International Journal of Research
Available at https://pen2print.org/index.php/ijr/

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 06 Issue 2
February 2019

Trace Elements Interaction in Eggs from Brahmanapalli Asbestos Mining Area, Andhra Pradesh, south India

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ABSTRACT:

Trace element analysis of the eggs of the hen in chrysotile asbestos mining area of Bramhanapalli, Pulivendla mandal, Kadapa District, Andhra Pradesh was carried out on ash weight and dry weight basis to determine their indicator characteristics and its significance in applied environmental geochemistry. Trace element analysis of these samples was carried out for Mn, Ni, Co, Cr, Al Mg, Fe, Ba, Sr, Cu, Pb, and Zn. It is observed that different elements show their presence or absence on both ash weight and/or dry weight bases in eggs. All individual parts of raw and boiled egg samples show high concentration of Mg, Fe, and Al on ash weight than dry weight. Mg occupies first position in the sequence in all parts of the raw eggs both on ash weight and dry weight. The enrichment of Mg concentration in eggs may be due to the presence of asbestos mineral in the study area. Hence the backyard poultry eggs may ideally be used as tools for their possible application in mineral exploration. There are wide variations for Coefficient of Apparent Organic Binding (CAOB) for the elements and also observed that there is no systematic order of elements in case of CAOB. This study reveals that the eggs of backyard poultry may be extremely useful in biogeochemical exploration related to geochemistry, in reconnaissance surveys, and also to study the levels of environmental pollution of an area.

Key words: Trace elements, Raw and boiled eggs, Asbestos mine, Brahmanapalli, Andhra Pradesh

INTRODUCTION

Biogeochemistry has gained prominence as its scope in recent years has been extended to health implication of the geochemical environment. Many workers (Underwood, 1971 Bowie and Web, 1980; Thornton, 1983) have studied the excess or deficiency of trace elements in soil, water, plants and animals, and have linked these imbalances with human health. Biogeochemistry deals with mineral exploration, agricultural geochemistry and environmental geochemistry including public health (Rose et al, 1979; Adriano et al, 1997). The chicken or the domestic fowl is the most important among the poultry birds. Normally they are maintained as backyard poultry or caged system poultry. Backyard poultry includes small flocks of several kinds of birds such as chicken, ducks, and guinea fowls. These backyard fowls are kept in henneries or in some places covered with big baskets during night times and are released in the morning especially in rural areas. These fowls freely move for pecking small insects, grains in the surrounding habit during the day time.

TRACE ELEMENTS IN POULTRY

Humans have increased the trace element content of their environment while exploiting mineral reserves. In such areas mine dumps or tailings cause a major problem since they contain concentrations of heavy metals that are toxic to plants and animals. Earlier workers studied on nutritional (Underwood, 1971), and management (Stadelman and Cottrell, 1973; Mountney, 1976) aspects of poultry. Birds serve as indicators in biogeochemical prospecting for mineral deposits (Brooks 1983). Razin and Rozhkov (1996) reported upto 30 ppb of gold in five species of Siberian birds. Excreta of hens and peacocks (Pardhasaradhi Sarma, 1979) and their curative properties for the treatment of different human diseases and disorders were described. Eggs have been recognized as an important food from the time primitive men first snatched them form the nests of wild birds.

GEOLOGY OF THE STUDY AREA

Chrysotile asbestos deposit of Brahamanapalli area is located in Pulivendla mandal of Cuddapah District, Andhra Pradesh, and is included in the Survey of India toposheet No. 57J/3. The NW-SE trending Pulivendla asbestos belt forms a small segment in the S-W part of the Cuddapah Basin. This area is primarily consists of quartzites, shales,. limestones and dolomites. Chrysotile asbestos occurs chiefly in association with massive serpentine. The mineralized zone comprising yellow, green, black serpentine and talc. Chrysotile fibers are found as veins in serpentines, in serpentinized ultramafic rocks. Chrysotile asbestos is a hydrous magnesium silicate with the chemical composition of $Mg_3Si_2O_5(OH)_4$. Earlier workers have carried out geological (Prasad and Prasannan, 1976), mineralogical (Vyasa Rao, 1980; Prasad and Prasannan, 1976), economical (Krishnan and Venkataram, 1942).Biogeochemical and trace elements interaction in grazing cattle products(Chandra Sekhar Reddy, 2015) from asbestos mineralization of Brahmanapalli, Andhra Pradesh have been studied.

