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Nickel as an emerging environmental pollutant in goats

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Abstract
In this study, the levels of nickel were determined in blood and tissues of goats reared in industrial, urban and rural areas of Jabalpur, Madhya Pradesh, India. Total 67 blood, 57 liver and kidney, 16 lung and 26 muscle samples were subjected for acid digestion in microwave digester. The nickel concentration was analysed by Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES). Mean blood nickel level was recorded as 0.560±0.135 ppm which was higher than acceptable limit. Results reported that 8% of goats had high blood nickel level (02 to 07 ppm). Mean nickel concentration in liver, kidney, lung and muscle were 0.350±0.050, 0.494±0.053, 0.791±0.115 and 0.552±0.073 ppm, respectively. In this study, 02 liver, 02 kidney, 04 lung and 02 muscles had high nickel concentration of >1 ppm. It was concluded that there was appreciable concentrations of nickel were found in blood and tissues of goats especially from industrial areas.

Keywords: Nickel, goats, blood, tissues, ICP-OES

1. Introduction
Nickel is naturally occurring trace metal widely distributed in the environment. It is present in the soil, water and air in different forms. Normally, it occurs at low concentration in environment but day by day its concentration is increasing because of anthropogenic activities such as production or use of nickel, nickel alloys or nickel compounds in industries, improper industrial waste disposal, release of nickel from power plants and trash incinerators. A lot of nickel released into the environment ends up in soil or sediment, further via ground water it reaches in plants and ultimately in food chain and causes deleterious effects on animals and human health. Nickel may accumulate in body-tissues of animals as well as humans and disrupt functions of their vital organs. In experimental animals, nickel toxicity induces embryo-toxic, teratogenic and carcinogenic effects. Hence it is considered as one of the important metal pollutants.

India has a large goat population, used for milk, meat and leather production. Environmental contamination with heavy metals increases their load in blood and tissues of goats1 which adversely affect their growth and health. Residual metals in edible animal-tissues and animal products above critical levels may create severe public health hazards [2].

Various factories like Gun Carriage Factory, Ordinance Factory and Vehicle Factory of Jabalpur city are manufacturing/using the raw materials containing nickel. Industrial effluents, fossils fuels, batteries and sewage water expose the city to heavy metal pollution. Recent studies by the workers have also pointed the increased level of nickel in different water bodies of Jabalpur region [3, 4].

Though, previous efforts are made to measure the adverse effects of other heavy metals in bovine5 but no work has been performed to determine the presence of nickel in goats of Jabalpur area. Thus the present study was designed to evaluate the concentration of nickel in blood and tissues of goats.

2. Materials and methods
In the present study, approximately 05 ml of blood samples were collected ethically and aseptically from 67 goats reared near the highways as well as various industrial, urban and rural areas. Tissue samples like liver, kidney, lung and muscle from 57 goats were also collected from slaughter house and post-mortem cases of goats reared near the highways as well as various industrial, urban and rural areas (Table: 01).

(Table: 01). The protocol of the study was approved by the Institutional animal ethics committee (IAEC) (letter no. 89/IAEC) of College of Veterinary Science and Animal Husbandry, Jabalpur, M.P. (CPCSEA registration no. 2071/GO/Re/S/19/CPCSEA).

Table 1: Collection of samples

Group	Area category	Blood samples	Tissue samples
Area 1	Industrial	35	27
Area 2	Urban	20	19
Area 3	Rural	12	11
Total		67	57

2.1 Digestion of blood samples
Digestion of the samples was done in Microwave Digester. For this, in a conical flask, 01 ml of blood sample, 06 ml of concentrated nitric acid and 02 ml of 30% hydrogen peroxide were mixed and subjected for digestion in Microwave Digester for 45 minutes [6].

2.2 Digestion of tissue samples
200 mg of tissue- liver, kidney, lung as well as muscles were taken in a conical flask in which 07 ml of concentrated nitric acid and 01 ml of hydrogen peroxide were added. This mixture was digested in Microwave digester for 45-50 minutes [6].

