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Effects of Buried Environment on Trace Element Profile of Bones from Experimental Himalayan Domestic Goat *(Capra Jharal)*

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Abstract

Various types of studies on morphological and chemical analysis have provided an invaluable source of information for historians as well as archaeologists to reconstruct the past history, palaeodiet and palaeoenvironmental conditions of the ancient settlement. During last two decades a number of researches have been carried out on this discipline by different archaeologists, through physical and chemical analysis of archaeological bones, recovered from varied archaeological sites of the world.

Present study was conducted in the bone remains of experimental goats, as they were fed by various types of induced diet sometimes eight years back. It was aimed to establish a base-line data of different elements in the bone remains of Himalayan domestic goats *(Capra jharal)* relation to induced diet and different buried levels of depth.

Trace elements were analyzed from bone remains of experimental/controlled goats, through inductively coupled Plasma Emission (ICPE) Spectrophotometer. The results obtained are significant and it is observed that the preservation status i.e. pH of soil, plays an important role in altering the concentration level of trace elements, and it is seen that the alteration is directly proportional to the buried level. Meanwhile it was also noticed that the lowest level i.e. 1.80 meter of depth was found suitable for the preservation of skeletal remains, as the value of pH and concentration of different trace elements analysed in the bone remains of goatburied at this level were unchanged up to eight years.

Keywords: Trace Element Profile, Himalayan Domestic Goat, *Capra jharal*, Bone Remains.

Introduction

Dietary reconstruction is an important aspect of historical, archaeological and anthropological science. Different types of scientific and traditional methods have been used by zoologists, archaeologist and anthropologists to reconstruct various components of diet and dietary behaviour of ancient human occupation. However, on the basis of scientific methods, it is assumed that determination of the concentration level of particular trace element preserved in the bone, provides a potential pathway for reconstructing the diet of extinct primate species and archaic human beings. Earlier studies has proved that, strontium (Sr), barium (Ba), magnesium (Mg), calcium (Ca) and zinc (Zn) are some of the most useful trace elements for dietary reconstruction, it includes work done by Farswan and Singh (2015); Farswan and Pharswan (2015); Farswan et. al. (2014); Farswan and Pharswan (2013); Farswan (2012); Farswan and Singh (2012); Farswan (2012); Al-Bashaireh and Al-Muheisen (2011) Pharswan and Farswan (2011); Pharswan and Farswan (2011); Farswan and Pharswan (2009); Farswan (2007); Farswan and Price (2002); Farswan (2002); Geidel (1982); Tuross et al. (1989); Sealy and Sillen (1988); Antoine et al. (1988); Schoeninger (1989); Tuross et al. (1989); Price (1989); Morgan and Schoeninger (1989); Grupe and Piepenbrink (1989); Pate (1994), Gilbert et al. (1994), Burton et al. (1999), Schakowsky and Herrmann (1999) etc.

Research work carried out by the aforesaid archaeologists have also proved that the lower values of magnesium in animal bone indicate the consumption of terrestrial diet and higher values of the same indicate the consumption of marine diet, while the higher concentration of strontium, calcium, magnesium, zinc and lower values of barium and barium-strontium

ratios clearly indicates the consumption of marine diet; continuous intake of terrestrial diet increases the values of barium and barium-strontium ratios while it reduces the concentration level of magnesium, strontium and zinc in the animal bones; and herbivores generally have very lower concentration of zinc in their bone than the carnivores; meanwhile, higher ratio of bone strontium to calcium and barium to calcium represent a greater percentage of vegetable food in their diet and lower ratio of the same, indicate greater percentage of meat in their diet.

Earlier studies on bone chemistry and palaeodietary reconstruction in archaeological faunal remains has also evidenced that trace elements are significantly helpful in reconstructing the dietary behaviour of various animal population domesticated by ancient peoples, during different cultural phases of cultural revolution. But after conducting a number of such type of studies it has to be clarified that, fool proof results through such type analysis is only possible when we get animal as well as human bone remains in good and well preserved conditions. Therefore, to know the effects of buried conditions of soil on bones we have carried out the present study.

For this purpose we have set up an experiment of induced feeding with three goats, eight years back to see the effects of various induced diets on trace element profile and isotopic ratios of carbon in the bones of goat, results obtained are published (Farswan & Pharswan, 2015), while to see the effects of different depth levels of soil on the preservation condition and concentration level of trace elements, the second group of bones from all the experimental goats, as discussed in first study were buried in the earth at different levels of depth. After eight years all these faunal remains were recovered systematically from the earth and trace elements in various bone samples were measured with the help of inductively coupled Plasma Emission (ICPE) Spectrophotometer, and the results obtained were calculated in ppm. The results obtained were further calculated and correlated statistically to establish relationship between trace elements and diet as well as buried environmental conditions.