MATERIALS AND METHODS

In the present study an attempt is made to know the elemental interactions in eggs of the hens of the backyard poultry of Brahmanapalli to determine their indicator characteristics and its significance in biogeochemical surveys. Eggs of the birds of backyard poultry of Brahmanapalli mining area were collected. Thirty eggs from different hens were collected for the sampling. These eggs were washed thoroughly with distilled water and the sample preparation was made individually for both raw and boiled eggs. About twelve eggs were taken, and their shells were separated and then crushed into small piece. Their edible parts (yolk and albumen) were collected separately in a beaker and mixed thoroughly. Another three eggs were taken and their three components viz., shell, albumen, and yolk were mixed thoroughly to represent whole egg. Thus, raw eggs were made into composite samples of three parts, viz., (i) shell, (ii) edible part and (iii) whole egg. Another twelve eggs were taken and boiled in tap water for forty five minutes. After boiling their shells were separated and then crushed into small pieces. Their edible parts (yolk and albumen) were separated and made individual sample for yolk and albumen. Some boiled eggs were taken and their three components viz., shell, albumen and yolk were mixed thoroughly to represent as a whole egg sample. Thus, the boiled eggs were made into composite samples of four parts viz., (i) shell (ii) albumen (iii) yolk and (iv) whole egg. Moisture from the egg samples was eliminated by keeping them at 110^{o}C in hot air oven for eight hours. Further, the organic mater from the moisture-free samples was eliminated at 500^{o}C in a muffle furnace for three hours. In this study 0.5 gm of samples were digested in

2M HCl as suggested by Brooks (1972). These samples were analyzed for trace elements viz., Mn, Ni, Co, Cr, Al Mg, Fe, Ba, Sr, Cu, Pb, and Zn. by means of atomic absorption spectrophotometer.

RESULTS AND DISCUSSIONS

Physical Properties

Before the sample preparation, measurements of some physical parameters, such as mass, volume and density for about fifteen eggs from the area of investigation were determined (Table.1). From the data, it is observed that the values of mass ranges from 45 to 56 gm; volume ranges from 45 to 52 ml; and density ranges from 0.97 to 1.07 of the raw eggs of Brahmanapalli asbestos mining area. The average values of mass, volume and density of eggs are recorded as 49.8 gm, 48.60 ml, and 1.02 respectively. Romanoff and Romanoff (1949) state that the external characteristics of the egg vary because the reproductive function of the bird is influenced by numerous hereditary, physiological and environmental factors. They also showed that the size of the eggs depend on the age of laying cycle and later the hens exposed to higher environmental temperatures to produce smaller eggs. The authors suggested that the environmental temperature might affect egg size by influencing the rate at which the component parts are deposited.

