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Elemental analysis of the hair of local cattle of Mizoram, India: An evidence of man-made pollutions

Pranab Chandra Kalita[1]*, **Swarup Debroy**[2], **Utpal Bora**[3]

[1]*Dept. of Veterinary Anatomy and Histology, College of Veterinary Sciences and Animal Husbandry, Central Agricultural University, Aizawl, Mizoram, India*
[2]*Section of Veterinary Anatomy, Indian Veterinary Research Institute, Bareilly, Uttar Pradesh, India*
[3]*Dept. of Biosciences and Bioengineering, Indian Institute of Technology, Guwahati, Assam, India*

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ABSTRACT

Background: Investigation of elemental concentration in hair is an appealing method of determining trace elements and heavy metals status. This study was conducted to check the elemental concentration in the body of Mizoram local cattle by investigating their hair.
Methods: This study was conducted on the hair of 40 apparently healthy animals from each of four different districts of Mizoram. Light colored hair were sampled and cleaned in a 1:1 ether-alcohol combination and dried between two filter papers. The FESEM-EDX machine was used to check different element concentrations in the studied hair.
Results: A total of 33 elements were identified in the hair of local cattle of Mizoram. Out of which eight numbers of major elements were found with seven trace elements and 18 heavy metals. Carbon showed the highest weight percentage compared to all other 32 elements. Among all those trace elements, the weight percentage of Sulfur was highest in all the animals under study. Higher concentration Lead (Pb) in Aizawl districts and other heavy elements such as Gold (Au), Radium (Ra), Radon (Rn), Thulium (Tm), Tantalum (Ta) which were detected only from the above-mentioned district, might be the indication of excessive pollution in that area. Excessive accumulation of unwanted elements in the animal hair is direct indication of the adverse affect of the man-made pollution.

1. Introduction

Mizoram is a hilly state in India's north-east region with Aizawl as the capital city. The cattle population of Mizoram is combined mainly of local cattle with a small population of crossbred cattle. Trace elements are required in small amounts, usually less than 100 mg/kg dry matter, and are present in very minute quantities in the animal body but play a vital role in boosting and maintaining the body's immunity and sustaining good health as well as contributing to growth and reproduction.[1] The growing development of industries comes with a huge drawback, including water and air pollution and contamination of soil with toxic heavy metals emitted from these industries; this significantly deteriorates the quality of life for animals as well as humans. All farm animals are affected by the contamination of the environment with these metals because of their natural habit of pasturing in fields in the neighborhood of the emission sources. These elements can be present on the body hair and on the skin of an animal and can act as an exogenous reserve, which can go inside an animal and can get absorbed in the alimentary canal while licking their hair and also while grazing on the field, These endogenous reserves of ingested heavy metals get distributed to different organs

* *Corresponding author*.
E-mail address: kalitapc@yahoo.co.in (P. C. Kalita).

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and tissue by blood and get taken up by the hair during its growth phase, which subsequently increases the amount of trace elements in an animal body.[2] Conventionally, analysis of blood and urine is more preferable method to detect and evaluate the amount of trace elements present in an animal body, though there is a chance of fluctuation in the level of trace elements in blood and urine when there are changes in physiology of an individual and also in surrounding environments. On the other hand, analysis of hair imparts a better permanent record of the presence of trace elements in both typical and atypical metabolism on top of the amount of trace elements incorporated from the surrounding environments.[3] Considering the fact that collection of hair samples, as well as sampling and preserving, is unintrusive and straightforward, and also since the amount of trace elements is thought to be higher in hair than in blood and urine, elemental analysis of hair seems to be a striking approach for the evaluation of the status of trace elements.[4] Since hair has the capacity to mimic the concentration of the elements in the food particles as well as soil, so, therefore, this study was conducted to determine the concentration of trace elements as well as heavy metals exposed by the local cattle of Mizoram in their hair which can be the direct depiction of the elemental concentration in different zones of Mizoram.

2. Materials and Methods

This experiment involved local cattle in Mizoram pastured in different district zones. Hair samples for this experiment were collected from the four districts of Mizoram. To increase the randomization of the experiment, the selection of the districts was based on the parts of the state. The four selected districts for Mizoram were Aizawl, Mamit, Champhai, and Siaha. Forty apparently healthy local cattle were selected from each of the districts with no visible skin infection. Only animals with light color hairs were selected to control excessive copper concentration. Hairs were sampled by plucking out a tuft of hair with the bare hand or with the help of tweezers. Plucked samples were stored in a plastic zip bag and were kept at room temperature. A quick wrench was found to be more effective in collecting the samples than a slow pull.

