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Evaluation of lead (Pb) concentration in animal tissue, soil, and water samples from grazing pasture near mining industry in southern part of Mongolia

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Abstract

Lead (Pb) is a substance that can cause serious damage to the brain and kidneys, soften bones, adverse effect to the reproductive system, and can be fatal. Long-term exposure to the substance can damage not only children, but also adults' nervous systems. Lead does not belong into the category of toxic substances due to its effects on the human body. It is considered as a harmful substance.
In this study, we analyzed lead concentration in liver and kidney of cattle, horse, sheep, and goat from the mining areas located in the Ulaanbadrakh, Zuunbayan, and Airag soums of Dornogovi province.
As a result, the level of lead in the liver of sheep and goat Zuunbayan soum of Dornogovi province was slightly higher than in other soums. The content of heavy metals in water and soil samples did not exceed the international standard average.

Keywords: lead, heavy metal, neurotoxin, livestock

Introduction

Mongolian nomadic pastoral animal husbandry has a long history and tradition of managing the health and productivity of livestock suited to soil, water, feed supply, and plant compositions through the rotational use of pasturelands. However, due to the long-term waste of large mining companies and living under their influence the evidence of the cases of technopathic diseases in recent years in both human and animals is increasing. The negative effects caused by mining practices may lead to the emergence of various new diseases of technopathic origin [1].
Less than 10% of imported products sold in the markets are tested by the Central laboratory of State specialized inspection agency. Results of the testing revealed that approximately 55% of fruits do not ensure toxicological and bacteriological safety and heavy metal [2].
Therefore, research in this area has become one of the actual problems. This research was conducted under the goal to ensure food safety and quality assurance, bring the food control system to the international level, and develop measures and recommendations to protect livestock from technopathic diseases caused by mining industry wastes. As part of the study, the lead, a heavy metal, content was determined in the soil and water as well as in the some internal organs of animals grazing near mining area.

Materials and methods

Study area
This study was conducted at three locations of Dornogovi province (Ulaanbadrakh, Zuun-bayan, and Airag soums). Dornogovi (44°53′N 110°09′E) is a one of the 21 provinces of Mongolia, located about 456 kilometers southeast of the capital city, Ulaanbaatar. Dornogovi is located in the Gobi desert and frequent sand- and snowstorms amplify the hard weather conditions of Mongolia.

Sample collection
Liver and kidney tissue samples from 30 animals, including horse, goat, sheep, and cattle as well as 30 soil and 20 water samples were collected from mining areas in Dornogovi province. All samples were kept frozen at the Toxicology laboratory, School of Veterinary Medicine and subjected to the lead (Pb) analysis.

Standard procedures of sample preparation
All samples of were extracted by acidic treatments using Mars Xpress microwave extraction system and measured by the inductively coupled plasma mass spectrometer (ICP-MS). Homogenized specimen (tissues, soil and water) weighed in amounts of 1 g to put into extraction vessels. Then relevant chemical reagent and solvent (mixture of 0.1 ml sulfuric acid, 5.0 ml nitric acid and 1.0 ml hydrogen chloride) solutions in 6 to 10 ml were added, the mixture was covered, and placed in microwave system at temperature 180^0C at the pressure of 175 psi for 10 to 20 minutes. Then, after chilling for 10 minutes the vessels were carefully opened, the samples were diluted with deionized water at ratio 10 ml, suitable matrix and stabilizer were added, and measured. Lead was determined by use of electro-thermal production system. The equipment measurement precision was calibrated by use of working standard prepared from stock solution, blank and reference specimen.

Statistical analysis
Analysis was performed using Mann-Whitney U test, or Turkey test after each data was normalized by transforming to a base 10 logarithm. Statistical analyses were performed using IMB SPSS statistical 23 and JMP 7.0.1 (SAS Institute, Cary, NC, USA).

Results

Lead content in kidney and liver tissues was determined in 5 cattles, 10 sheep, 10 goats and 5 horses grazed in mining area of Ulaanbadrakh, Zuunbayan, and Airag soums of Dornogovi province. The results are shown in Table 1.