In the study area, the parameters of moisture, organic matter and ash content were calculated and the data is presented in Table 2 for the raw and boiled egg samples. From the data (Table 2) it is observed that, in boiled egg samples, the highest amount of ash content (89.70%) is recorded in shell and the lowest (1.15%) in albumen; and the highest amount of organic matter (30.15%) in yolk and lowest (5.10%) in shell; and moisture content is recorded as high (80.10%) in albumen and low (5.20%) in shell. In raw eggs the highest amount of moisture content (68.70%) is recorded in edible part and lowest (6.15%) in shell. Organic matter is recorded as high (30.00%) in edible part and low (5.20%) in shell. Ash content is recorded as high (88.65%) in shell and low (1.30%) in edible part. Romanoff and Romanoff (1949) have reported that the percentage of moisture organic matter and ash in entire chicken egg is 65.6, 23.2 and 10.8 respectively; whereas in the shell 1.6, 3.3 and 95.1 respectively. Stadelman and Cotterill (1973) have reported that the percentage of water and ash in albumen is 88 and 0.8 respectively and in yolk 48 and 2 respectively. Romanoff and Romanoff (1949) also stated that the volume of albumen is twice than that of yolk, contains roughly two or three times as much water and only half as much solid matter. Romanoff and Romanoff (1949) have reported that the percentage of moisture organic matter and ash in entire chicken egg as 65.6, 23.2 and 10.8 respectively and in the shell 1.6, 3.3 and 95.1 respectively.

Trace Element Analyses

The raw and boiled egg samples were analyzed both on ash weight and dry weight bases for twelve elements consisting of viz., Mn, Ni, Co, Cr, Al Mg, Fe, Ba, Sr, Cu, Pb, and Zn by atomic absorption spectrophotometry (AAS) and the data is presented in Table 3. From the data it is observed that different elements show their presence of absence on both ash weight and dry weight bases in eggs.

1. In Brahmanapalli asbestos mining area, all individual parts of raw and boiled egg samples show high concentration of Fe, Mg and Al on ash weight than dry weight.

2. Both on ash and dry weight basis, Pb is not detected in raw egg samples but this element is present in boiled eggs.
3. Cr is present on ash weight basis in all parts of raw and boiled egg but absent on dry weight basis except in whole boiled egg sample.
4. Ni is not detected in raw egg samples on ash weight, but it is present on dry weight basis. In boiled egg samples, Ni is present only in whole egg but it is not detected in the other parts on ash and dry weight bases
5. The elements like Mg, Cu, Fe and Al show the concentration is high in edible part than in shell.

Table.1 Mass, Volume and Density of Raw Eggs in Bramhanapallli Asbestos Area

S.No	Mass (gm)	Volume (ml)	Density
1	50	49	1.02
2	49	47	1.04
3	48	47	1.02
4	51	49	1.02
5	47	46	1.04
6	50	51	0.98
7	47	45	1.04
8	49	48	1.02
9	51	52	0.98
10	46	45	1.02
11	45	46	0.97
12	51	51	1.00
13	56	52	1.07
14	53	50	1.06
15	54	51	1.05
Average	49.80	48.60	1.02

Table.2 Moisture (Water), Organic matter and Ash content (in %) in Different parts of Raw and Boiled Eggs in Bramhanapallli Asbestos Area

S.No	Name of the part	Moisture %	Organic matter %	Ash %
Raw egg				
1	Shell	6.15	5.20	88.65
2	Edible part (yolk & albumen	68.70	30.00	1.30
3	Whole egg	67.00	28.00	5.00
Boiled egg				
1	Shell	5.20	5.10	89.70
2	Albumen	80.10	18.75	1.15
3	Yolk	65.10	30.15	4.75
4	Whole egg	61.50	21.90	16.60

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p-ISSN: 2348-795X
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Elemental sequences

The elements of eggs are arranged in sequence of decreasing order based on their absolute concentration on both ash weight and dry weight bases (Table 3). From the data, variations in the elemental sequences among the raw and boiled eggs on both ash weight and/or dry weight basis are observed as follows:

1. In the study area, Mg occupies first position in the sequence in all parts of the raw eggs both on ash weight and dry weight.

2. On ash weight basis, Mg>Al>Fe>Mn is the sequence in shell and edible part; and on dry weight basis the sequence is Mg>Fe>Al in edible part and whole egg sample of raw egg.
3. In boiled egg, the sequence is Mg>Al>Fe>Zn in shell and yolk; Al>Zn in albumen and whole egg on ash weight basis.
4. In boiled egg, on dry weight basis, Mg>Fe>Sr>Cu is the sequence in shell and albumen; Fe>Al>Mg is the sequence in yolk and whole egg.

