestion of contaminated feed and water. The higher blood lead and cadmium level in animals around different industrial areas in India have been reported by several workers (Patra *et al*., 2005; Swarup *et al*., 2006).

Correlation between toxic and trace elements in blood and hair

The blood lead levels had a significant ($p<0.01$) positive correlation with blood cadmium and significant ($p<0.05$) negative correlation with blood iron while blood cadmium level showed significant ($p<0.01$) negative correlation with blood copper and iron and non significant negative correlation with blood zinc (Table). The blood lead levels had significant ($p<0.01$) positive correlation with hair lead and cadmium and significant ($p<0.05$) negative correlation with hair copper and iron. The blood cadmium level had significant ($p<0.01$) positive correlation with hair lead and cadmium and significant ($p<0.01$) negative correlation with hair copper, and iron (Table 3).

Levels of trace elements in blood and hair

Significantly low ($P<0.05$) copper and iron concentration in blood and hair were recorded in the animals from area 1 and area 2 as compared to area 3 and control animals suggesting influence of blood lead and cadmium on trace mineral concentration. This is further supported by

Table 2: Lead and Cadmium concentration and trace mineral profile of hair of cattle reared around industrial effluent contaminated area (Mean± S. E.)

	Parameters				
	Lead (µg/ml)	**Cadmium (µg/ml)**	**Copper (µg/ml)**	**Iron (µg/ml)**	**Zinc (µg/ml)**
Area 1	3.46 ± 0.24^{a}	5.43 ± 0.22^{a}	1.71 ± 0.20^{a}	310.12 ± 29.61^{a}	61.62 ± 2.71^{a}
(n=29)	(2.20-5.60)	(3.24-6.62)	(0.18-3.22)	(119.40-571.10)	(17.0-89.0)
Area 2	2.19 ± 0.29^{b}	4.39 ± 0.32^{b}	1.67 ± 0.27^{a}	303.79 ± 28.47^{a}	58.87 ± 2.86^{a}
(n=15)	(0.50-4.40)	(2.40-6.70)	(0.22-3.75)	(162.20-440.30)	(40.8-77.0)
Area 3	1.06 ± 0.10^{c}	2.90 ± 0.22^{c}	2.72 ± 0.24^{b}	440.53 ± 50.69^{b}	55.46 ± 1.47^{a}
(n=16)	0.70-1.75)	(2.01-4.48)	(1.10-3.78)	(167.30-737.0)	(47.6-65.2)
Control	0.69 ± 0.12^{c}	1.95 ± 0.15^{c}	2.68 ± 0.28^{b}	432.92 ± 64.50^{b}	60.98 ± 2.91^{a}
(n=10)	(0.20-1.35)	(1.09-2.62)	(1.11- 3.72)	(202.0-968.0)	(47.0-71.8)

Values with different superscripts in a column differ significantly ($p<0.05$),

Figures in parenthesis indicate range

Area 1- villages located on the river bank, Area 2- villages within 1km distance from the river,

Area 3- villages more than 2 km distance from the river, Control- villages away from the river

Table 3: Correlation of toxic metals with trace minerals in blood and hairs

Parameters			Blood		
Blood	**Pb**	**Cd**	**Zn**	**Cu**	**Fe**
Lead	1.0	o.625**	-0.061	-0.084	-0.138*
Cadmium	o.625**	1.0	-0.054	-0.379**	-0.395**
			Hair		
Blood	Pb	Cd	Zn	Cu	Fe
Lead	0.575**	0.418**	0.176	-0.178*	-0.302*
Cadmium	0.605**	0.603**	0.252	-0.377**	-0.482**

*(0.05), ** (0.01)

negative correlation between blood lead and cadmium with copper, and iron in blood and hairs (Table 3). Blood and hair zinc levels were not significantly different among animals of different areas (Table 1 and 2). Absorption, utilization and excretion of many trace elements in body are influenced by other trace minerals or compounds in the diet and their levels in the body (Underwood, 1978). Heavy metals lead and cadmium interfere with normal bio-availability of trace elements by competing with them in the process of absorption from the intestine (Xu *et al*., 2004). The higher blood lead level causes hypochromic and microcytic anaemia resulting from interference with haeme synthesis leading to deficiency of trace minerals (Liu, 2003). Diaz and Barriga *et al*. (1996) found a negative correlation between blood lead and iron levels. Pond and Yen (1983) reported significantly low iron concentration in blood and hair with higher blood cadmium level. The possible mechanism of this negative correlation was the ability of cadmium to inhibit iron absorption from intestine. Cadmium disturb copper metabolism by reduced plasma ceruloplasmin concentration (Blanco-Penedo *et al*., 2006). Ceruloplasmin is the protein responsible for transporting copper through the circulatory system. Blanco-Penedo *et al.* (2006) reported that high cadmium level lead to copper deficiency. In the present study, similar mechanisms might be responsible for the lowered copper and iron concentration in blood and hair of cattle with high lead and cadmium levels. Swarup *et al*. (2006) observed lower blood copper contents in goats reared around lead-zinc smelter and revealed negative correlation between blood lead and copper. The factors such as grazing seasons, physiological status of the body, heavy metal pollution like lead and cadmium have been reported to influence trace mineral status of blood and hair (Tanasescu and Avram, 1995). Trace elements such as copper, zinc, iron etc. are very much essential for normal growth, disease resistance, production and reproduction in farm animals. Chronic exposure with low levels of lead and cadmium may affect health and production in cattle by altering trace mineral concentration in the animal body. In general, a deficiency of these essential elements increases toxicity of heavy metals, whereas an excess appears to be protective. This suggests that the dietary presence of the essential elements may contribute to the protection of man and animals from the effects of heavy metal exposure, while their deficiency may increase toxicity (Diaz-Barriga *et al*., 1996). In the present investigation no change in blood and hair zinc levels could be recorded however, Coppen-Jaeger and Wilhem (1989) observed lowered zinc level in blood in experimental studies on cadmium toxicity.