Materials and Methods

At the stage of completion of the induced feeding experiment of goats, all goats i.e. experimental and controlled, were butchered, bones from each goat were recovered and divided in two groups, first were analyses for obtaining concentration of trace elements and isotopic ratios of carbon, second group of bones from each goat were buried at different levels into earth, at 60, 120 and 180 cm depth. During this process acidity and alkanity of soil was recorded properly i.e. hydrogen ion concentration (pH) of soil at different buried levels and locations.

After eight years the buried boneremains from controlled and experimental goats were recovered by conducting a systematic excavation, during excavation the hydrogen ion concentration (pH) of soil at different buried levels and locations were also examined through pH meter, to see the status of the natural soil. Bone samples from controlled and experimental goat were broken separately to expose the medullary cavity and cleaned with sand paper and deionised water to remove non bone tissues.

For elemental analysis all the selected cleaned bone samples from both the groups of reference and experimental goat were again broken into small pieces, a few millimeters in diameter, placed in separate glass vial (20 cc liquid scintillation vials with linear lids), rinsed with de-ionized water, covered again with de-ionized water and allowed in a Ultrasonic bath for thirty minutes. After sonication, the liquid was then drained and all the samples were rinsed again with de-ionized water. Later on the bone pieces in the same vial were covered with 1-Molar acetic acid solution and allowed to sit at room temperature and are removed after half an hour. The acid washed bone were then rinsed with de-ionized water and dried in an oven at 80-90 degree Celsius for overnight. Approximately one and half gram (1.5 gm.) of each bone sample was taken into pre-labeled porcelain crucible and these crucibles were then placed into a muffle furnace at 725-degree Celsius for eight hours to ash the samples.

For each sample, 50 milligram (0.50 gram) of bone ash was weighed into a disposable 16x25 mm Pyrex test tube. A reference (H5), (B5407) (B1026) and a controlled sample were also included in addition to the experimental samples. One milliliter of concentrated nitric acid was added to each test tube (using micropipette) and the tubes were placed in an aluminium heater block on a hot plate and heated to 100-120 degree Celsius for one hour, allowed to cool and diluted with 16 milliliters of 5% nitric acid to a total volume 17 milliliter. Finally the solution obtained was then introduced directly into the Inductively Coupled Plasma (ICP) Emission spectrophotometer for elemental analysis. The results obtained were calculated and correlated statistically, which are presented in tables-1, 2, 3 as well as in figures 1, 2,3,4,5 & 6 respectively.

Table-1

Hydrogen Ion Concentration (pH) in the Soil of Experimental Site at different Levels of depth

Sl. No.	Buried Level	pH Value
When bones were buried at different levels		
1.	Surface	6.36
2.	60 cm.	6.32
3.	120 cm.	6.45
4.	180 cm.	6.28
During excavation of bones after eight Years		
1.	Surface	5.28
2.	60 cm.	5.34
3.	120 cm.	7.45
4.	180 cm.	7.84

Table-2
Mean Concentration Values of Different Elements in the Bones of Experimental and Controlled Goat after Termination of the Induced Feeding Experiment

Bones of	Concentration of Elements (in ppm ±SD)				
	Ca	Sr	Ba	Mg	Zn
Induced Goat-1 *(Capra jharal)*	41656.80 ± 123.08	675.50 ± 17.04	165.93 ±20.50	1989.26 ± 111.50	109.12 ± 17.06
Induced Goat-2 *(Capra jharal)*	41233.32 ± 123.13	718.90 ± 19.25	168.57 ± 24.21	1867.62 ± 82.05	103.42 ± 15.03
Controlled Goat *(Capra jharal)*	38253.12 ± 101.28	538.35 ±22.03	152.32 ±29.35	1755.37 ± 107.52	96.25 ± 14.09
Coastal Ref-1 Herbivore	32252.77 ± 111.50	554.32 ± 11.30	70.82 ± 5.50	2493.64 ± 25.35	92.45 ± 7.10
Terrestrial Ref-2 Omnivore	34736.07 ± 112.51	356.10 ± 23.00	225.75 ± 17.21	5632.00 ± 32.54	215.05 ± 12.34
Carnivore Ref-3	41720.50 ± 124.51	278.10 ± 11.00	263.52 ± 16.23	7233.54 ± 32.54	415.23 ± 18.22

Table-3
Mean Concentration Values of Different Elements in the Burried Bones of Experimental and Controlled Goat after Eight Years

