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Biogeochemical Surveys Using Poultry Components from Mangampeta Barite Area, Andhra Pradesh, India

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Abstract

The present work deals with the trace element interactions in excreta, feathers, and eggs of hens of backyard poultry of Mangampeta barite area, Kadapa District, Andhra Pradesh to determine its significance in biogeochemical surveys. For purpose of comparison, excreta, feathers and eggs from the birds of caged system of poultry in Tirupati, Andhra Pradesh are also collected. The excreta and eggs of hens of backyard poultry reflect the composition of their immediate geochemical environment while those of hens of caged system of poultry show their feed composition. Variations in trace element content are observed in poultry components on ash weight and dry weight basis. Organic matter plays an important role in the behavior and distribution of trace elements. The excreta of hens of backyard poultry can be utilized as a tool in biogeochemical orientation surveys as they reflect their surrounding geochemical environment. The biogeochemical investigations of all these biological samples are helpful in the preparation of multi-element atlases for the effective study of environmental geochemistry.

Keywords: Barite area; Biogeochemical surveys; Eggs; Excreta; Feathers; Organic matter; Trace elements

Introduction

In India, among all the poultry birds, the chicken or the domestic fowl occupies the first place for its dietary value. They are generally maintained as "backyard poultry" or as a "caged system" also called "confinement system" of poultry as a rural cottage enterprise. In backyard poultry, small flocks of several kinds of birds such as chicken, ducks, geese, turkeys, and guinea fowls are maintained. In rural areas, these backyard fowls are kept in henneries or in some places covered with big baskets during nights and are released in the morning. These birds freely move about pecking small insects and grains in the surrounding habitat during the day time.

The importance of birds was discussed way back during 5-3rd century B.C. The ancient scientific Sanskrit texts such as Ayurveda (science of longevity) describe physico-chemical properties of the eggs of the birds such as swans, hens, peacocks, and sparrows [1] and internal application of excreta of hens and peacocks [2], sparrow and bat [3] for the treatment of different human diseases and disorders. There is a vast modern literature on nutritional [4-8], management [5,9,10], and commercial [9,11] aspects of poultry.

In Finland, birds are used as a tool in environmental monitoring by studying the value of birds as biological indicators in integrated bird monitoring with an emphasis on interpretation of the data [12]. Analysis of feathers of nestlings with known origin suggested that the elemental composition of feathers depended largely upon the micro-geographical location of the colony [13]. Poesel et al. [14] stated that the elemental profile of a feather may reveal information about the geographic origin of a bird provided that molting occurs on the breeding grounds and those elemental differences exist between breeding areas.

From an exploration point of view, Razin and Rozhkov [15] reported up to 30 ppb of gold in five species of Siberian birds. Brooks [16] stated that birds serve as indicators in biogeochemical prospecting for mineral deposits. Shacklette [17] stated that element content in feathers of adult migrating birds may characterize the geochemistry of the soil in locations where the birds were hatched and produced their first feathers while feeding on local vegetation. Average lead concentrations were high compared to concentrations in eggs from other countries and correlated well with lead concentrations in soil, indicating that the soil is an important source [18].

Certain bird species have been increasingly used as bio-indicators of metal bio-accumulation especially by taking benefit of non-invasive procedures, such as collecting feathers and excrements. Since metal levels showed a consistent pattern in feathers and excrements of nestling great tits, both represent good and non-invasive methods for the evaluation of As, Cd, Cu, Hg, Ni, Pb, Se and Zn in polluted areas [19]. Feathers, eggs, and excreta of Gentoo penguin (Pygoscelis papua ellsworthii), adults, from Livingston Island (South Shetlands), chosen as bioindicators, were used to test the quality of the Antarctic environment and found that the concentrations of almost all trace elements were significantly higher in the feathers compared to those in the eggs [20]. The domestic avian accumulated heavy metals in their eggshell and egg content in various concentrations although all avian feed the same diet and lived in the same location and such studies might be useful in bio-monitoring studies [21].

Objective

In the present study, a biogeochemical orientation survey has been carried out through excreta, feathers, and eggs of hens of backyard poultry from Mangampeta barite area to distinguish their bioindicator characteristics for the use in different problems of applied environmental geochemistry. For purpose of comparison, hens of caged system of poultry from Tirupati are also considered.