Collected hair samples were extensively cleaned in a 1:1 ether-alcohol combination and dried between two filter papers.[5] After cleaning, 5 mm sized dissected hairs were placed on a carbon sample holder, and concentrations of different elements were recorded under Field Emission Scanning Electron Microscopy-Energy Dispersive X-Ray Analysis [FESEM (GeminiSEM500/EDX (Octane Elect EDS)] machine.

The data was examined using the SPSS 20 statistical package. To assess the significant difference in different elemental concentrations in the local cattle hair among different districts, a general linear model with one-way ANOVA was utilized. Tukey's test was used to confirm the significance of the ANOVA's significant values. The differences were judged significant when $p<0.05$, and the results are shown as mean ± standard error.

3. Results

Table 1, Table 2 and Table 3 showed the weight percentage of different trace elements analyzed from the hair of local cattle of Mizoram collected from four different districts of the state. A total of 33 elements were identified in the hair of local cattle of Mizoram. Out of these, eight major elements were found, along with seven trace elements. Eighteen numbers of heavy metals were also found in some of the hair examined. Carbon showed the highest weight percentage compared to all other 32 elements. The concentration of Carbon was highest in the hairs collected from the Aizawl district (72.45 ± 0.51), and the lowest was reported in the Champhai district (56.41 ± 1.72) (Table 1). Significant differences were observed in the weight % of Oxygen in all four districts of Mizoram. Lowest weight % of Oxygen was seen in the Aizawl (22.67 ± 1.28) district (Table 1). All the other detected macro elements, i.e., Sodium, Magnesium, Calcium, Potassium, Chlorine and Phosphorus, showed no significant differences between the animals from different districts.

Seven trace elements that were recorded from all four districts are: Fluorine, Zinc, Manganese, Iron, Cobalt, Copper, and Sulfur. Among all those trace elements, the weight percentage of Sulfur was highest in all the animals under study from all four district zone of Mizoram with no significant differences between them. Siaha district of Mizoram showed a comparatively lower weight % fluorine than the other four studied districts. The highest fluorine concentration was seen in the Aizawl (2.3 ± 0.05) districts of Mizoram (Table 2). Cobalt concentration was significantly higher in the Aizawl (2.24 ± 0.21) and Mamit (1.75 ± 0.08) districts compared to other two (Table 2). There were no significant differences between all four districts in the weight percentage of Zinc, Manganese, Iron, and Copper.

Among all the heavy metals detected in the cattle hair concentration of lead was significantly higher than any other heavy elements, highest in Aizawl (37.64 ± 2.648) district (Table 3). A low concentration of Arsenic was detected in all the hair samples. An alarming concentration of mercury and gold was found in all four districts of Mizoram, which was significantly highest in the Mamit and Aizawl districts, respectively. There were no significant differences in the weight percentage of Chromium and Cadmium in all the animal hairs from different districts under study. A trace of many heavy metals, i.e., Radium (Ra), Radon (Rn), Thulium (Tm), and Tantalum (Ta) was detected only from the Aizawl districts. Uranium concentration differed significantly from the Aizawl district to other three districts. A small amount

of Scandium (Sc), Titanium (Ti), and Vanadium (V) were traced from all the animals.

Table 1: Weight % of different major elements present on the cattle hair samples collected from four different districts of Mizoram

Elements	Aizawl	Mamit	Siaha
C	72.45 ± 0.51^{b}	57.49 ± 1.22^{a}	60.58 ± 1.1^{c}
O	22.67 ± 1.28^{a}	37.22 ± 1.29^{b}	34.4 ± 1.7^{b}
Na	0.08 ± 0.005	0.09 ± 0.011	0.07 ± 0.01
Mg	0.49 ± 0.02	0.48 ± 0.028	0.48 ± 0.05
Ca	0.25 ± 0.1	0.33 ± 0.01	0.17 ± 0.16
K	3.10 ± 2.10	2.29 ± 1.17	7.82 ± 0.9
Cl	2.21 ± 1.11^{a}	2.49 ± 1.18	3.21 ± 1.10^{a}
P	0.15 ± 0.15	0.14 ± 0.15	0.15 ± 0.49

a, b, c marked with different letters in a single row differs significantly at 5%.