	Concentration of elements (in ppm ±SD)				
	Ca	Sr	Ba	Mg	Zn
Buried Level: 60cm					
Bones of					
Induced Goat-1 *(Capra jharal)*	37023.80 ± 123.08	488.50 ± 17.21	128.34 ±20.50	1668.56 ± 112.50	97.82 ± 12.02
Induced Goat-2 *(Capra jharal)*	38032.32 ± 123.13	524.90 ± 19.71	147.72 ± 21.21	1758.26 ± 26.05	96.43 ± 14.04
Controlled Goat *(Capra jharal)*	37223.12 ± 111.25	492.35 ± 24.22	145.20 ± 19.71	1672.73 1672.73	88.27 88.27
Buried Level: 120 cm					
Bones of					
Induced Goat-1 *(Capra jharal)*	41165.80 ± 117.08	599.15 ± 17.05	149.25 ±19.01	1772.25 ± 115.05	112.57 ± 12.20
Induced Goat-2 *(Capra jharal)*	42237.32 ± 130.13	624.92 ± 19.12	167.73 ± 20.12	1825.62 ± 82.05	100.44 ± 15.23
Controlled Goat *(Capra jharal)*	38212.12 ± 91.15	552.35 ±22.11	150.32 ±17.29	1627.35 ± 99.42	98.99 ± 17.23
Buried Level: 180 cm					
Bones of					
Induced Goat-1 *(Capra jharal)*	41054.80 ± 132.03	697.23 ± 13.04	167.37 ±25.09	2057.53 ± 102.51	108.52 ± 16.70
Induced Goat-2 *(Capra jharal)*	42772.32 ± 123.13	715.79 ± 16.33	168.66 ± 21.61	1898.25 ± 73.03	106.45 ± 12.50
Controlled Goat *(Capra jharal)*	39198.25 ± 121.27	554.52 ±23.16	155.32 ±22.58	1795.35 ± 117.25	99.65 ± 14.25

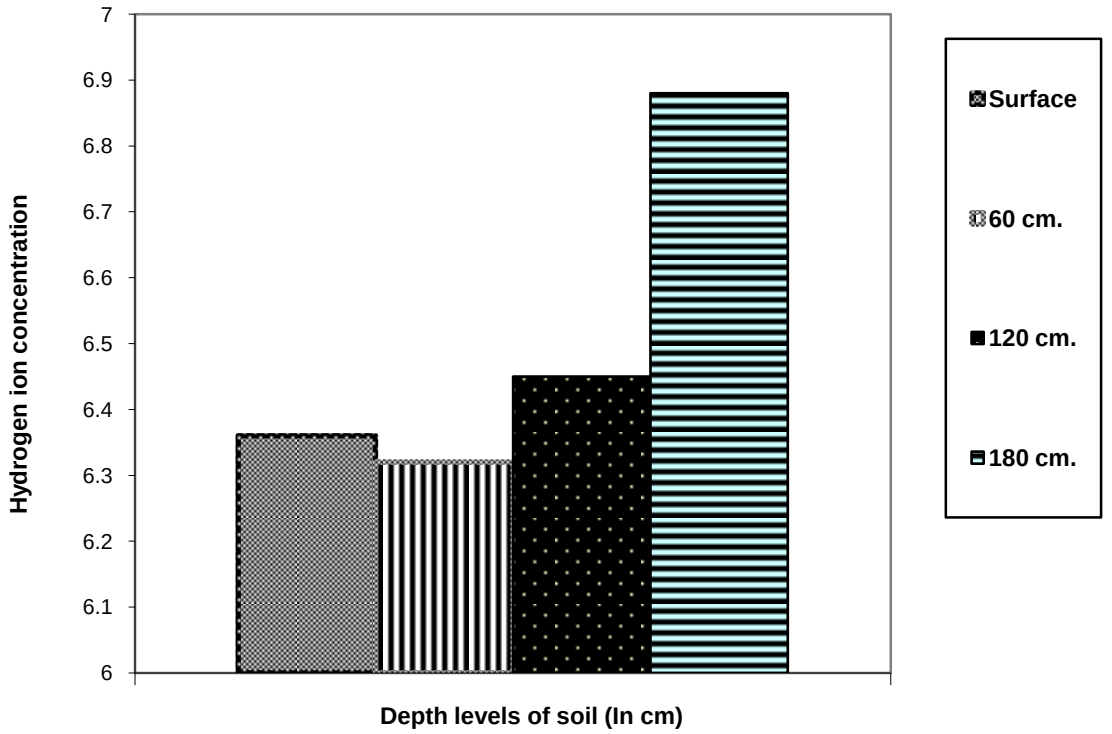

Figure-1 Hydrogen Ion Concentration (pH) of Soil at different Levels when Bones were Buried

