

Study of The Dietary Intake of Fe, Zn, Co, Ni, Th and U From Composite Food Samples by an Adult in and Around Domiasiat Village, West Khasi Hills, Meghalaya, India



Chemistry

KEYWORDS: Adult, Dietary, Domiasiat, Elements, Intake

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ABSTRACT

The surrounding areas of Domiasiat village in West Khasi Hills District of Meghalaya, India have been identified by the Atomic Mineral Division, Government of India as one having a uranium ore deposit. Dietary intake of selected trace elements (Fe, Zn, Co and Ni), uranium and thorium was performed to understand the potential health threats from the radionuclides through the diet. In this area, the presence of radioactive analogues of stable elements is very much likely. Analysis of the selected stable and radioactive elements was performed using Instrumental Neutron Activation Analysis Technique available at Bhabha Atomic research Centre, Mumbai. With respect to uranium and thorium the diet of the inhabitants of the four villages is observed to be rich in these isotopes, which is a matter of great concern for the Inhabitants of these villages.

INTRODUCTION:

Elemental determination of food samples is important from the point of view of nutritional, radiation protection and health related studies. Studies related to the radioactive mineral content of significant radionuclide like U and Th in the dietary item were studied by Markose, (1990). Apart from the radioactive components, some trace elements in food items are also important pertaining to uranium mineralization. For accessing risk to human health, information regarding intake of trace elements are important because of the associated biochemical interaction with living organism. The toxicity and necessity vary from element to element and from species to species. For the rural population residing in villages around the uranium mineralization zone of Domiasiat and its adjacent areas, ingestion is the main pathway of exposure of these elements. The intake of trace element mainly through ingestion depends mainly on food habits. It is difficult to arrive at a realistic estimate of intake on the basis of the analysis of individual food item due to variability in food habits. (Jha *et al.* 2010) Moreover, wide variation in food habits from one village to the other may lead to erroneous conclusion for actual intake in a particular area. To overcome this difficulty, prepared whole meal from 4 (four) villages situated in and around the uranium mineralization zone were collected and analysed. The diet type of the Domiasiat area is mostly vegetarian. However, non-vegetarian food items are also available but are not so often incorporated in the main diet. The aim of the present work is to determine the concentration of Fe, Co, Ni, Zn, Th and U in composite food samples collected from four villages in and around Domiasiat by Neutron Activation Analysis.

The aim of the present work is to determine the dietary intake of Fe, Zn, Co, Ni, Th and U for an adult residing in four villages in and around Domiasiat by NAA. The intake through ingestion is computed on the basis of average consumption of processed whole meal collected from different houses situated in and around the mineralization

EXPERIMENTAL:

STUDY AREA:

Meghalaya, "The abode of clouds" also known as "Scotland of the East" is a plateau country famous for its rain, mist and picturesque rolling hills and glens. It is bounded by the mighty Brahmaputra River in the North, Bangladesh Plain in the South and West and plains of Assam in the North and East. Meghalaya lies between 25° and 26°15' North Latitude and 89°45' and 92°47' East Longitude. The surrounding areas of Domiasiat village, West Khasi Hills District, Meghalaya are identified as one having a Uranium ore deposit. Four Villages in and around the uranium mineralization zone was selected for this study. The selected villages are Domiasiat (with a population of 20 – 30 people approximately), Nongbahjynrin (Population 40-50 people approximately), Nongtynger (Population 80 – 100 people approximately)

and Mawthabah (population 80 – 100 people approximately). The sampling locations along with their respective GPS readings are depicted below:

Domiasiat: (N25°33' 82.3" ; E91°22' 28.8")

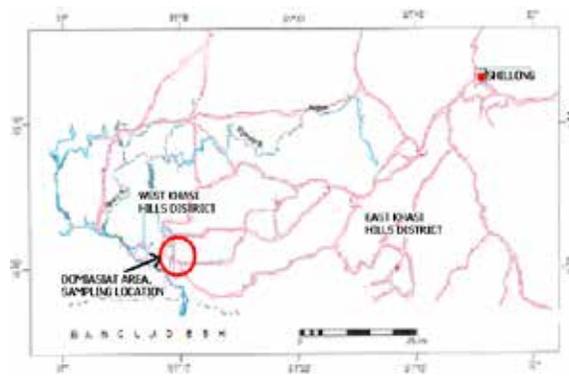
Nongbahjynrin: (N25°31' 84.9" ; E91°20' 18.9")

Nongtynger: (N25°20' 36.3" ; E91° 12' 05.4")

Mawthabah: (N25°31' 11.1" ; E91°19' 60.3")

The location of the Domiasiat area in the West Khasi Hills District of Meghalaya, India is depicted in Fig-1.