CONCLUSION

It is concluded from the study that blood lead and cadmium influenced the concentration of trace minerals like copper and iron in the blood and hair. Zinc was not influenced by lead and cadmium concentration in blood and hairs.

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REFERENCES

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

Chojnacka, K., Saeid, A., Michalak, I. and Mikulewicz, M. 2012. Effect of local industry on heavy metal contents of human hair. *Pol. J. Environ. Stud*., **21**: 1563-1570.

Coppen-Jaeger, D.E. and Wilhem, M. 1989. The effect of cadmium on zinc absorption in isolated rat intestinal preparations. *Biol. Trace Elem. Res*., **21**: 207-212.

Diaz-Barriga, F., Caldron, L., Batres, L. and Yanez, L *et al.* 1996. Children's nutritional status and exposure to metals. Proceedings of conference on modulation of chemical toxicological risk assessment, pp. 37.

Kolmer, J.A., Spaudlding, E.H. and Robinson, H.W. 1951. Approved Laboratory Techniques, ed. 5, Appletion Century Crafts, New York, pp. 1090–1091.

Kotwal, S.K., Sharma, R.K. and Srivastna, A.K. 2005. Industrial pollutants and animal health - A review. *Indian J. Anim. Sci*., **75**: 713-722.

Kulshreshtha, A., Soni, R.K., Shinde, C.P. 2015. Quantitative estimation of heavy metals in ground water in Meerut region in Uttar Pradesh. *IOSR –J. Appl. Chem*., **8**: 46-49.

Kumar, A., Rathi, D. and Dixit, R. 2014. Physiochemical analysis of heavy metals in soil and ground water of industrial area partapur, Meerut (U.P). *Int. J. Bioassays*, **3**: 3256-3259.

Liu, Z.P. 2003. Lead poisoning combined with cadmium in sheep and horses in the vicinity of non-ferrous metal smelters. *Sci. Total Environ*., **249**: 117–126.

Maurya, P.K. and Malik, D. S. 2016. Distribution of heavy metals in water, sediments and fish tissue (*Heteropneustis fossilis*) in Kali River of western U.P. India. *Int. J. Fish. Aquat. Stud*., **4**: 208-215.

Oishi, S. Nakagawa, J.I. and Ando, M. 2000. Effect of cadmium administration on the endogenous metal balance in rats. *Biol. Trace Elem. Res*., **76**: 257–278.

Patra, R.C. and Swarup, D. 1998. Effect of long term exposure of cadmium on level of zinc in rat tissues. *Indian J. Vet. Res*., **7**: 47-49.

Patra, R.C., Swarup, D. Naresh, R. Kumar, P. and Shekhar, P. 2005. Cadmium level in blood and milk from animals reared around different polluting sources in India. *Bull. Environ. Contam. Toxicol*., **74**: 1092–1097.

Pond, W. G. and Yen, J.T. 1983. Protection by dinoptilolite on zeolite NaA against Cd-induced anaemia in growing swine. *Proc. Soc. Exp. Biol. Med*., **173:** 332–337.

Rajaganapathy, V., Xavier, F., Sreekumar D. and Mandal, P.K. 2011. Heavy metal contamination in soil, water and fodder and their presence in livestock and products: A review. *J. Environ. Sci. Technol.,* **4**: 234-249.

Reis, L.S.L.S., Pardo, P.E., Camargos, A.S. and Oba, E. 2010. Mineral element and heavy metal poisoning in animals. *J. Med. Medical Sci*., **1**: 560-579.

Sharma, D. and Shukla, A.K. 2013. Analysis of heavy metals in soil and vegetables irrigated with wastewater in Meerut city region. *Int. J. Adv. Life Sci*., **6:** 287-292.

Snedecor, G.W. and Cochran, W.G. 1994: Statistical Methods, 8^{th} edn. Iowa State University Press, Ames, Iowa.

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

Tanasescu, V. and Avram, N. 1995. Magnesium and copper concentration in cattle hair: season, physiological status and heavy metal pollution dependent variations. *J. Pasteur Inst*., **3**: 103–110.

Underwood, E.J. 1978. Interaction of trace elements. In: Oheme, F.W. (ed.), Toxicology of Heavy Metals in the Environment. Part I. pp. 641–645. M. Dekker, New York, USA.

Xu, Z.R., Han, X.Y. and Wang, Y.Z. 2004. Effect on growth and cadmium residues from feeding cadmium-added diets with and without montmorillonite nanocompoite to growing pigs. *Vet. Hum. Toxicol*., **46**: 238–241.