Coefficient of Apparent Organic Binding (CAOB)

In general, elemental concentration is higher on ash weight basis than on dry weight basis. There is a controversy among biogeochemists whether to report the results on the basis of dry weight or ash weight. Warren et al (1995) recommended reporting of the results on ash weight basis; but Brooks (1983) emphasizes on dry weight basis in order to get a true life situation. In view of this controversy, analysis was made in the present study on the basis of both dry weight and ash weight. Hence a biogeochemical parameter called Coefficient of Apparent Organic Binding (CAOB) is used. It is obtained as follows:

$$\text{CAOB} = \frac{\text{Concentration of an element on ash weight basis (Caw)}}{\text{Concentration of an element on dry weight basis (Cdw)}}$$

In the present study, this parameter has been calculated for each element for both the raw and boiled eggs and presented in Table 3. The CAOB values of all elements are arranged in decreasing order as shown in Table 5. From this table it may be seen that there are wide variation for CAOB for all elements. There is no systematic order of elements in case of CAOB. Loneragan (1975) points out that the order of bonding of divalent metal ions varies with organic matter in soils. These variations are attributed to: i) the influence of organic matter in dry samples, and ii) degree of volatilization of different elements while ashing. Organic matter has extremely important effects on the chemistry of the trace elements. Greater concentration of trace elements occurs in the presence of organic matter (Hoffman and Fletcher, 1980). The bonding of many metals with organic mater is extremely variable and complex, ranging from simple adsorbed ions to metallo-organic compounds (Rose et al, 1979). Ashing of biological materials results in partial or complete lose of volatile elements (Kovalevskii, 1979). Wide variations are found in the CAOB values of the elements in different parts of the eggs. The CAOB for Mg, Al and Fe is above unity in both raw and boiled egg samples.

Trends of Elemental Distribution in Different Parts of Raw and Boiled Eggs

The sequence of the individual parts of both raw and boiled eggs is arranged in the decreasing order based on elemental concentration (Table

4). From the data the following observations are made.

1. In raw eggs, the elements like Cu and Fe the concentration is less in shell than in edible part (E>S) both on ash and dry weight.
2. The elements like Cu, Fe, Mg and Al in raw eggs the concentration is high in edible part than in shell (E>S) on ash weight, but the reverse trend (S>E) is noticed in the case of Ba, Sr, Zn, Mn, and Cr
3. On dry weight, the elements Sr, Cu, Zn, Mn, Ni ad Fe in raw eggs the concentration is high in edible part than in shell (E>S); but the reverse trend (S>E) is noticed in egg samples in the case of Mg and Al.
4. Both on ash and dry weight bases, in boiled eggs it is observed that the concentration of the elements like Mn, Fe and Al are progressively decreasing from yolk to shell (Y>A>S),i.e inner most layer to outermost layer.
5. It may be noticed that Y>A>S trend is found in the case of Zn, Mn, Fe, Mg and Al and reverse trend i.e S>A>Y is found in case of Cr on ash weight basis in boiled eggs.
6.On dry weight basis only, the elements like Mn, Fe, and Al the concentration is progressively decreasing from yolk to shell (Y>A>S); whereas, Pb and Mg show the reverse trend (S>A>Y) in boiled eggs.

