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Zinc in Cattle from Area Polluted by Long-Term Emissions

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Enterprises of chemical and mainly of metallurgical industry belong to the main source of pollution of air as well as environment with metals. The negative impact of emission is visible in all branches of agricultural production. Transition metals at trace levels play an important role in animal body. Zinc is an essential element for ruminants and is required for normal growth, development, and function in all animal species. While some elements such as copper, iron, zinc, etc. are necessary for animal life (Solyak et al. 2001a,b; Turkoglu et al., 2004) they may be toxic and harmful at high levels of exposure. Industrial pollution can produce very high concentrations of zinc. The movement of zinc into and within the body is precisely regulated at levels of intake within the requirement range. Zinc binds to sulfhydril, amino, imidazole, and phosphate groups, thus, amino acids, proteins, nucleic acids, and other organic molecules bind zinc under physiological conditions (Massanyi, et al., 2000). In animal body the concentration of essential transition metal elements is regulated in the metabolic pathways in contrast to the toxic elements, which accumulate from the polluted nutrients (Blazovics et al., 2003; Pistl et al, 2003). Those causing toxicity are the ones which accumulate in the body through the feed, water, and air. The amount of an element which accumulates in the organs depends on the interval of exposure, the quantity ingested, the production and reproduction phases of the animals, as well as their age and breed (Kleczkowski et al., 1995; Kottferová, 1996). The aim of this study was the long - term and systematic biomonitoring of the zinc concentrations in the body tissues of cows from polluted area.

MATERIALS AND METHODS

In 1995-1999, 124 samples (muscle, heart, liver and kidney) of cattle (female) were taken from area located in Eastern Slovakia (the Slovak Republic), 5.5 km to the south - west of metallurgical plant (Figure 1).

This was done to ensure that the samples collected were representative of the polluted region. Cows aged between 3 and 5 years old. All animals were healthy at the time of slaughter.

The samples were collected at the slaughter and immediately transported to the laboratory. Samples were frozen and stored at -20° C until analysed. The analysis

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Figure 1. Slovak Republic.

consisted of digestion (5 ml HNO_3 and 1 ml HCl per 1g of sample) in the microwave oven Milestone and determination of zinc concentration by the method of Kocourek (1992).

The reproducibility of the method was tested with the help of analysis reference materials (MBH Anal Ltd., England). Samples were analysed for the presence of Zn using an atomic absorption spectrophotometer (AAS), Unicam Solar 939 at wavelength 324.8 nm.

The flame conditions were optimised for maximum absorbency and linear response while aspirating known standards. The standards were prepared from the individual 1000 mg/kg standard (Merck, Germany); 100 ml of five combined standards were prepared in 0.1 N HNO_3. The lamp current used was 75%. The signal type was continuous for Zn. Measurement time was 3s. The recovery methods were 96-98% and reproducibility was better than 1.0%. Quantification limit was 0.130 $mg.l^{-1}$ and detection limit was 0.039 $mg.l^{-1}$. The zinc concentrations were expressed on a wet weight (w.wt.).

Data were evaluated and presented as maximum, mean and standard deviation (Microsoft Excell 7.0). Non detectable residues were not included.

RESULTS AND DISCUSSION

In the period of 1995-1999 altogether 124 samples of 31 heads of cows (muscle, heart, liver and kidney) were investigated for the presence of zinc. The results obtained were compared with the maximum permissible hygiene limits for Zn in muscle (60.0 mg/kg) and inner organs (80.0 mg/kg) according the Codex permissible hygiene limit for zinc were recorded in 14 of 31 samples of liver; in 7 of 31 samples of muscle in 1 of 31 samples of heart, in 5 of 31 samples of kidney Alimentorum of the Slovak Republic No. 98/1996. Levels reaching the highest.

The mean concentrations of Zn measured in muscle were observed in the years 1995-1999 (39.670; 24.736; 14.494; 81.180; 36.948 mg/kg w.wt., respectively) in the polluted area. The mean Zn levels determined in the biological materials are given in Table 1. The relatively low mean concentration was in the year 1997, on the other hand the highest mean level was found in the year 1998. This mean level was higher than permissible limit for zinc in muscle.