2.3 Estimation of nickel in blood and tissue samples
Analysis of nickel was performed by using ICP-OES (Thermo scientific; iCAP 7000 series). Volume of digested sample was made upto 10 ml by rinsing with triple glass distilled water and samples were stored in 25 ml tarson tubes at -20ºC till further analysis [6]. Processed samples were thawed to room temperature. In ICP-OES, Argon flame was used as a fuel and calibration of instrument was achieved with 06 standards of known concentrations (01, 10, 40, 80, 120 and 150 ppb) prior to analysis of unknown sample. Concentrations of nickel in the samples were obtained in ppb which further converted to ppm for data presentation (Wavelength (nm): 231.604, 228.802).

2.4 Statistical analysis
Data gathered from the study were tabulated and analyzed using statistical one way analysis of variance (ANOVA), followed by Fisher pair wise comparison [7].

3. Results and Discussion
3.1 Nickel concentration in blood
In the present study, nickel level observed in all studied blood samples. Mean blood nickel level recorded in the goats was 0.560±0.135 ppm. Observed value was quite higher than the normal acceptable standard [8] of nickel for goats in blood i.e. upto 0.290 ppm.

Blood samples were collected from different areas of Jabalpur and classified under three areas i.e. area 01 (Industrial), area 02 (Urban) and area 03 (Rural). The mean nickel level recorded in different areas is presented in Table 02. There was no significant difference observed in three studied areas but numerically highest level of nickel in blood was recorded in area 01, followed by area 02 as compared to blood nickel level in goats of area 03.

Table 2: Blood nickel level (ppm) in goats from different areas

Area	Area category	N	Blood nickel level (Mean±SE)
Area 1	Industrial	35	0.745±0.234
Area 2	Urban	20	0.457±0.180
Area 3	Rural	12	0.190±0.014

Sex and age wise evaluation of blood did not show any statistical significant influence on nickel concentration in blood as presented in Table 03 and 04. However numerically, high level recorded in adult and male goats.

Table 3: Blood nickel level (ppm) in goats of different age groups

Age	N	Blood nickel level (Mean±SE)
<1year	07	0.180±0.019
>1 year	60	0.604 ±0.150

Table 4: Blood nickel level (ppm) in goats of different sex

Sex	N	Blood nickel level (Mean±SE)
Female	39	0.462 ±0.124
Male	28	0.695 ±0.274

Further, based on the information available on Puls criteria [8] for goat, we classified the concentration of blood nickel level under three range, GI (<0.3 ppm), GII (0.3 to <2 ppm) and GIII (2-7 ppm). We noted that, in our study, 79% of goats fall under GI, 13% of goats under GII and 08% of goats had blood nickel concentration in range of 2-7 ppm. The nickel values from all three groups differed significantly to each other (Table: 05).

Table 5: Blood nickel level (ppm) in goats of different groups

Group (G)		N	%	Blood nickel level (Mean±SE)
I	Acceptable (<0.3 ppm)	53	79	0.183^{A}±0.007
II	Low (0.3 to <2 ppm)	09	13	0.987^{B}±0.232
III	High (2 to 7 ppm)	05	08	3.780^{C}±0.879

Means with different superscripts in column differ significantly ($p \leq 0.01$)

3.2 Nickel concentration in tissues
Present study indicated that there was presence of nickel in all analysed sample of liver, kidney, lung and muscles of goats. The observed mean nickel concentration in liver, kidney, lung and muscle were 0.350±0.050 ppm, 0.494±0.053 ppm, 0.791±0.115 ppm and 0.552±0.073 ppm respectively. There was good correlation noticed between the nickel concentration of liver and kidney. There was no statistical significant difference observed between the mean nickel values of the various tissues.

In this study, tissue samples for metal analysis were collected from the industrial, urban and rural areas of the Jabalpur. However, there was no significant difference observed in the tissue nickel concentration between the three studied areas but numerically highest concentration of nickel recorded in tissues of area 02 i.e. urban area followed by area 01 (industrial) as compared to goats of rural area (Table: 06).

