Activity Concentration in Cassava Tubers Grown In Ebedei Community, an Oil Producing Area of Delta State, Nigeria

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Abstract: Exploration and exploitation of crude oil and other human activities is known to technologically enhance the naturally occurring radionuclides in an area. This study is aimed to determine the activity concentration in cassava and estimate annual effective dose due to the consumption of these tubers by the populace. The activity concentration of potassium –40, Radium-226 and thorium – 232 in six samples from the study area have been measured using a hyper pure germanium (HpGe) detector system. The radioactive concentration of the samples ranges from 370.62 ± 15.3 Bq/kg for potassium – 40, 2.32 ± 0.8 - 8.90 ± 1.9 Bq/kg for thorium-232 and 1.68 ± 1.1- 10.40 ± 3.2 Bq/kg for Radium- 226. Estimated annual effective dose were also determined for each sample. Overall, the results are within the range of internationally recommended limits and no significant radiological hazard was found. The results of this study may be considered as the baseline levels of radioactivity in foodstuffs in these areas to check future activities.

Keywords: Annual effective dose, cassava, food crop, oil producing community, radioactivity

1. Introduction

Radiation is a natural part of the environment in which we live. All people receive exposure from naturally occurring radioactivity in soil, water, air and food. The greatest natural radiation exposure we receive comes from a radioactive radon gas. Radon (222Rn) is emitted from uranium, a naturally occurring mineral in rocks and soil; thus, radon is present virtually everywhere in the air over the earth [1, 2]. These radionuclides in the natural environment find their way into the human body majorly through food and water. The most predominant naturally occurring radionuclides in foodstuffs is 40K. Other contributions to the radio-nuclides in foods include deposited fallouts from fission and activation products released during nuclear accidents and constituents of weapons tests released after detonation [3]. It is a known fact that the status of the soil on which food crops are grown determines, to a great extent, the quality of foodstuffs produced [4]. Terrestrial radiation level varies from one geographical location to another depending upon the variation of radionuclide concentration in soil which is a function of the local geology [5, 6, 7]. As, plant uptake of radiation varies from species to species and also from place to place; hence the intake of different food products forms a secondary source of variability in radionuclides concentration ingestion. 238U, 232Th and 40K are three long-lived naturally occurring radionuclides present in the earth crust [8]. Naturally occurring radionuclides of 232Th and 238U have significant contributions in the ingestion dose and are present in the biotic system of plants, animals, soil, water and air. Distribution of radionuclides in different parts of the plant depends on the chemical characteristics and several parameters of the plants and soil [9]. Inhalation and ingestion are the main pathways through which natural radionuclides enter into the human body.

Tawalbeh et al [10], opined that ingested radionuclides could be concentrated in certain parts of the body. For example, Chemical uranium toxicity primarily affects the kidney, causing damage to the proximal tubule, while this metal has also been identified as a potential reproductive toxicant [11], 232Th causes effect in lungs, liver and skeleton tissues and 40K in muscles. Depositions of large quantities of these radionuclides in particular organs will affect the health condition of the man such as weakening the immune system, induce various types of diseases, and finally increase in mortality rate [10].

A study by Akpabio and Ituen [12] attempted to measure the radioactivity level in roots grown in the coastal and hinterlands of the oil producing areas of Akwa Ibom state, Nigeria. The study reported the highest radioactivity level in yam and cassava samples. This may be due to oil activity happenings in the area.

Addo et al [13] investigated natural radioactivity ingestion from cassava grown and consumed by inhabitants around a cement factory in Ghana. The study revealed an annual effective dose of 1.23mSv/y which is above the annual dose limit set by the International Convention for Radiological Protection (ICRP) for the general public, indicating a human health risk for the cassava consuming population in the study area. This study was therefore meant to assess radioactivity concentration in cassava in the oil producing community of Ebedei and make relevant recommendations to farmers, the cassava consuming populace and government agencies.

2. Materials and methods

2.1 The Study Area

The study area situated in two local government areas of Delta State namely: Ukwani local government area (Ebedei...
an oil producing community) and Aniocha South local
government area (Ubulu Ukwu a non oil producing
community). The people in the study area are predominantly
farmers. They are well known for their farming prowess
producing yam, cassava, melon, maize, tomatoes plantain and
oil palm plantations. The study area lies within the Niger Delta sedimentary basin which is characterized by both
Marine and mixed continental quaternary sediments that are
composed of abandoned beach ridges and mangrove swamps
[14]. The area experience wet and dry season which are
typical seasons in Nigeria [14,15,16].