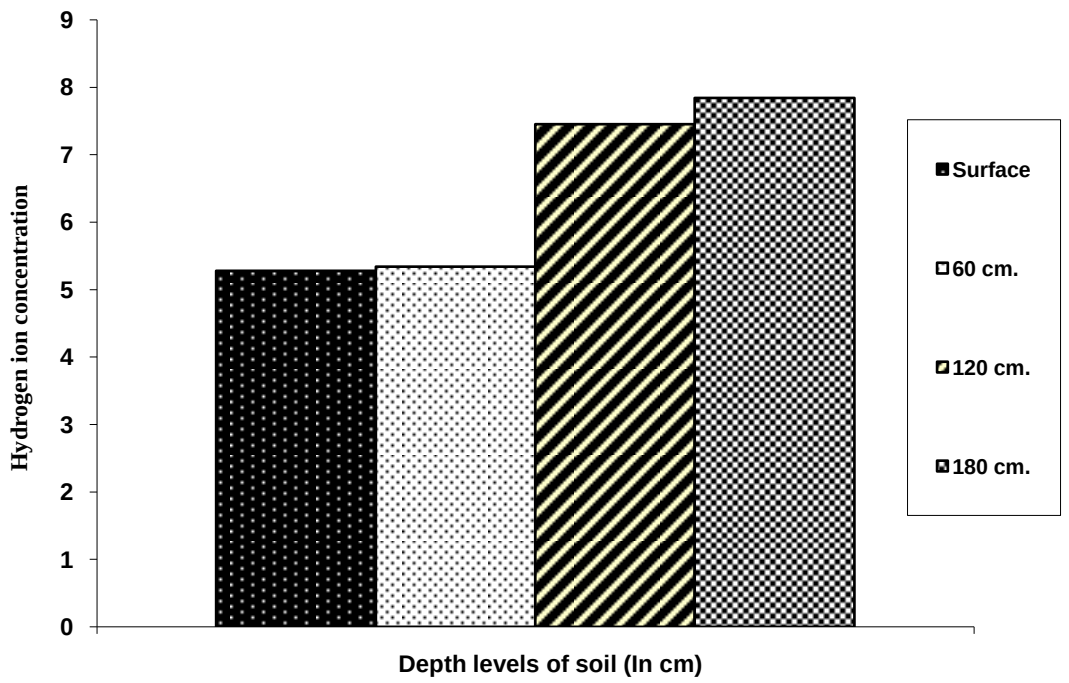

Figure-2 Hydrogen Ion Concentration (pH) of Soil at different Levels during Recovery of Bones after Eight Years

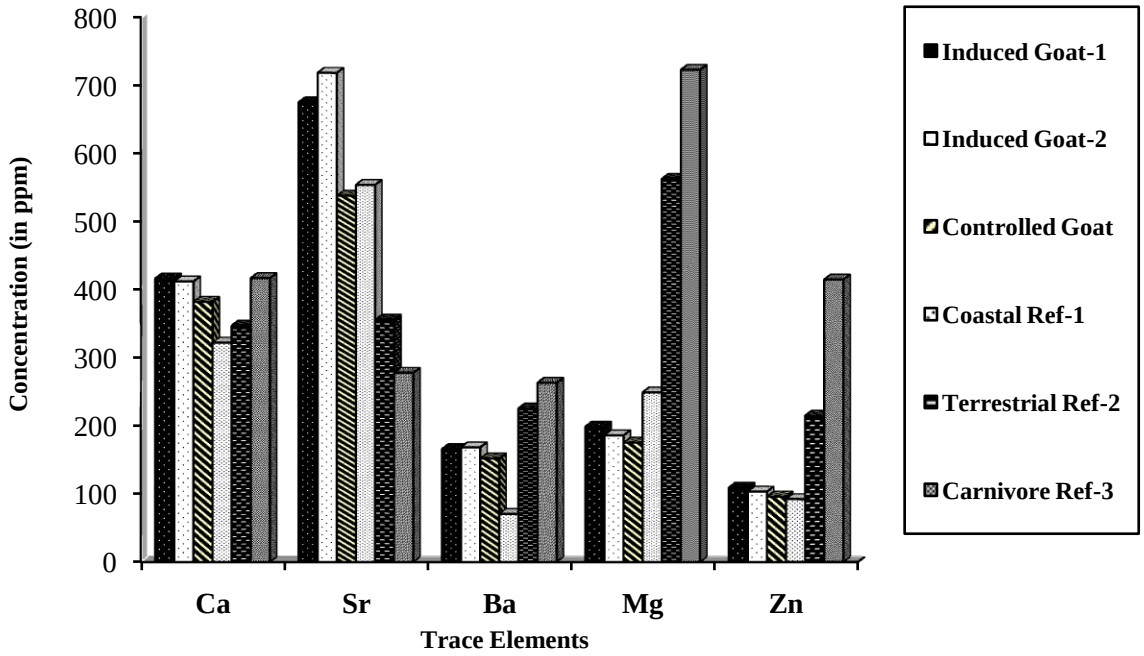

Figure-3 Concentration of Different Elements in the Bones of Goats after termination of Experiment