Area of study

The Mangampeta barite mining zone (Lat. 14 01' N; Long. 79 19' E), a rural area in a semi – arid tract is located in Kadapa District, Andhra Pradesh (Figure 1). It is the largest among the known bedded barite deposits of the world. The deposit consists of quartzites, shales, and dolomites. At some places, the deposit is also associated with minor occurrences of pyrite, chalcopyrite, azurite, and malachite. In the present work, birds of backyard poultry from Mangampeta, Kadapa District and birds of caged system of poultry from Tirupati in Chittoor District, Andhra Pradesh were selected.

Earlier biogeochemical studies of Mangampeta barite area were carried out to study the significance of dungs [22], dung, urine and milk [23] of different grazing animals as a tool in biogeochemical exploration.

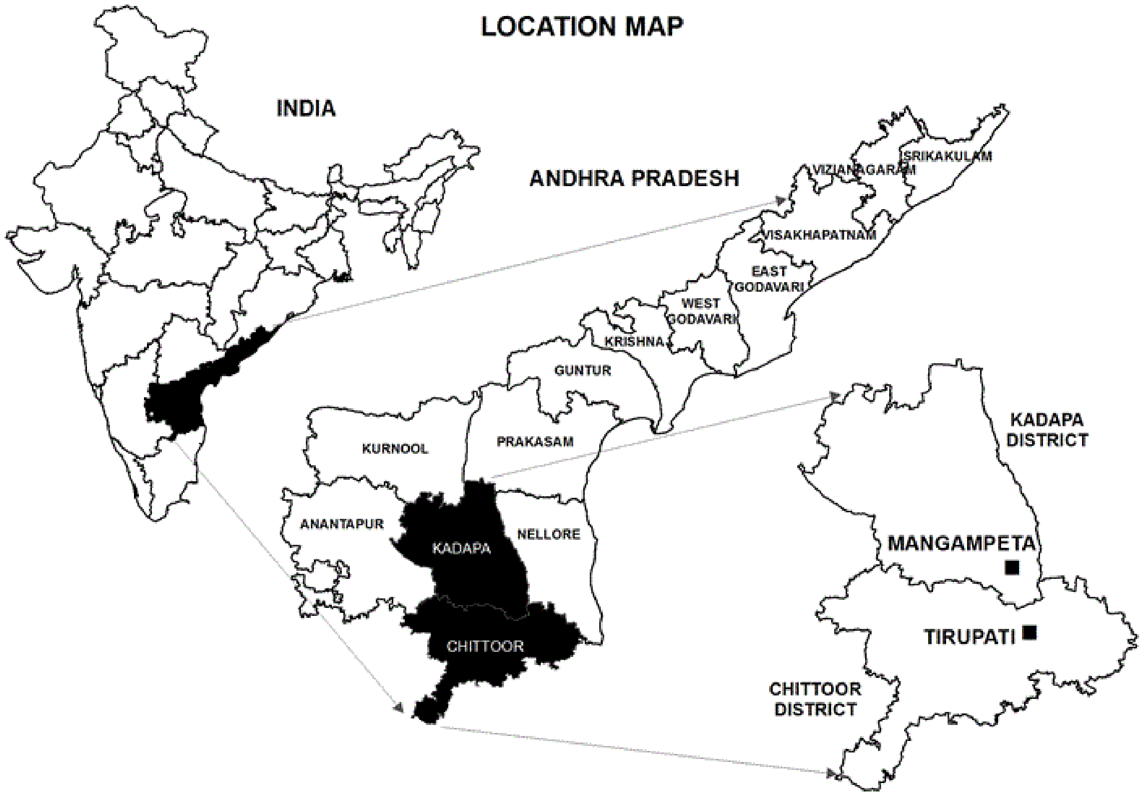

Figure 1: Location map of the study area.

Sampling

Composite sample of the feed of the birds of caged system of poultry from Tirupati was collected. The feed consists of maize 45%, fish, 7.5%, groundnut cake, 20%, rice polish, 20%, mineral mixture 2.5% and shell 5%. Composite samples of excreta, feathers, and eggs of the matured hens of the two poultry systems were collected. Excreta of backyard hens were collected from Mangampeta barite area by placing a clean polythene sheet in their henneries before they come to rest prior to dusk. After the hens were released in the morning the poultry dropping on the plastic sheet were collected. Thus, composite sample of the excreta of about 20 matured hens was obtained. From these hens a few feathers were plucked from different parts of the body of each bird and combined. All these sample collections were made within a week to avoid seasonal variation. In this sample collection, sample collected from those of hens do not exhibit any clinically detectable signs of disease and disorder.