Fig 1: Map depicting the location of the Domiasiat Area in West Khasi Hills District of Meghalaya



Materials and Methods:

Whole meal (Duplicate diet) that was collected from the 4 villages was weighed and homogenized using a mixer blender and then dried in an oven at 110°C. This is then ash in a muffle furnace at 450°C, cooled and again weighed.

Doubly sealed Polyethylene capsules filled with 50mg of powder homogenized samples and standard reference materials (named mixed Polish herbs, INCT-MPH- 2) prepared in the same way were placed in a standard irradiation can simultaneously irradiated for 7hours in the Apsara research reactor facility in Bhabha Atomic Research Centre (BARC), Mumbai, India. The samples were exposed under a neutron flux of $10^{12} \text{ n.cm}^{-2} \cdot \text{s}^{-1}$.

After providing necessary cooling time, polythene pouches containing the samples and the comparator were washed under running tap water, wiped and mounted on the standard Perspex plates. Samples were assayed for Gamma activity of the activation product using emitted from the irradiated samples and the standards were counted for 3 hours each. The counting system

consists of a γ -spectrometer with a High Purity Germanium (HPGe) detector 20% relative efficiency coupled to a PC based 8K channel analyzer in an efficiency calibrated position with reproducibility sample to detector geometry.

Calculation:

$$\text{Rate of formation, } R_f = \frac{\phi \cdot \sigma \cdot N_0 \cdot F \cdot A}{m}$$

where ϕ is the neutron flux, m and A are the mass and atomic weight of the trace element in the sample, respectively; F is the fractional isotopic abundance of the target nuclide, σ is the reaction cross section, and N_0 is the Avogadro's number.

Amount of trace elements,

$$m = \frac{A \cdot D(t)}{\phi \cdot \sigma \cdot F \cdot \epsilon \cdot \gamma \cdot (1 - e^{-\lambda t_i}) (1 - e^{-\lambda t_c}) (1 - e^{-\lambda t_m})}$$

where $D(t)$ is the disintegration rate of the radionuclide in the sample, γ is the intensity of E_γ line related to the trace element, ϵ is the full energy peak detector efficiency at energy E_γ . t_i , t_c and t_m are the irradiation, cooling and measuring time periods, respectively, in seconds.

Table 1: Data for irradiation, decay and counting times for NAA

Irradiation time in hours	Decay time in months	Counting time in hours	Element determined
7	1	3	Fe, Zn, Co, Ni, Th and U.

Table 2: Minimum Detection limit for the analysis of Fe, Zn, Co, Ni, Th and U using NAA

Fe (ppm)	Zn (ppm)	Co (ppm)	Ni (ppm)	Th (ppb)	U (ppb)
1	0.15	2	0.1	0.05	0.05

Results and Discussion:

Using Neutron Activation Analysis technique, the concentration of the selected elements in the food samples was analysed and determined. The intake of different elements by the adult population residing in the four selected villages in and around the Domiasiat uranium mineralization zone was assessed by the distribution of these elements in processed whole meal. Average consumption of vegetarian meal was computed to be 500g/meal. For consumption of elements from processed whole meal, two meals per day (lunch and dinner) were considered excluding breakfast and other components of consumable items.