Table 1

Analysis of lead concentration (mg/kg) in the liver and kidney of livestock

Animal	Number of sample	Standard division	Samples species (mg/kg)	
			liver	kidney
Sheep	10	Average ± SD	0.609 ± 0.188	0.262 ± 0.06
		Maximum	1.217	0.67
		Minimum	0.2169	0.1
Goat	10	Average ± SD	0.441±0.062	0.362 ± 0.09
		Maximum	1.768	1.05
		Minimum	0.0186	0.056
Horse	5	Average ± SD	0.767±0.09	0.181 ± 0.01
		Maximum	0.8764	0.299
		Minimum	0.5749	0.16
Cattle	5	Average ± SD	0.2914±0.01	0.635 ± 0.2
		Maximum	0.3493	1.08
		Minimum	0.2	0.25

As a result, the content of lead was various in all samples. The lead concentration in liver and kidney of cattle were at 0.291±0.0173 mg/kg and 0.635 ± 0.2 mg/kg, respectively. Horses contained lead at amount of 0.767±0.096 mg/kg in liver, while in kidney at 0.181 ± 0.01 mg/kg. In sheep samples, lead concentration was revealed at 0.609 ± 0.188 mg/kg in liver and at 0.262 ± 0.06 mg/kg in kidney. While in goat samples were measured having lead at concentration of 0.441±0.062 mg/kg in liver and 0.362 ± 0.09 mg/kg n kidney.

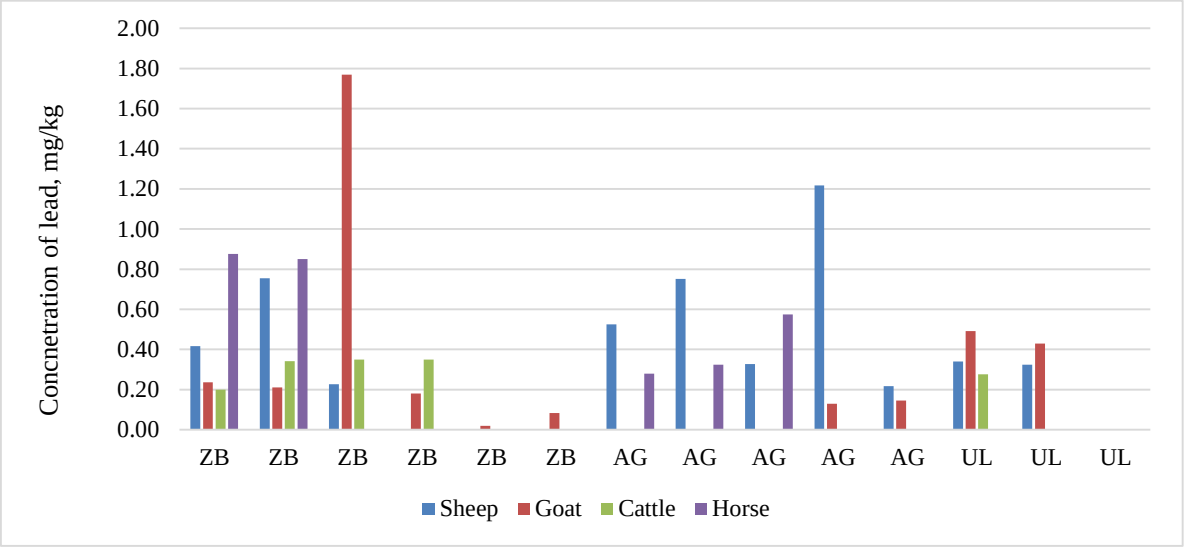

Figure 1. Lead (Pb) concentration in animal liver samples
ZB-Zuunbayan, AG-Airag, UL-Ulaanbadrakh soum (small administration unit of province)

It was observed that one liver sample of sheep from Airag soum has high amount of lead that is 33% higher than the international maximum limit level. Rest of samples have shown was lower level at the average of concentration of lead in the liver of all livestock than the international maximum limits.