CONCLUSIONS

Trace element analysis of the eggs of the hen in asbestos mining area was carried out to determine their indicator characteristics and its significance in applied environmental geochemistry. In the study area, wide variations in the physical properties of eggs may be attributed to their diet and conditions of their habitat. It is observed that different elements show their presence or absence on both ash weight and/or dry weight bases in eggs. Both on ash and dry weight basis, Pb is not detected in raw egg samples but this element is present in boiled eggs. Ni is not detected in raw egg samples on ash weight, but it is present on dry weight basis. In boiled egg samples, Ni is present only in whole egg but it is not detected in the other parts on ash and dry weight bases. All the individual parts of raw and boiled egg samples chiefly show high concentration of Mg, Fe, and Al on ash weight than dry weight. Mg occupies first position in the sequence in all parts of the raw eggs both on ash weight and dry weight. There are wide variations for coefficient of apparent organic binding (CAOB) for the chemical elements and also there is no systematic order of elements in case of CAOB. In asbestos mining area, the concentration of magnesium in the eggs of backyard hen is remarkably high. The enrichment of Mg concentration in eggs of backyard poultry may be due to the presence of magnesium rich mineral and their surrounding habitat. These magnesium rich mineral is responsible for the release of Mg predominantly in large amounts, as the biogeochemical province (Vinogradov, 1964) is influenced by local enrichment of metals due to the existence of ore bodies and their associated dispersion halos. Further this data may be considered for the monitoring of the pollution levels of mining environment. In the study area eggs consisting of high concentration of Mg and therefore backyard poultry eggs may ideally are used as tools for their possible application in magnesium mineral exploration. This study has given greater scope on the backyard poultry-soil relationship in the mining zones and their significance in biogeochemical orientation surveys, nutrition status of an area and environmental studies.

Table. 3 Trace Element Analyses (in ppm)of Backyard Poultry Eggs from Asbestos Area

Element	Raw Egg				Boiled Egg			
		Shell	Edible part	Whole egg	Shell	Albumen	Yolk	Whole

								egg
Mn	a)	310	290	150	125	210	229	450
	d)	195	224	450	80	110	162	360
	c)	1.58	1.29	0.33	1.56	1.90	1.41	1.25
Ni	a)	ND	ND	ND	ND	ND	ND	690
	d)	10	15	20	ND	ND	ND	560
	c)	-	-	-	-	-	-	1.23
Co	a)	ND	ND	ND	18	24	12	65
	d)	ND	ND	275	ND	ND	ND	355
	c)	-	-	-	-	-	-	0.18
Cr	a)	93	72	55	298	260	194	125
	d)	ND	ND	ND	ND	ND	ND	1350
	c)	-	-	-	-	-	-	0.09
Al	a)	1280	1465	1500	1135	1300	1860	2500
	d)	850	800	1015	200	100	650	1400
	c)	1.50	1.83	1.47	5.67	13.00	2.86	1.78
Mg	a)	3400	3620	3975	2856	2998	3215	3818
	d)	2210	1862	2435	2000	1752	620	1375
	c)	1.53	1.94	1.63	1.42	1.71	5.18	2.77
Fe	a)	850	1275	1560	1050	1326	1410	3824
	d)	620	930	1275	510	749	1200	1650
	c)	1.37	1.37	1.22	2.05	1.77	1.17	2.31
Ba	a)	90	50	35	20	15	30	66
	d)	ND	ND	860	ND	ND	ND	40
	c)	-	-	0.40	-	-	-	1.65
Sr	a)	260	150	50	216	310	85	520
	d)	490	610	218	280	395	120	476
	c)	0.58	0.24	0.22	0.77	0.78	0.70	1.09
Cu,	a)	115	120	30	250	372	55	195
	d)	300	420	265	210	300	65	130
	c)	0.38	0.28	0.11	1.19	1.24	0.84	1.50
Pb	a)	ND	ND	ND	ND	ND	ND	390
	d)	ND	ND	ND	32	29	18	45
	c)	-	-	-	-	-	-	8.66
Zn	a)	216	175	76	320	694	850	1000
	d)	150	175	310	20	50	17	95
	c)	1.44	1.00	0.24	16.00	13.88	50.00	10.52
a = Ash Wt; d= Dry Wt; c = CAOB								

Table.5 Elemental sequences of Backyard Poultry Bramhanapallli Asbestos Area

Raw Eggs Shell	a) Mg>Al>Fe>Mn>Sr>Zn>Cu>Cr>Ba,Pb*,Ni*,Co* d) Mg>Al>Fe>Sr>Cu>Mn>Zn>Ni,Ba*,Pb*,Co*,Cr*