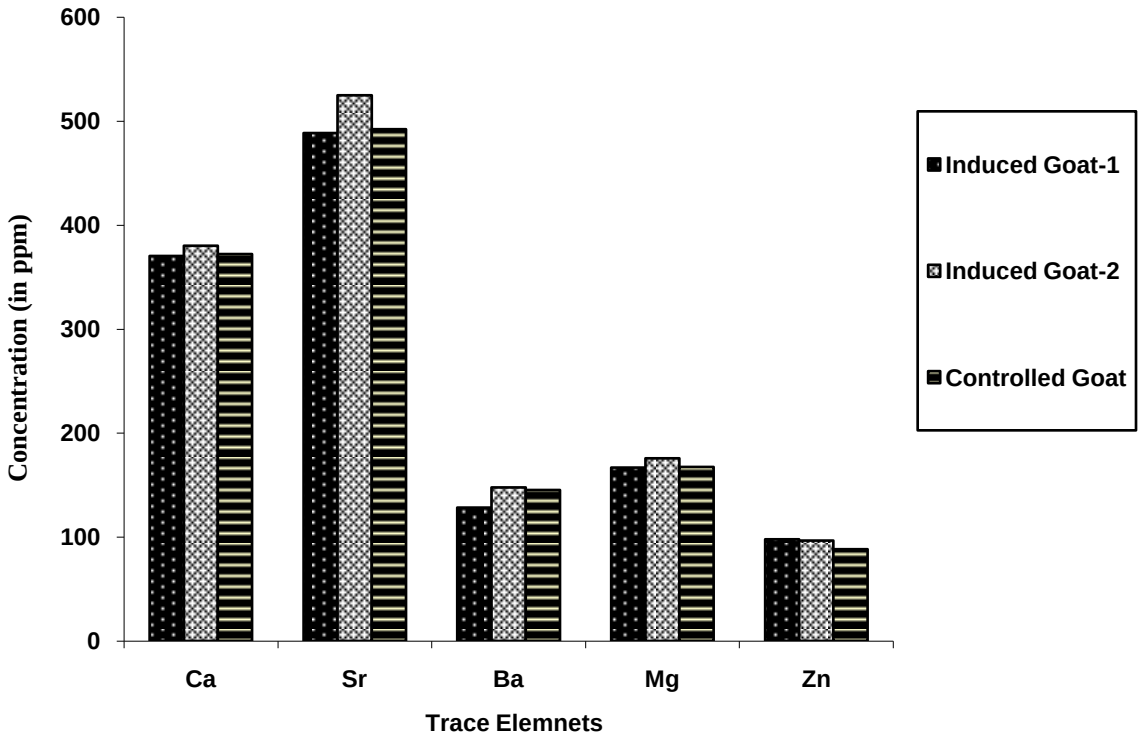

Fig-4 Concentration of Different Elements in the Buried Bones of Experimental and Controlled Goats at 60 cm level