2.2 Samples Collection and Preparation
Twelve samples of cassava tubers were collected from farms
around a flow station at Ebedei, where there is constant gas
flaring activity and cassava farms in Ubulu Ukwu community
where there is no oil activity. Samples from Ubulu Ukwu
served as control. At Ebedei two sampling locations around
the flow station were selected and three samples were
collected from each location. Six samples were also collected
from two different sampling sites in Ubulu Ukwu community.
All samples were sliced into bits, sun dried and then oven
dried at 80°C until a constant weight is reached. Each sample
was crushed and sieved using sieve mesh (2mm) and kept in
Marinelli container that has been washed, rinsed with dilute
HCL and dried previously. The crushing and sieving was
crucial for achieving homogeneous state of the sample [17].
The Marinelli containers and contents were hermetically
sealed for at least 28 days to allow a sufficient time for
radioactive contamination. To ensure some level of accuracy of results the background was subtracted from the measured spectra of each sample before calculating the activity concentrations. The mass of cassava sample of used ranged between 75 and 200g [18]. The activity concentrations were obtained using the expression [19]:

\[
C(Bq/kg^{-1}) = \frac{\sum n \epsilon p m}{C_n}
\]

Where C is the activity concentration of the radionuclide in
the sample, C is the count rate under each photopeak due to
each radionuclide, \( \epsilon \) is the detector efficiency of the specific
gamma ray, \( p \) is the absolute transition probability of the
specific gamma ray and \( m \) is the mass (dry weight in kg) of
the sample.

2.3 Determination of Radioactivity in Samples
Gamma-ray spectrometer equipment is used. The gamma
spectrometry system was equipped with a High purity
germanium (HPGe) detector Model GR 2518-7500L
(Canberra Industries Inc.) coupled to a computer based
PCA-MR 8192 MCA mounted in a cylindrical 100 mm thick
lead shield and an internal volume of approximately 88.50
L. The detector is cooled by liquid nitrogen from
vertically dipstick cryostat dipped in 35 L liquid
nitrogen Dewar. The detector has a relative efficiency of
25% to NaI detector, 1.8 keV energy resolution at the
energy peak of 1333 keV of \(^{60}\)Co isotope, and a peak-to-
Compton ratio of 55:1. The radionuclides were identified
using gamma-ray spectrum analysis software, ORTEC
MAESTRO-32.

The resolution of the HPGe detector made it possible to
identify a large number of gamma–rays in the samples The
photopeaks observed with regularity in the samples were
identified as belonging to the radioactive decay series of \(^{238}\)U
and \(^{232}\)Th and non-series radionuclides \(^{40}\)K and \(^{137}\)Cs. In some
samples \(^{137}\)Cs radionuclide appeared at low levels, or
occurred at levels below the detectable limit (BDL). All the
measurements were each carried out in a time of 36,000 s and
same geometry was used to determine peak area of samples
and references. The specific radio-activities of \(^{40}\)K and \(^{137}\)Cs
were determined directly by their gamma –lines of energies
1460.8 and 661.3 keV respectively while that of \(^{228}\)Ra and
\(^{232}\)Th were estimated by taking the mean of specific radio-
activities obtained from the gamma –ray lines of energies
609.3 and 1120.3 keV of \(^{228}\)Bi; for \(^{238}\)U and 969.0 keV of
\(^{228}\)Ac and 583.0 keV of \(^{208}\)Tl for \(^{228}\)Th [3]. The gamma – ray
background inside the shield was determined using an empty
container the same measurement conditions. To ensure some
level of accuracy of results the background was subtracted from the measured spectra of each sample before calculating the activity concentrations. The mass of cassava sample of used ranged between 75 and 200g [18]. The activity concentrations were obtained using the expression [19]:

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Where C is the activity concentration of the radionuclide in
the sample, C is the count rate under each photopeak due to
each radionuclide, \( \epsilon \) is the detector efficiency of the specific
gamma ray, \( p \) is the absolute transition probability of the
specific gamma ray and \( m \) is the mass (dry weight in kg) of
the sample.

3. Results and Discussion
Table1 presents the results of activity concentrations in the
samples analyzed. The activity concentration of \(^{40}\)K in
cassava samples are relatively high and compared very well
with results obtained elsewhere within the region. The
highest value of 370.62 ± 15.3 Bq/kg and 128.87 ± 8.3 Bq/kg
in cassava samples from Ebedei1 and Ubulu ukwu1 respectively were registered for \(^{40}\)K. The high concentration
of \(^{40}\)K in cassava may be due to the use of fertilizers by
farmers in the area. Also it has been reported that the major
bedrocks in the study area are known to accumulate naturally
occurring radioactive material may probably be responsible
for the high activity of \(^{40}\)K in samples both at the study area
and the control area (Ubulu Ukwu) where there are no oil
activities [20]. The activity concentration for
232Th are slightly higher than that from 226Ra. The cassava tubers are usually big and long penetrating into the soil with increased ability to absorb more radionuclides [3]. 226Ra activity ranged from 1.68 ± 1.1 - 10.40 ± 3.2 Bq/kg while 232Th values were within the range of 2.32 ± 0.8 - 8.90 ± 1.9 Bq/kg. The activity levels detected, although relatively high, are within the internationally accepted range and comparable with those reported in other parts of Nigeria [18].