Table 2: Weight % of different trace elements present on the cattle hair samples collected from four different districts of Mizoram

Elements	Aizawl	Mamit	Siaha	Elements
F	2.3 ± 0.05^{a}	1.39 ± 0.07^{b}	0.94 ± 0.09^{b}	1.04 ± 0.02^{b}
Zn	0.12 ± 0.11	0.15 ± 0.02	0.16 ± 0.02	0.15 ± 0.005
Mn	1.52 ± 0.06	1.56 ± 0.07	1.57 ± 0.13	1.44 ± 0.13
Fe	1.94 ± 0.29	2.90 ± 0.49	1.77 ± 0.21	2.16 ± 0.20
Co	2.24 ± 0.21^{a}	1.75 ± 0.08^{ab}	1.24 ± 0.08^{b}	1.41 ± 0.12^{b}
Cu	3.83 ± 0.79	3.07 ± 0.11	3.02 ± 0.21	3.54 ± 0.38
S	30.23 ± 4.13	29.98 ± 4.26	28.34 ± 6.23	32.10 ± 1.76

a, b, c marked with different letters in a single row differs significantly at 5%.

Table 3: Weight % of different heavy metals present on the cattle hair samples collected from four different districts of Mizoram

Elements	Aizawl	Mamit	Siaha	Elements
Si	1.74 ± 0.05^{a}	1.02 ± 0.017^{b}	1.12 ± 0.02^{b}	1.15 ± 0.1^{b}
Sc	0.02 ± 0.005	0.02 ± 0.005	0.03 ± 0.005	0.04 ± 0.02
Ti	0.03 ± 0.11	0.03 ± 0.011	0.11 ± 0.01	0.06 ± 0.005
V	0.15 ± 0.23	0.1 ± 0.005	0.1 ± 0.02	0.1 ± 0.01
Pb	37.64 ± 2.648^{a}	18.77 ± 3.06^{b}	27.38 ± 0.8228^{ab}	27.04 ± 2.548^{ab}
Cd	1.47 ± 0.36	1.63 ± 0.13	2.69 ± 0.58	2.95 ± 0.45
Cr	2.27 ± 0.26	2.31 ± 0.27	1.95 ± 0.26	2.10 ± 0.13
Ni	2.79 ± 0.63	2.08 ± 0.19	1.93 ± 0.09	1.78 ± 0.23
Hg	41.11 ± 5.7^{a}	65.91 ± 2.72^{b}	58.41 ± 1.63^{b}	57.57 ± 2.14^{b}
As	0.03 ± 0.01	0.02 ± 0.00	0.02 ± 0.00	0.01 ± 0.00
Al	2.71 ± 1.36^{a}	0.00^{b}	0.80 ± 0.8^{c}	0.48 ± 0.75^{c}
Au	56.77 ± 1.32^{a}	43.20 ± 4.57^{b}	42.64 ± 8.92^{b}	46.71 ± 3.15^{b}
Br	0.88 ± 0.88^{a}	0.00^{b}	0.00^{b}	0.00^{b}
Ta	3.03 ± 3.03^{a}	0.00^{b}	0.00^{b}	0.00^{b}
Tm	1.85 ± 1.85^{a}	0.00^{b}	0.00^{b}	0.00^{b}
Rn	3.96 ± 3.73^{a}	0.00^{b}	0.00^{b}	0.00^{b}
Ra	0.02 ± 0.02^{a}	0.00^{b}	0.00^{b}	0.00^{b}
U	1.17 ± 0.63^{a}	0.16 ± 0.017^{b}	0.29 ± 0.16^{b}	0.27 ± 0.06^{b}

a, b, c marked with different letters in a single row differs significantly at 5%.