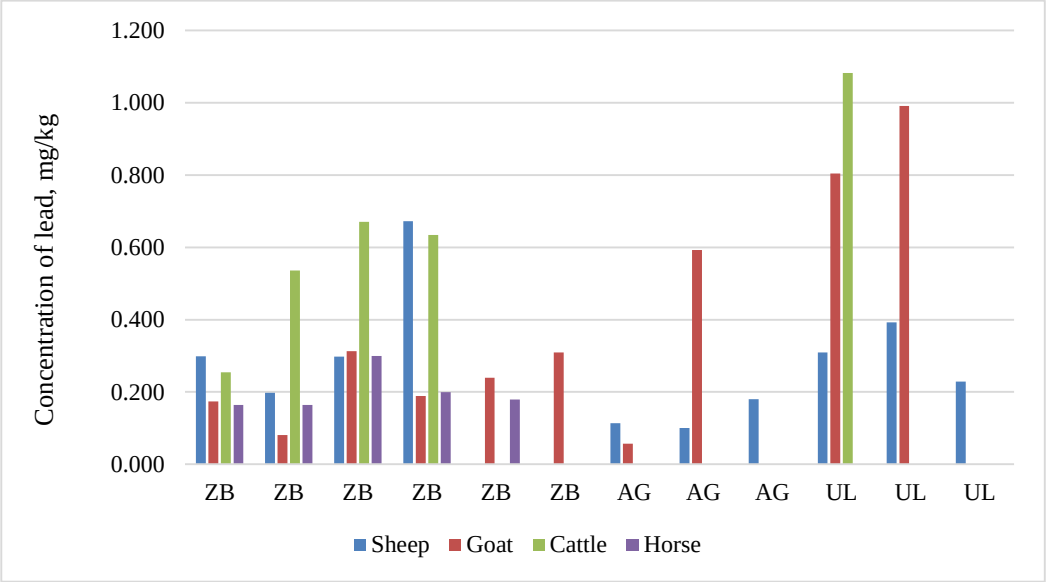

Figure 2. Lead (Pb) concentration in animal kidney samples
ZB-Zuunbayan, AG-Airag, UL-Ulaanbadrakh soum (small administration unit of province)

Results of kidney samples showed that the average of concentration of lead in the kidney of all livestock was counted lower than the international maximum limits.

Besides the animal samples, the soil and water from mining areas were subjected to lead analysis. Level of lead in 30 soil samples from the suspected area is shown in Table 2.

Table 2

Analysis of lead concentration (mg/kg) in the soil samples

Sampling area	Number of sample	Standard division (SD)	Pb, (mg/kg)
Zuunbayan	13	Average ± SD	12.403 ± 4.2
		Maximum	76.49
		Minimum	2.372
Airag	9	Average ± SD	6.86 ± 0.71
		Maximum	10.512
		Minimum	2.701
Ulaanbadrakh	8	Average ± SD	4.255 ± 0.4
		Maximum	5.44
		Minimum	1.7

Among 30 soil samples, two samples taken from Zuunbayan soum at 44˚31'55"N, 109˚41'34"E and 44˚04'35.69"N, 110˚02'07.66"E coordinates had higher concentration of lead at amount of 36.13 and 76.5 mg/kg. Rest of soil samples contained lead concentration ranged from 10.5 to 1.7 mg/kg, which is under the maximum limits of Mongolian standard (MNS 5850:2008).

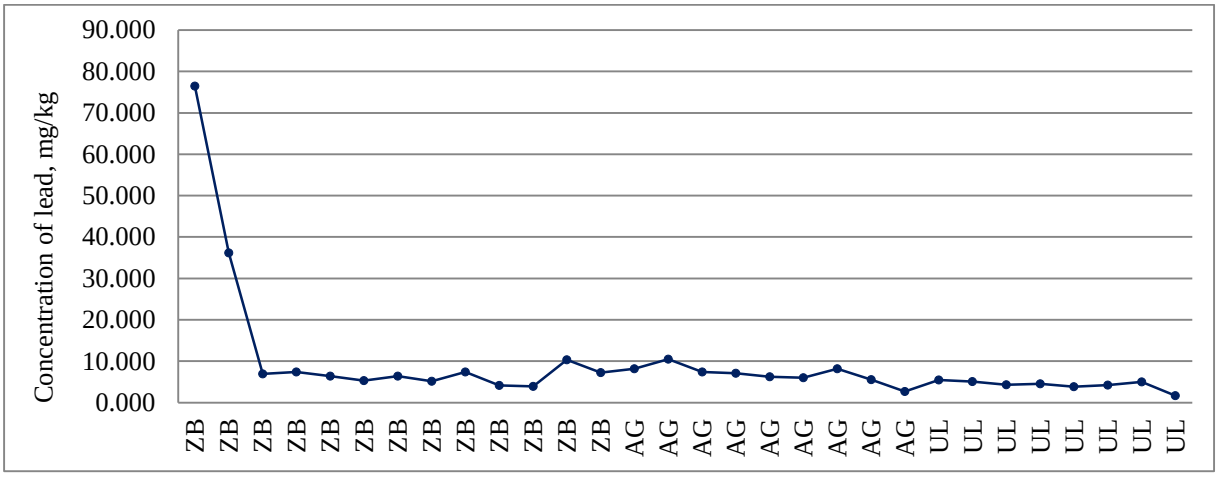

Figure 3. The concentration of lead in the soil sample
ZB-Zuunbayan, AG-Airag, UL-Ulaanbadrakh soum (small administration unit of province)