### Annual Effective Dose from Ingestion of Cassava Samples

The effective dose $E$ (Sv per year) due to intake of a radionuclide with the ingested material is calculated using the following expression [21]:

$$ E = \sum C_i \times DCF_i \times A $$

Where $A$ (kg/yr) is mean annual consumption of foodstuff; $C_i$ (Bq/kg) is activity concentration of radionuclide $i$ in the ingested material; and $DCF_i$ (Sv/Bq) is dose coefficients for radionuclide $i$. In summing over $i$ which should include all the radionuclides present in the ingested material, but only, 232Th, 226Ra, and 40K, were considered, and the corresponding dose coefficients are 2.8 E-07, 0.23 E-07 and 0.06 E-07 Sv/Bq, respectively [22]. The mean consumption of cassava per capita is 115.46kg/year in Nigeria [23]. Using these conversion factors in equation (2), the effective doses due to ingestion were estimated in the various samples. The result of this computation is in column five of Table 1. The average annual effective dose from ingestion of cassava was 0.45 and 0.31mSv/y for the study area and control site respectively. The annual effective dose values registered in the study area were higher than those of the control site; this may probably be due to the activities of petroleum exploration in the area [12]. These values are below the annual dose limit of 1mSv/y for the general public.

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### Table 1: Results of activity concentration in cassava samples

| Sample location | Sample code | 40K (Bq/kg) | 232Th (Bq/kg) | 226Ra (Bq/kg) | Annual Effective Dose (mSv/y) |
|-----------------|-------------|------------|--------------|--------------|-------------------------------|
| Ebedei 1        | E1          | 324.01 ± 18.3 | 5.56 ± 2.3  | 9.01 ± 3.0  | 0.35                          |
|                 | E2          | 201.34 ± 14.2 | 12.84 ± 3.5 | 8.34 ± 2.5  | 0.37                          |
|                 | E3          | 128.87 ± 8.3  | 16.78 ± 3.1 | 10.40 ± 3.2 | 0.47                          |
| Ebedei 2        | E4          | 192.66 ± 10.4 | 6.12 ± 2.4  | 7.56 ± 2.2  | 0.39                          |
|                 | E5          | 180.45 ± 5.2  | 18.03 ± 4.2 | 6.02 ± 2.1  | 0.37                          |
|                 | E6          | 243.54 ± 7.0  | 8.90 ± 1.9  | 9.23 ± 2.7  | 0.49                          |
| Ubulu Ukwu1     | U1          | 345.60 ± 9.7  | 4.62 ± 2.0  | 2.46 ± 1.5  | 0.33                          |
|                 | U2          | 300.23 ± 12.5 | 6.24 ± 3.2  | 4.71 ± 2.1  | 0.38                          |
|                 | U3          | 370.62 ± 15.3 | 5.21 ± 2.2  | 3.21 ± 1.3  | 0.37                          |
| Ubulu Ukwu2     | U4          | 256.88 ± 17.5 | 3.54 ± 1.9  | BDL          |                                |
|                 | U5          | 290.01 ± 12.2 | 2.32 ± 0.8  | 1.68 ± 1.1  | 0.26                          |
|                 | U6          | 351.42 ± 13.9 | 4.12 ± 2.1  | 1.98 ± 1.3  | 0.32                          |
| Average         |             | 211.81 ± 10.6 | 11.37 ± 2.9 | 8.43 ± 2.6  | 0.45                          |
| Average (control)|          | 319.13 ± 13.5 | 4.34 ± 2.0  | 2.34 ± 1.2  | 0.31                          |

BDL = below detection limit

This study reveals high radioactivity concentration in the study area and control, in all samples and the activity was primarily from 40K. The values of 232Th were slightly higher than that 226Ra in all studied samples and were comparable with values observed in Jos- Plateau. Also the estimated annual effective dose from the ingestion of cassava were below permissible limits and seen not to pose any serious internal health problem due to ingestion by individuals in the study area. However, a community based sensitization of the people on the issues of environmental contamination and its health implication is recommended for relevant regulatory agencies.

### 4. Conclusion and Recommendations

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