Sample preparation and analysis

Feathers were cut into small pieces (3-5 cm). Feathers and eggs were washed thoroughly with distilled water. Each egg was broken and the edible part (yolk and albumin) was collected into a breaker. The shell was crushed in to small pieces and mixed thoroughly with the edible part. Similarly, composite sample of dozen eggs was obtained from each poultry system.

Moisture was eliminated from the samples of poultry components namely excreta, feathers, eggs, and feed by keeping them at 110°C in a hot air oven for eight hours. Further, organic matter from all the moisture–free samples was expelled by placing them at 500°C in a muffle furnace for three hours. Feed and excreta on ash weight and dry weight bases, feathers and eggs on ash weight basis were analyzed for ten trace elements namely Ba, Sr, Mn, Cu, Pb, Zn, Ni, Co, Cr, and Cd by atomic absorption spectrophotometry. From the data (Table 1) the following observations are made.

Serial Number	Sample	Barium	Srontium	Copper	Lead	Zinc	Manganese	Nickel	Cobalt	Chromium	Cadmium
Detection Limits		0.10	0.04	0.03	0.20	0.02	0.03	0.08	0.07	0.05	0.006
I. Mangampeta barite mining area											
1	Excreta	830 (1453)	298 (139)	35 (70)	33 (ND)	372 (258)	326 (230)	133 (25)	85 (41)	54 (35)	2 (ND)
2	Feathers	103	940	690	ND	2095	353	20	49	59	5
3	Whole Egg	207	1174	63	186	204	58	44	74	14	2
II. Tirupati area											
1	Excreta	112 (ND)	1176 (411)	92 (40)	ND (ND)	843 (233)	993 (333)	56 (28)	ND (27)	18 (1)	8 (3)
2	Feathers	ND	994	140	146	3016	189	ND	ND	ND	13
3	Whole egg	ND	2814	8	21	240	3	ND	30	1	5
4	Feed	67 (ND)	3634 (344)	48 (39)	167 (48)	297 (74)	493 (120)	33 (13)	ND (22)	16 (1)	8 (ND)
ND : Not Detected											

Table 1: Values given in brackets are expressed on dry weight basis and others on ash weight basis.

Results

- Different elements show their presence or absence (not detected) on both ash weight and dry weight bases in the feed and excreta; and on ash weight basis in feathers and eggs of the poultry birds. In a majority of the cases, the trace element concentration on ash weight basis is higher than those of dry weight basis.
- Highest concentration of Ba is observed in the excreta (830 ppm), eggs (207 ppm), and feathers (103 ppm) of hens of backyard poultry reflecting their geochemical environment. Though the feed contain Ba (67 ppm), it is not detected in the feathers and eggs of hens of caged system of poultry.
- Strontium with the highest concentration in the feed (3634 ppm) is released in high proportions through eggs (2814 ppm) and excreta (1176 ppm) of hens of caged system of poultry.
- Zinc shows highest concentration in the feathers of backyard (2095 ppm) and caged (3016 ppm) systems of poultry followed by Sr. The trace element concentrations of each sample are arranged in the descending order (Table 2) and the following observations are made.
- Variations in the trace element sequences among all poultry components on both ash weight and/or dry weight bases are observed.
- In both feed and excreta of birds of caged system, Sr, Mn, and Zn show the same sequence on both ash weight and dry weight bases. On ash weight basis, Pb in feathers, Sr, Pb, and Cr in eggs show the same sequence as that of feed.
- In the excreta of birds of backyard poultry, on both ash weight and dry weight bases, Ba, Zn, Mn, Sr, Co, and Cr show the same sequence.
- Zinc and Sr in the feathers, Sr, Pb, and Mn in eggs follow the same sequence in both the poultry systems.