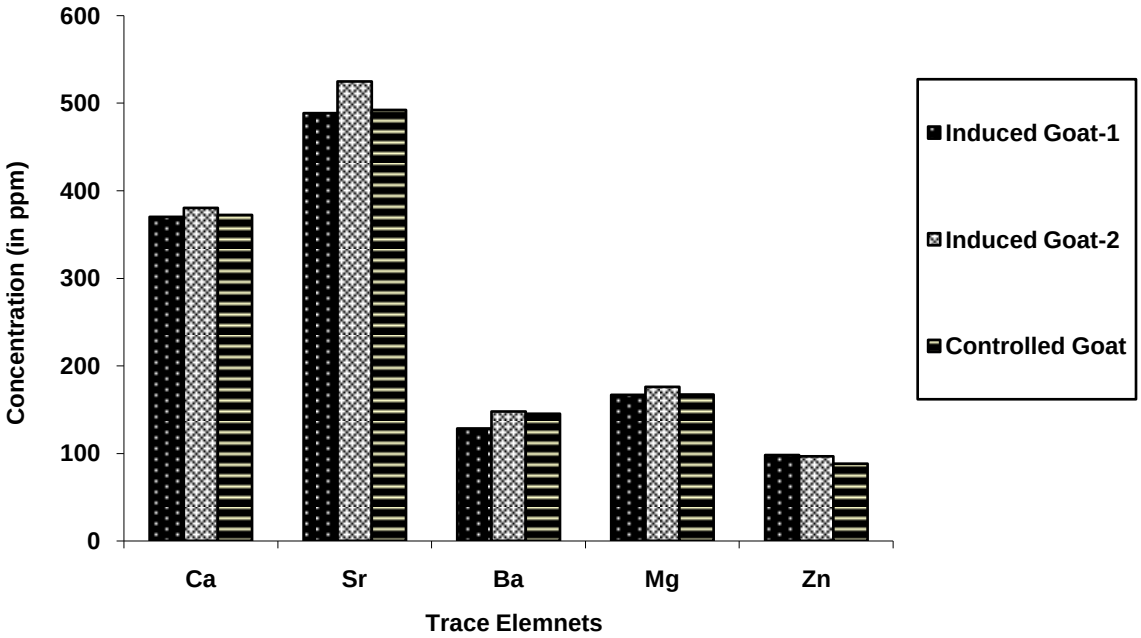

Fig-5 Concentration of Different Elements in the Buried Bones of Experimental and Controlled Goats at 120 cm level

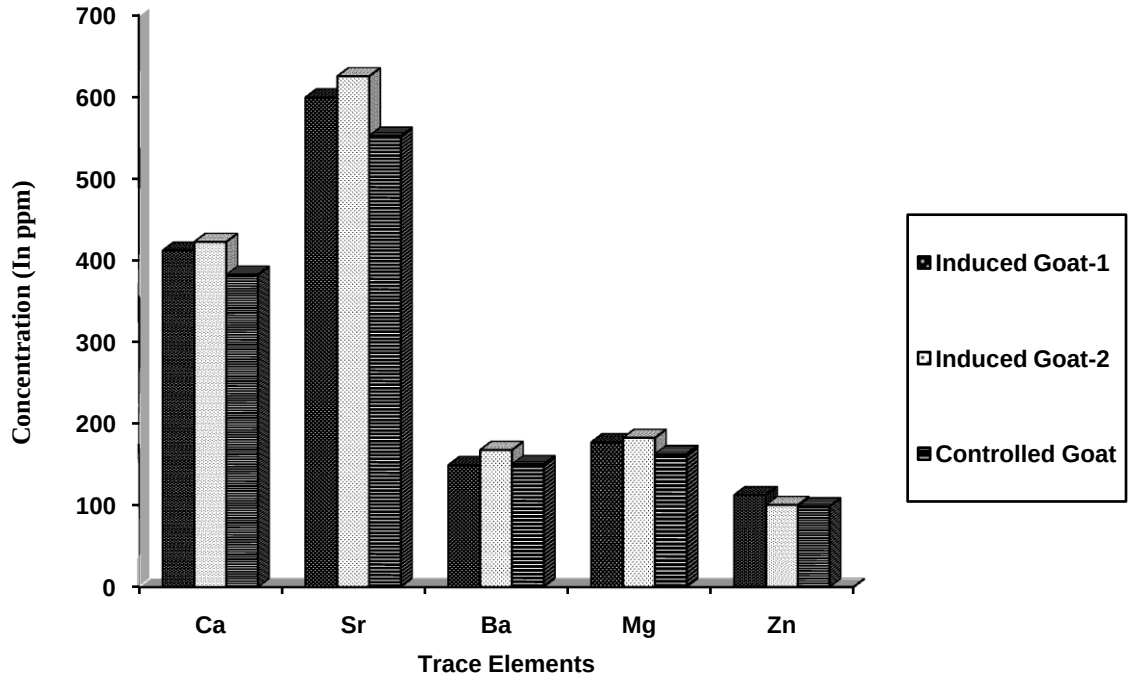

Fig-6 Concentration of Different Elements in the Buried Bones of Experimental and Controlled Goats at 180 cm level

Results and Discussions

To know the degree of variations in the concentration of trace elements, obtained from chemical analysis of different samples of the experimental and controlled goats, through Inductively Coupled Plasma Emission Spectrometer (ICP), as these bones were buried in the earth for eight years. Concentration of different trace elements, obtained from different goats were calculated statistically to get the mean value. These results of experimental and controlled goat along with certified reference bone samples are presented in tables-1, 2 & 3, which are also shown in the figures-1, 2, 3,4, 5 & 6 respectively.