Table 6: Tissue nickel concentration (ppm) in goats of different area

Area	Area category	Tissue	N	Nickel concentration (Mean±SE)
Area 1	Industrial	Liver	27	0.320±0.035
		Kidney	27	0.469±0.044
Area 2	Urban	Liver	19	0.424±0.139
		Kidney	19	0.543±0.145
Area 3	Rural	Liver	11	0.296±0.064
		Kidney	11	0.469±0.060

In the present study, we did not find any statistical influence on age and sex in nickel concentration of tissues. However, numerically high level recorded in adult and male goats (Table: 07 and 08).

Table 7: Tissue nickel concentration (ppm) in goats of different age groups

Age group	Tissue	N	Nickel concentration (Mean±SE)
<1year	Liver	10	0.241±0.046
	Kidney	10	0.538±0.072
>1year	Liver	47	0.373±0.060
	Kidney	47	0.484±0.063

Table 8: Tissue nickel concentration (ppm) in goats of different sex

Sex	Tissue	N	Nickel concentration (Mean±SE)
Female	Liver	38	0.325±0.047
	Kidney	38	0.476±0.052
Male	Liver	19	0.400±0.120
	Kidney	19	0.528±0.123

Further, based on the information available on Puls criteria [8] for goat and previous literature [9, 10], we categorized the animals under three groups as presented in Table 09, in which 02 liver, 02 kidney, 04 lung and 02 muscles had nickel concentration of >1 ppm. Nickel concentration for liver and kidney differed significantly between the groups.

Table 9: Tissue nickel concentration (ppm) in goats of different groups

Group	I-Acceptable (<0.5 ppm)		II- Low (>0.5 to 1 ppm)		III- High (>1 ppm)	
	N %	Mean±SE	N %	Mean±SE	N %	Mean±SE
Liver	46 (81)	0.228A±0.020	9 (16)	0.594B±0.021	2 (3)	2.051C±0.356
Kidney	28 (49)	0.224A±0.025	27 (47)	0.651B±0.017	2 (4)	2.135C±0.339
Lung	3 (19)	0.412B±0.076	09 (56)	0.632AB±0.053	4 (25)	1.433A±0.225
Muscle	11 (42)	0.250±0.035	13 (50)	0.664±0.040	2 (8)	1.487±0.320

Means with different superscripts in rows differ significantly ($p \leq 0.01$)

Literature review revealed limited studies on the nickel concentration in blood and tissues, indicated that nickel has not attend the attention of the scientific world. However, in a study, concentration of Ni in liver 0.188±0.001 ppm, in kidney 0.125±0.001 ppm and in meat 0.063±0.003 of goat was recorded [9]. In another study of goats, the observed concentrations of Ni were 0.19, 0.63 and 0.22 ppm in liver, kidney and lung tissues respectively [10]. Our findings are in agreement with findings of these researchers.

In our study, high concentration of nickel reported in goats reared near the industrial or urban area [10] whistling towards the chronic exposure in goats and long back contamination of environment from this metal as industrial and urban wastes are rich source of this metal which further channelized to the water and soil further in fodder of that area. Animals raised on these resources get exposed with this heavy metal.

Sufficiently high concentration of tissue nickel in urban areas, pointing the presence of continuous source of nickel in these localities. Excess use of nickel containing fertilizers in agriculture practices and lead-nickel batteries, diesel fuel primarily consumed by the urban areas could have been probable cause of excess contamination in these areas.

Our results are similar to the finding of earlier studies [9, 10] in which quite high concentration of nickel in blood and tissues of goats were recorded. Though, not enough studies have been performed to study the contamination of nickel in animals. However, the reports on water bodies nearby Jabalpur [3, 4] pointing the heavy contamination of water bodies with nickel pollutant.

4. Conclusions

Present study concludes that goats of Jabalpur region showed much higher concentration of nickel in their blood and tissues which are quite higher than the normal acceptable standards and may reaching to the substantial proportion. Nickel pollution becomes an emerging threat for environment that not only affects the quality of soil, air and water but also the animal and human health. The effect of environmental pollution by this metal on contamination of foods and on their safety for human consumption is a serious global public concern

5. Acknowledgement

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