4. Discussions

Concentration Carbon was highest since the keratin protein of hair is mainly formed by carbon and oxygen; therefore, the weights of these two elements were very high. Similar findings were also reported by Das *et al.* (2018) in the Assam hill goat.[6] No significant differences in other macro elements might be an indication of the similar food habits and breeds of the animals. Therefore, the concentration of these elements in the animal's blood or in other tissue in all those districts might be similar. Similar findings in sodium and magnesium were also reported by Asano et al. (2005) in different hair of a horse.[7] Low concentrations of fluorine were found in all of the four districts. There was a significant difference in the weight % of fluorine when it was compared between all of the districts. The highest fluorine concentration was seen in the Aizawl (2.3 ± 0.05) districts of Mizoram. This might be because of the fact that the Aizawl district is where the capital of Mizoram is located, and mineral fluorite is mainly found in different industries and is also associated with other manufacturing goods.[8] So, being reared near the most urbanized place of Mizoram, these local cattle have a higher chance of getting exposure to fluorite than other animals from any other studied districts. High concentrations of sulfur were found with no significant differences between the districts. High concentrations of sulfur were found with no significant differences between the districts. Among which lowest sulfur weight % was found in the Siaha (28.34 ± 6.23) district of Mizoram. The statement of Zazzo et al. (2011) suggested that, the presence of sulfur isotopes in the hair is negatively correlated with its distance to sea level.[9] So, a similar concentration of sulfur might be because of the almost similar altitude of all the above

districts of Mizoram. Das et al. (2018) reported that sulfur weight % was much higher than any other elements except for carbon and oxygen in Assam hill goat. There was no significant difference in the Copper concentration, which might be related to the sampling procedure since only light-colored hair was selected. Cygan-Szczegielniak et al. (2014) mentioned that copper concentration in dark-colored hair is significantly higher since copper plays an essential role in melanin and other pigment synthesis.[10] Significantly low concentrations of copper were recorded in the blood and hair of cattle reared in industrial areas.[11] They also found out that the presence of different heavy metals in the environment reduced the concentration of some trace elements in blood and hair. This statement is supported by the statement of Blanco-Penedo et al. (2006).[12] Rogowska et al. (2009) also reported that, cattle reared near copper smelter had higher concentrations of copper in hair than cattle reared away from it.[13] No significant differences in Zinc, Iron, Manganese, and Copper might be the reflection of similar dietary habits, similar age, and similar geographical location. Saba et al. (1992) reported that the concentration of many microelements is related to animal herd location and the type of food consumption. Asano et al. (2002) reported a significant negative correlation between age of the animals with Iron and Manganese concentrations.[14] Chand et al. (2017) noted that the concentration of Zinc was not affected much by the concentration of heavy metal presence in the environment. Dahiya and Yadav (2013) stated that, the concentration of the elements contained in the hair samples matches that of the soil samples perfectly.[15] So, the concentration of zinc could be due to the presence of zinc in foodstuffs in the state of Mizoram. Cygan-Szczegielniak et al. (2014) studied that iron concentration is somewhat lower in cattle.

High concentration of lead was recorded in all four districts, with Aizawl being the highest. Rashed and Soltan (2005) reported that Lead concentration in different domesticated animals reflects the concentration of those elements in those areas and is higher in industrially efficient areas.[16] Gould (2009) reported that breeding centers of animals near national road and traffic could lead to more exposure of Lead to the animals.[17] Higher concentration Lead (Pb) in Aizawl districts and other heavy elements such as Gold (Au), Radium (Ra), Radon (Rn), Thulium (Tm), Tantalum (Ta) which were detected only from the above-mentioned districts, might be the indication of excessive pollution in that area. Aizawl being the capital of Mizoram is the most populated and developed district compared to other three; evidence of some of the hazardous elements in the hair of the local cattle of those areas suggests that the exposure is mainly human-made and can have many adverse affect on the livelihood in that vicinity.

5. Conclusion

The concentration of different elements in the animal hair can rightly reflect the concentration of macro and trace elements as well as the heavy metals it is exposed to. Even though the development of an area can guide a generation towards a smooth lifestyle, it has a regressive effect on its surrounding environment; evidence of many toxic heavy elements found in the most developed district of Mizoram directly indicates that.

6. Source of Funding

None.

7. Conflict of Interest

None.

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Author biography

Pranab Chandra Kalita, Professor and Head https://orcid.org/0000-0002-9711-9707

Swarup Debroy, Assistant Professor https://orcid.org/000-0002-8845-8010

Utpal Bora, Professor

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