Twenty water samples were taken from the 9 places (between $44^0$31’55.02 - $44^0$37’40.12” N to $109^0$25’34.98 - $109^0$55’21.70” E) of Zuunbayan, 5 places (between $45^0$45’38.96 - $45^0$65’52.35” N to $109^0$07’08.75 - $109^0$10’02.37” E) of Airag, and 6 places (between $44^0$04’35.69” N to $110^0$00’17.40-$110^0$42’07.28” E) of Ulaanbadrakh soums of Dornogovi province, respectively. Results are shown in Table 3.

Table 3

Analysis of lead concentration in the water samples

Sample places	Number of samples	Standard division /SD/	Maximum allowable amount 0,01 mg/L /MNS 0900:2005/
Zuunbayan	9	Average ± SD	0.0054 ± 0.004
		Maximum	0.007
		Minimum	0.004
Airag	5	Average ± SD	0.0054± 0.007
		Maximum	0.0082
		Minimum	0.0064
Ulaanbadrakh	6	Average ± SD	0.0053 ± 0.003
		Maximum	0.0077
		Minimum	0.004

In water samples, the observed highest concentration at 0.0082 mg/L of lead was lower than maximum allowable limit according the Mongolian standard (MNS 5850:2008).

Discussion

Lead is one of the heavy metals which is poisonous to human and animals. It accumulates in soft tissues and bones, damages the nervous system and interferes with the function of biological enzymes, causing neurological disorders, such as brain damage and behavioral problems.

The main sources of lead are grass and water in areas of lead rich mining [3]. However, poisoning of natural origin is very rare. Thus, the main source of lead poisoning in humans and animals is industrial lead products [4]. The main source of lead poisoning in livestock includes lead-acid and alkaline waste batteries and accumulators [5]. According the National standard of Mongolia (MNS: 4504:2008), the maximum allowable level of lead in animal origin products, meat of large animals, sheep and pig is 0.1 mg/kg [8]. While as recommended by Food and Agriculture Organization, the maximum allowable levels of lead in the meat of cattle, sheep, pig and checken is 0.1-0.5 mg/kg [6]. Also, European Union and United States Environmental Protection Agency (US-EPA) allow the maximum level of lead in the meat at 0.15 mg/kg [7]. In addition, The Food and Drug Administration recommends that lead should not exceed 0.5 mg/kg amount in food [6].

In the present study, the concentration of lead was different in the tissue type and animal species. The concentrations of lead in the liver of cattle were 0.2914±0.0173 mg/kg, in the liver of sheep were 0.609 ± 0.188 and 0.262 ± 0.06 mg/kg in the kidney, in the liver of horse was 0.7674±0.0965 mg/kg, respectively.

As permitted in the National standard of Mongolia, MNS 5850: 2008 the maximum allowable amount of lead content in soil is 5-100 mg/kg [9], while the maximum allowable amount of lead content in water is 0.01 mg/L according the National standard of Mongolia, MNS 0900: 2005 [10]. That the lead concentration in soil sample was 36.13-76.5 mg/kg and in water samples was 0.0077-0.0082 mg/L is under the maximum allowable amount of lead content according the Mongolian standards.

Conclusion

1. The lead (Pb) concentration in the liver samples from the sheep and goat in the Zuunbayan soum of Dornogovi province was counted slightly higher.
2. The lead (Pb) concentrations in liver samples of cattle (0.2914±0.0173 mg/kg), sheep (0.609 ± 0.188 mg/kg), and horse (0.7674±0.0965 mg/kg) as well as in kidney sample of sheep (0.262 ± 0.06 mg/kg) are considered under the international maximum limits.
3. Observed highest concentration of lead in all soils samples at 76.49 mg/kg does not exceed the maximum limit of National standard of Mongolia, MNS 5850:2008.
4. Water lead (Pb) maximum concentration at 0.0082 mg/L is lower level than the maximum limits of heavy metal content in the Mongolian drinking water standard, MNS0900:2005.

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