The main aim of the present study was to see the effects of various environmental conditions of the soil on the trace element profile of goats during eight years of buried condition. It has already been described in introduction that before considering present study, an experiment of induced feeding was carried out with two young goats of about same age group and they were fed with three different types of protein rich induced diets along with their normal food. Feeding experiment was carried out for eight months on contract basis with a local butcher, as they have procured the experimental young goats for butchering. For the purpose of controlled samples, another third young goat of same age group was fed with their normal foods, during the experimental period. After the completion of feeding experiment the bones of second group obtained from butchering of experimental and controlled goats, buried in different depth levels of earth, were recovered after a gap of eight years. Meanwhile, it was noticed that the bones recovered from 60 and 120 cm levels were undergoing to the process of degeneration, while bones recovered from the levels of 180 cm depth were found in normal and well preserved conditions.

Besides experimental study with goats, we have also adopted estimation of hydrogen ion concentration (pH) in the soils of buried conditions, these values were measured twice i.e. before the bones were buried and during recovering the bones after eight years, the measured values from different locations/levels are calculated and presented in tables-1, 2 and figures-1, 2 respectively. However, the calculated mean values of pH clearly indicated that the nature of soil at the level of 60 and 120 cm becomes more acidic during the span of eight years, while these values were unchanged at the depth of 180 cm, which clearly suggested that the degeneration process was undergone in the bones of goats, buried at 60 and 120 cm depth, and it happened due to the acidic condition of soils at these locations. As hydrogen ion concentration (pH) of soil was unchanged at 180 cm depth, therefore, the bones recovered from this location were found in good conditions.

The analytical results presented in tables-2 as well as in figures-4, 5 and 6 also revealed that the concentration of different traceelements i.e. Strontium (Sr), barium (Ba), magnesium (Mg), calcium (Ca) and zinc (Zn) has been affected adversely in the bones buried at the level of 60 & 120 cm depth, as compared to the bones which were buried at 180 cm depth, these results can also be compared with the results obtained from the bones of same goats before buried experiment (Table-2 and Figures-3), as these values are differing with each other. Not only this, similar results have also been obtained from the bones of a buried ox (Farswan & Singh, 2012) and in early medieval skeletal remains (Schakowsky and Herrmann, 1999), which positively suggested that such type of studies are potentially helpful in establishing the base-line data on bone chemistry and palaeodiet.

Conclusion

As we have discussed earlier that the main aim of the present study was to see the effects of different buried locations and conditions of the soil on the morphological status and chemical composition of bones. In this regard, the analytical results obtained from the bones of experimental and controlled goats, as well as hydrogen ion (pH) concentration estimated before and after completion of experiment, which are discussed aforesaid (Table-1, 2 & 3; and Figures-1, 2, 3, 4, 5, & 6 respectively), significantly indicated that buried locations and environmental conditions of the soil play an important role in the preservation of organic materials, such as bones, and for altering the chemical composition of faunal and other organic remains. Finally we can say that everybody should carry on such type of studies for maintaining the base-line data of bone chemistry and palaeodiet.

References

1. Farswan, Y.S. and Singh Jaibir (2015). Study of Preservation Status and Dietary Reconstruction in the Human Remains Recovered from Roopkund Lake through Chemical Analysis of Faunal Remains, Journal of Chemistry and Chemical Engineering, USA, Vol.9:15-22.
2. Farswan, Y.S. and Pharswan, J.S. (2015). Effects Of Induced Feeding on Trace Element Profile and Isotopic Ratios of Carbon in Himalayan Domestic Goat (Capra jharal), The Mirror (An Annual Journal of History), Vol.2: 1-10.
3. Farswan, Y.S. Pharswan J.S. and Rawat H.S. (2014). Effects of Buried Environment on the Morphology and Trace Element Profile of Faunal Remains: An Experimental Study, Asian Man (The): An International Journal: Vol. 8(2): 129-134.
4. Farswan, Y.S. and Pharswan, J.S. (2013). Reconstruction of Intensity of Occupation through Trace element analysis of Archaeological soils from Garhwal Himalaya Uttarakhand, in Himalayee Itihaas ke Vividh Aayaam (Proceedings of Uttarakhand Itihaas Avam Sanskriti Parishad), Anamika Publishers and Distributers (Pvt.), New Delhi, pp. 104-115.
5. Farswan, Y.S. (2012). Effects of Buried Environment on the Bones of a Modern Ox (Boss indicus)-II: Study of Isotopic Analysis, Research Journal of Social and Life Sciences, Vol.-XIII(II): 305-309.
6. Farswan, Y.S. and Singh J. (2012). Effects of Buried Environment on the Bones of a Modern Ox (Boss indicus)-I: Study of Trace Element Analysis, Research Journal of Arts, Management and Social sciences, VII-I (4): 191-198.
7. Farswan, Y.S. (2012). Study of Preservation Status and Dietary Reconstruction in the Human Remains recovered from Roopkund Lake, through Chemical Analysis, Proceedings of Indian