From the consumption database of processed whole meal, boiled rice was common in every house surveyed. Depending on the income and availability, either pulses or vegetables (mixed) were accompanied by boiled rice in processed whole meal. The mean concentration with standard deviation of Fe, Co, Ni, Zn, Th and U in processed whole meal is presented in Table 3(a&b). It can be seen that the values of Fe was highest in Mawthabah ($43 \pm 3.7 \mu\text{g/g}$) and lowest at Nongbahjynrin ($10 \pm 0.2 \mu\text{g/g}$). Co concentration was highest in Nongtynger ($0.03 \pm 0.002 \mu\text{g/g}$) and the lowest value of ($0.01 \pm 0.001 \mu\text{g/g}$) was observed in all the other three locations. Zn highest concentration was observed in Nongtynger ($19 \pm 1.5 \mu\text{g/g}$) and lowest at Nongbahjynrin ($8 \pm 0.1 \mu\text{g/g}$) and for Ni the highest was found out be from Domiasiat

($1.2 \pm 3.5 \mu\text{g/g}$) and lowest in Nongbahjynrin ($0.1 \pm 0.001 \mu\text{g/g}$). Th and U concentrations were found to be maximum from Mawthabah village with mean values of $30 \pm 1.3 \mu\text{g/Kg}$ and $39 \pm 2.8 \mu\text{g/Kg}$ respectively with concentration below the detection limit of $<0.05 \mu\text{g/Kg}$ observed from Nongtynger and Domiasiat respectively.

From Table 4 (a&b), the intake values of almost all the trace metals were found to be less than the World Health Organisation and ICRP prescribe values (WHO, 1996 and ICRP, 1994). However, as evident from Table 3, the concentration of the different trace elements varies with location. The concentration of Th and U in the food samples also varies with location and U concentration was found to be higher than Th except for Domiasiat village where U concentration was very low and was below the detection limit of the instrument. This is in accordance with the reported presence of the uranium deposit in selected areas.

Table 3(a): Mean Concentration of Fe, Co and Zn in whole meal samples from different villages

Location	Ni ($\mu\text{g/g}$)	Th ($\mu\text{g/Kg}$)	U ($\mu\text{g/Kg}$)
Domiasiat	1.2 ± 0.1	10 ± 2.1	<0.05
Nongbahjynrin	0.01 ± 0.001	4.8 ± 0.5	17 ± 1.8
Mawthabah	0.4 ± 0.02	30 ± 1.3	39 ± 2.8
Nongtynger	0.05 ± 0.002	<0.05	14 ± 2.0

Table 3(b): Mean Concentration of Ni, Th and U in whole meal samples from different villages

Location	Fe ($\mu\text{g/g}$)	Co ($\mu\text{g/g}$)	Zn ($\mu\text{g/g}$)
Domiasiat	20 ± 3.5	0.01 ± 0.001	7.8 ± 0.6
Nongbahjynrin	10 ± 0.2	0.01 ± 0.001	8 ± 0.1
Mawthabah	43 ± 3.7	0.01 ± 0.001	18 ± 0.9
Nongtynger	20 ± 1.3	0.03 ± 0.002	19 ± 1.5

Table 4(a): Daily intake estimate of Fe, Co and Zn $\mu\text{g/day}$ for an adult from the four different villages

Location	Fe	Co	Zn
	(mg/ Day)	(mg/ Day)	(mg/ Day)
Domiasiat	13.3	0.1	5.2
Nongbahjynrin	6.7	0.1	5.3
Mawthabah	28.7	0.1	12.0
Nongtynger	13.3	0.1	12.7
WHO / ICRP* limit	48	0.3	30

Table 4(b): Daily intake estimate of Ni, Th and U $\mu\text{g/day}$ for an adult from the four different villages

Location	Ni	Th	U
	(mg/ Day)	(μg / Day)	(μg / Day)
Domiasiat	0.8	6.7	<0.05
Nongbahjynrin	0.01	3.2	11.3
Mawthabah	0.3	20.0	26.0
Nongtynger	0.01	<0.05	9.3
WHO / ICRP* limit	300	3*	-

Conclusion:

The study of the concentration of elements in composite food samples is important from the point of view of nutritional, radiation protection and health related studies. The study becomes more relevant in and around the proposed uranium mining site as intake of radioactive analogues of stable elements can be modeled and assessed using this data. The concentration of the different elements in the food samples was found to be below the IAEA and ICRP reference value (ICRP, 1994) in almost all four locations. But, no matter how low the concentration is, if radioisotopes and radioactive analogues of stable metal are present, then that elements can be regarded as a potential threat to the health of an individual from radioactivity point of view. It can be regarded as toxic and can induce a negative effect to an individual. With respect to uranium and thorium the diet of the inhabitants of the four villages is observed to be rich in these isotopes, which is a matter of great concern for the inhabitants of these villages.

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