According to Lopéz Alonso et al., (2000a), muscle is one of the most important tissues for Zn accumulation, and Zn muscle concentrations were similar to those in the liver. The results of our study indicate that values of muscle Zn in cattle were relatively high only in the year 1998. The muscle Zn concentrations in cattle from observed polluted area were relatively low in the years 1995, 1996, 1997 and 1999 compared to those in the liver. Surveys to determine the levels of Zn concentrations in muscle and liver have been conducted in many countries e.g. Spain (47.8; 47.7 mg/kg w.wt.), Burundi (53.7; 63.1 mg/kg w.wt), Poland (34.0; 42.0 mg/kg w.wt.).

We recorded relatively low mean levels of Zn in heart (10.57; 12.04; 8.68 $mg.kg^{-1}$, w.wt. respectively) during 1995-1997 However in 1998-1999 we found higher concentrations of Zn in heart, in comparison to previous years.
The mean concentrations of Zn measured in liver were detected in 1995-1999 (64.478; 76.985; 38.678; 66.544; 89.894 mg/kg^{-1}, w.wt. respectively) in the observed region. The low concentration was in year 1997, on the other hand the highest mean level was found in 1999. This mean level was higher than permissible limit for zinc in liver.

The highest mean concentration of Zn in kidney was observed in 1999 (122.756 mg/kg^{-1} w.wt.). However, in 1995 - 1997 mean values of Zn in kidney (Table 1) were similar to results reported by other authors as López Alonso et al. (2000b) Benemariya et al. (1993) and Falandysz (1993), e.g. 22.0; 23.4; 22.0 mg/kg w.wt., respectively. Gallo et al. (1996), reported the highest mean concentrations of Zn in the kidney and heart. The observations were performed on a farm 5 km in the straight line from the source of the pollution.

Farmer and Farmer, (2000) analyzed animal and meat (cattle, horse and sheep) products from a metal processing region in east Kazachstan. Samples were collected from a range of districts of differing distances from the main source of anthropogenic pollution. Analyses for Zn revealed high concentrations in many feed and meat samples. Horse samples had higher levels of contamination than cattle, which were higher than in sheep.

In recent years, sources and pathways of Zn in our environment have been of increasing public interest. The animal receive industrial emission by breathing them with air or through the digestive tract from contaminated feed. The reception of emissions from feed is more important for the animals than the inhalation with regard to the amount of intake. Evaluation of the Zn levels in cattle is an efficient way of obtaining information on the environmental state in the area of metallurgical plant.

Table 1. Concentration of zinc in the observed biological material of cattle (mg/kg w.wt.) from polluted area in Slovakia.

Years		Muscle	Liver	Heart	Kidney
	n	6	6	6	6
1995	x	36.970	64.470	10.570	23.570
	x max	80.050	153.850	19.000	36.000
	Sd	28.670	62.501	7.791	11.790
	limit	2	2	0	0
	n	7	7	7	7
1996	x	24.736	76.985	12.240	16.205
	x max	34.490	107.600	13.640	22.780
	Sd	7.511	20.933	1.433	4.883
	limit	0	2	0	0
	n	6	6	6	6
1997	x	14.494	38.678	8.680	18.718
	x max	19.875	57.012	10.880	29.075
	Sd	4.108	12.570	1.652	10.159
	limit	0	5	0	0
	n	6	6	6	6
1998	x	81.180	66.544	51.969	57.468
	x max	124.100	108.200	92.500	90.960
	Sd	34.759	33.237	23.870	25.696
	limit	5	3	1	1
	n	6	6	6	6
1999	x	36.948	89.894	54.894	122.756
	x max	49.480	143.500	59.660	118.800
	Sd	7.589	31.102	11.493	67.544
	limit	0	2	0	4

n, number of samples analysed; *x*, aritmetic mean; *x max*, maximal values; *Sd,* standard deviation; *limit*, number of samples exceeding permissible hygienic limit for zinc

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