Analysis of internal exposure associated with consumption of crops and groundwater from the high background radiation area of Mrima hill, Kenya

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INTRODUCTION

- Mrima Hill is located in Kwale county, costal region of Kenya

Fig 1: Mrima hill

- High background radiation area
  - Mainly ^{232}Th series (Patel, 1991)
- Mean ^{232}Th and ^{238}U concentration of 500 Bq/kg and 207 Bq/kg respectively is documented (Kebwaro *et al*., 2011)

- Lower slopes of hill, surrounding inhabited.
- Villagers mainly depend on small-scale farming for subsistence.

Fig. 2: Mrima hill settlement

Fig. 2: Kids at an open well with cassava crop in the background

- Grow mainly the cassava;
  - Tubers mainly consumed as snacks.
  - Leaves serve as vegetables.
- Use groundwater for drinking.

- The way of life of Mrima hill residents predisposes them to the risk of radiation exposure through ingestion.
- The objective of this research was to:
  - Determine the concentration of ^{226}Ra, ^{232}Th and ^{40}K in cassava and groundwater samples
  - Evaluated the effective dose due to cassava and ground water consumption

MATERIALS AND METHODS

Cassava sampling and preparation

- Cassava tubers and their leaves were collected from 7 farms around Mrima hill.
- 3 samples were collected from each farm, combined to form a single representative sample.
- The tubers were peeled and cut in to cubes, and together with the leaves dried to a constant weight.
- The samples were ground so as to pass through a 2-mm mesh-sieve.
- A portion of each sample was packed in standard 250 ml container and stored for 21 days before analysis.

Groundwater sampling and preparation

- Groundwater sampling was carried out during the dry season.

- Samples were collected from 8 randomly selected wells in the region using 500 ml recycled PVC bottles.
- As a preservative measure, the samples were acidified after collection using concentrated nitric acid to a pH of less than two.
- A portion of each sample was filled in a 250 ml PVC container and likewise stored for at least 21 days before analysis.

Spectral analysis

- Spectral analysis of cassava and groundwater samples was done using HPGe detectors coupled with MCA.
- The HPGe detector was calibrated using standard reference materials.
- ^{226}Ra and ^{232}Th were evaluated based on gamma energies emitted by their short-lived progeny and ^{40}K on gamma energy 1460 keV.
- The specific concentrations were calculated from the equation;

$$c_i = \frac{N_i}{b_i \varepsilon_i m_i t_i} \qquad (1)$$

Where N_i is the average net intensity of the gamma rays interest, b_i the emission probability of the gamma rays of interest, ε_i the detection efficiency of the gamma lines of interest, m_i the mass of the sample in kg and t_i the measurement time in seconds

Effective dose evaluation

- The risk imposed on an individual's health due to ingestion was evaluated using the relation:

$$E = q\sum(C_i F_i) \quad (2)$$

where is the content of radionuclide and its corresponding dose coefficient taken as for 226Ra, for 232Th and for 40K for adult members of the public; q is the annual ingested quantity of food/water.

- Effective dose was calculated based on the assumption that an average person in Mrima hill consumes (Kiome, 2009; Karuri, 2001)
  - 90 kg of cassava tubers yearly
  - 25 kg of cassava leaves annually
  - 2 liters of water daily

RESULTS AND DISCUSSION

Cassava samples

- ^{226}Ra
  - Highest conc. in tubes was 130 Bq/kg, average 60 Bq/kg.
  - Higher ^{226}Ra in leaves, maximum of 235 Bq/kg, av. of 142 Bq/kg.
- ^{232}Th
  - present in 2 tuber-samples, at 145 Bq/kg and 102 Bq/kg
- ^{40}K detected in all samples, higher values in leaves.
- Highest dose due cassava leaves, average 3.8 mSv/y. .
- Av. In tubers, 2.4 mSv/y.

Table 1: ^{26}Ra, ^{232}Th and ^{40}K conc. (Bq/kg) in cassava

Samples	^{226}Ra		^{232}Th	^{40}K	
	Tubers	Leaves	Tubers	Tubers	Leaves
S1	130	143	<5	915	1808
S2	44.5	139	<5	470	2202
S3	76	<5	<5	864	983
S4	<5	183	<5	942	2603
S5	78.3	108	145	1860	1278
S6	91.8	184	102	145	1460
S7	<5	235	<5	576	1624

Table 2: Effective dose (mSv/y) due to in cassava

Exposure pathway	Average	Maximum
Leaves	3.8	6.2
Tubers	2.4	5.2

Groundwater samples

- ^{226}Ra was detected in only 3 samples, highest 13.2 Bq/l, average 4.3 Bq/l.
- ^{232}Th was detected in only one sample, 15.8 Bq/l.
- ^{40}K detected in all samples,
  - minimum 45 Bq/l, max 131 Bq/l,
  - average 91 Bq/l.
- Dose due to groundwater higher than WHO limit of 0.1 msv/y.
- For a combined cassava tubers, leaves and groundwater, total effective dose is 7.9 mSv/y.
  - Nearly 80 times the prescribed limit.

Table 3: ^{26}Ra, ^{232}Th and ^{40}K concentration (Bq/l) in groundwater

Sample	^{226}Ra	^{232}Th	^{40}K
S1	11.9	<5	45
S2	13.2	<5	70.7
S3	<5	<5	86.6
S4	<5	<5	107
S5	<5	<5	112
S6	9.02	<5	104
S7	<5	<5	75.1
S8	<5	15.8	131

Table 4: Effective dose (mSv/y) due to in groundwater

Exposure pathway	Average	Maximum
Groundwater	1.7	3.3

CONCLUSION

- There exists significant radiation exposure due to ingested radionuclides in Mrima hill region.

RECOMMENDATION

- There is need to investigate the effect of the high exposure on the health of Mrima hill residents.
- More research is needed to establish largest contributor to radioactivity in food and water: natural sources vis-a-vis farm inputs to radioactivity in cassava/groundwater.

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Thank you for your attention