Backyard poultry	
Excreta	(A) Ba>Zn>Mn>Sr>Ni>Co>Cr>Cu>Pb>Cd
	(D) Ba>Zn>Mn>Sr>Cu>Co>Cr>Ni>Pb*, Cd*
Feathers	(A) Zn>Sr>Cu>Mn>Ba>Cr>Co>Ni>Cd>Pb*
Eggs	(A) Sr>Ba>Zn>Pb>Co>Cu>Mn>Ni>Cr>Cd
Caged system of poultry	
Feed	(A) Sr>Mn>Zn>Pb>Ba>Cu>Ni>Cr>Cd>Co*
	(D) Sr>Mn>Zn>Pb>Cu>Co>Ni>Cr>Ba*, Cd*
Excreta	(A) Sr>Mn>Zn>Ba>Cu>Ni>Cr>Cd>Pb*, Co*
	(D) Sr>Mn>Zn>Cu>Ni>Co>Cd>Cr>Pb*, Ba*
Feathers	(A) Zn>Sr>Mn>Pb>Cu>Cd>Cr*, Co*, Ni*, Ba*

Eggs	(A) Sr>Zn>Co>Pb>Cu>Cd>Mn>Cr>Ni*, Ba*
Ash weight basis (D) Dry weight basis * Not detected	

Table 2: Caged system of poultry.

Discussion

The variations in the concentration of trace elements on ash weight and dry weight bases are attributed to the influence of organic matter in dry sample and the degree of volatilization of different elements while ashing. Because of the unusual properties of organic matter, it has extremely important effects on the chemistry of trace elements. Organic matter contains appreciable amounts of many metals; and the bonding is extremely variable and complex, ranging from simple adsorbed ions to metallo-organic compounds. The adsorbed fraction is readily extracted by cold aqueous solutions. Complete release of the more firmly bonded metal generally requires complete destruction of the organic matter in ashing [24].

Ayurveda states that the physico-chemical properties of animal products depend upon the ecological and environmental conditions of their habitat and their feed and fodder [22,23]. The concentration of Ba in soils of Mangampeta mining area ranges from 116-802 ppm while Sr is in the range of 13-31 ppm [25]. In the present study, the highest concentration of Ba in the excreta, feathers, and eggs of hens of backyard poultry and Sr in the excreta and eggs of hens of caged system of poultry are observed reflecting their surrounding geochemical environment and composition of their feed respectively. Similar results are also obtained when eggs and feathers of backyard poultry from Agnigundala base metal area, Guntur District, Andhra Pradesh are analyzed [26]. They reported that when compared to the non-mineralized Tirupati area, feathers show higher concentration of Pb, Zn, and Co in Bandalamottu (lead and zinc mineralized area), and Cu, Zn, and Co, in Nallakonda (copper mineralized area). Further, eggs show higher concentration of Pb, Zn, Cu, Ni and Co in Bandalamottu and Pb, Cu and Co in Nallakonda. The concentration of these elements in eggs and feathers provides tangible evidence on the composition of the surrounding geochemical environment.

In asbestos mining area, the concentration of magnesium in the eggs of backyard poultry is remarkably higher which may be due to the presence of magnesium rich mineral in their surrounding habitat. This study has given greater scope on the backyard poultry-soil relationship in the mining areas and their significance in biogeochemical orientation surveys, nutrition status of an area and environmental studies [27].

Waheed et al. [28] stated that the toxic elements were generally concentrated in egg-white whereas essential elements are mostly present in egg-yolk. Nisianakis et al. [29] concluded that there is a substantial, up to threefold, variation for trace element contents in eggs among different domestic avian species offered the same feed. Forson et al. [30] provided baseline measurements of trace mineral contents of eggs and suggested measurable differences amongst the eggs from chicken, ducks and guinea fowls.

Birds are especially suitable for detecting unexpected changes which cannot be observed by measuring pre-selected physical and chemical parameters, and for monitoring biological, often cumulative and non-linear consequences of many environmental changes acting simultaneously [12]. Brooks [31] stated that animals restricted in their habitat can provide clues to the location of mineral deposits. Poesel et al. [14] stated that trace element analysis of feathers may provide a promising tool for identifying geographic origins of dispersing birds over small geographic scales given that elements in the environment differ on the same scale. Hens of backyard poultry has restricted habitat and reflect the deficiencies in elements due to nature of soils in the area, or are influenced by local enrichment of elements from the ore bodies and their dispersion halos. Further, detailed biogeochemical studies of poultry components may have great significance to establish their curative properties as pointed out in Ayurveda.

Conclusions

The excreta of hens of backyard poultry can be used as a tool in biogeochemical orientation surveys as they reflect their immediate geochemical environment.

Different sampling media, such as soils, stream and lake sediments, waters, and vegetation have been utilized for establishing multi-element atlases for effective study of environmental geochemistry [32]. For such a purpose, excreta, feathers, and eggs of hens of backyard poultry also serve as significant sampling media at micro-level.

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