History Congress, 72nd Session, held at Panjabi University, Patiala, 2011, pp. 1279-1288.
8. Al-Bashaireh, K., and Al-Muheisen Z. 2011. “Subsistence Strategies and Palaeodiet of Tell Al-Husn, Northern Jordan: Nitrogen and Carbon Stable Isotope Evidence and Radiocarbon Dates.” Journal of Archaeological Science 38 (10): 2606-2612.
9. Pharswan, J.S. and Farswan, Y.S. (2011). Role and Utility of Trace Elements in Palaeodietary Reconstruction, New York Science Journal, 4(11): 43-48.
10. Pharswan, J.S. and Farswan Y.S. (2011). Roopkund Ke Nar Kankal: Etihasik avam Vaigyanik Vivran, Samaj Vigyan Shodh Patrika, Vol.2:XII:15-19.
11. Farswan, Y.S. and Pharswan, J.S. (2009). Elemental Analysis and Estimation of Isotopic Ratios of Carbon in Archaeological Faunal Remains from Mid-Central Garhwal Himalaya: A note for Palaeodietary and Palaeoenvironmental Reconstruction, Proceedings of First Uttaranchal History and Culture Association, held in 2007, Vol-I, 25-43.
12. Farswan Y.S. (2007). Reconstruction of Palaeodiet and Environmental Condition of Ancient Population of Mid-Central Garhwal Himalayas through the Estimation of Trace Elements and Isotopic Ratios of Carbon in the Human and Animal Remains, International Journal of Essential Sciences, Vo.1 (1): 53-68.
13. Farswan, Y.S. and Price, T. D. (2002). Reconstruction of Palaeodiet through Trace Element Analysis of Archaeological Faunal Remains, Indian Journal of Environment and Ecoplanning, Vol.6 (2): 197-208.
14. Farswan, Y.S. (2002). Importance and Utility of Trace Element Analysis in Archaeological Study: Reflections on Palaeodietary Reconstruction. Summary Published in the Proceedings of Indian History Congress, 62nd Session, Bhopal, p.1130.
15. Schakowsky, H. and Herrmann, B. 1999. Diet, status and decomposition at Weingarten: trace element and isotope analyses on early mediaeval skeletal material. Journal of Archaeological Science. 26: 675-685.
16. Gilbert, C., Sealy, J. And Sillen, A. 1994. An investigation of barium, calcium and strontium as palaeodietary indicators in the southwestern cape, South Africa. Journal of Archaeological Science. 21: 173-184.
17. Pate, F. D. 1994. Bone chemistry and palaeodiet. J. Putting the "Chemistry" back into archaeological bone chemistry
18. Lambert, J. B. And Weydert-Homeyer, J. M. 1993. The fundamental relationship between ancient diet and the inorganic constituents of bone as derived from feeding experiments. Archaeometry. 35(2): 279-294.
19. Grupe, G. And Piepenbrink, H. 1989. Impact of microbial activity on trace element concentrations in excavated bones. Applied Geochemistry. 4: 293-298.
20. Price, T. D. (1989). The Chemistry of Prehistoric Human Bone., Cambridge University Press, Cambridge.
21. Antoine, S. E., Pollard, A.M., Dresser, P.Q. and Whittle, A. W. R. 1988. Bone chemistry and dietary reconstruction in prehistoric Britain: examples from Orkney, Scotland. Proceeding of the 26th International Archaeometry Symposium. Pp. 101-106.
22. Ambrose, S. A. 1987. Chemical and isotopic techniques of reconstruction in eastern North America. In: Emergent Horticultural Economics of the Eastern Woodlands (W. F. Keegan Ed.). Pp. 87-107.
23. Casey, C. E., Guthrie, B. E. and Mckenzie, J. M. 1982. Trace elements in tissue from New Zealanders, compilation of published data. New Zealand Medical Journal. 10: 768-771.
24. Geidel, R.A. 1982. Trace element studies from mississippian skeletal remains: findings from neutron activation analysis. Masca Journal. 2:13-16.
25. Bratter, P., Gawlik, D., Lausch, J. and Rosick, U. 1977. On the distribution of trace elements in human skeletons. Journal of Radio-analytical Chemistry. 37: 393-403.