Edible part (yolk & albumen)	a) Mg>Al>Fe>Mn>Zn>Sr>Cu>Cr>Ba,Pb*,Ni*,Co* d) Mg> Fe> Al>Sr>Cu>Mn>Zn>Ni,Ba*,Pb*,Co*,Cr*
Whole Egg	a) Mg> Fe> Al> Mn>Zn>Cr>Sr>Ba,Cu**,Pb**,Ni**,Co**, d) Mg> Fe> Al>Ba>Mn>Zn>Co>Cu>Sr>Ni,Pb**,Cr**
CAOB of Raw Egg	
Shell	Ba,Cr>Mn>Mg>Al>Zn>Fe>Sr>Cu>Ni,Pb*
Edible Part (yolk & albumen)	Ba,Cr>Mg>Al>Fe>Mn>Zn>Cu>Sr>Ni,Pb*,Co*
Whole Egg	Cr>Mg>Al>Fe>Ba>Mn>Zn>Sr>Cu>Ni,Co*,Pb*
<u>Boiled Eggs</u> Shell	a) Mg> Al> Fe> Zn> Cr> Cu> Sr> Mn> Ba> Co, Pb*, Ni* d) Mg >Fe> Sr> Cu> Al> Mn> Pb> Zn, Ba*, Ni*, Co*, Cr*
Albumen	a) Al> Zn> Cu> Sr> Cr> Mn> Co> Ba, Pb*, Ni* d) Mg> Fe>Sr> Cu> Mn> Al> Zn.> Pb, Ba*, Ni*, Co*, Cr*
Yolk	a) Mg> Al>Fe>Zn>Mn >Cr> Sr> Cu> Ba, Co**, Pb**, Ni** d) Fe> Al>Mg> Mn> Sr> Cu> Pb> Zn, Ba**, Ni**, Co**, Cr**
Whole egg	a)Fe> Mg> Al> Zn> Ni> Sr> Mn> Pb> Cu> Cr> Ba> Co d) Fe >Al >Mg >Cr >Ni >Sr >Mn >Co >Cu >Zn >Pb >Ba
CAOB of Boiled Egg	
Shell	Ba Co Cr >Zn >Al >Fe >Mn >Mg >Cu >Sr >Pb Ni**
Albumen	Ba Co Cr >Zn >Al > Mn >Fe > Mg >Cu >Sr >Pb Ni**
Yolk	Ba Co Cr >Zn >Mg>Al >Mn> Fe> Cu> Sr> Pb Ni**
Whole Egg	Zn> Pb> Mg> Fe> Al> Ba> Cu> Mn> Ni> Sr> Co> Cr
a) = Ash Wt, d) = Dry Wt, *= Not- detected	

Table.4 Distribution of Elemental Concentration in Different Parts of Raw and Boiled Eggs from Asbestos Area

Trend in Raw Eggs	**Elements**
a. E>S	Cu, Fe, Mg, Al
a. S>E	Ba, Sr, Zn, Mn, Cr
d. E>S	Sr, Cu, Zn, Mn, Ni, Fe
d. S>E	Mg, Al
Trend in Boiled Eggs	
a. Y>A>S	Zn, Mn, Fe, Mg, Al
a. S>A>Y	Cr
d. Y>A>S	Mn, Fe, Al
d. S>A>Y	Pb, Mg
S= Shell; E= Edible part; A= Albumen; Y= Yolk; a = Ash weight; d= Dry weight	

Acknowledgements

I deem it a great privilege to express my deep sense of gratitude to my research supervisor, the Late Prof. E.A.V. Prasad, but for whose guidance this paper could not have come up to its present form. I gratefully acknowledge the help of Dr. G. Sankaranna, Dr. M. Jayarama Gupta, Dr V. Raghu and Prof. A. Nagaraju, department of geology S.V.University Tirupati for their kind help in various ways during this study.

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