THE RADIOACTIVITY IN SOME GRASSES IN THE ENVIRONMENT OF NUCLEAR RESEARCH FACILITIES LOCATED WITHIN THE OAU, ILE-IFE, NIGERIA

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Abstract

Measurements of the radionuclide contents of some grasses in the environment of nuclear research facilities located within the Obafemi Awolowo University (OAU) campus, Ile-Ife, Nigeria have been undertaken. The grasses consisted mainly of those that are consumed by stock animals. They include; giant star grass (cynodon plectostachum), centro (centrosema pubescens) gliricidia (gliricidia sepium), leucaena (leucaena leucocephala), guinea grass (panicum maximum) siam's weed (chromolaena odorata) and elephant grass (penisetum purpureum). The measurements were carried out by means of gamma spectrometry using a well-shielded and well-calibrated HPGe detector located at the environmental radiation measurements laboratory at the Department of Physics, OAU, Ile-Ife. The results obtained in this work showed that the radionuclides detected in the vegetation belong to the natural radionuclide series headed by ^{226}Ra and ^{228}Ra as well as the singly-occurring natural radionuclide ^{40}K. The vegetation sample centrosema pubescens recorded the least content of ^{226}Ra (3.01 Bq kg^{-1}) while leucaena recorded the highest content of ^{226}Ra (15.41 Bq kg^{-1}) but this radionuclide was not detectable in giant star grass. Radium-228 was only detectable in guinea grass, siam's weed and elephant grass while giant star grass recorded the highest content of ^{40}K (86.50 Bq kg^{-1}) and elephant grass recorded the least content of ^{40}K (54.45 Bq kg^{-1}).

Key words: Nuclear research facilities, grasses, radionuclide.

Introduction

Radiation reaches man's tissue in two ways: from sources outside his body (external exposure) and from radioactive substances contained in the food or water which he consumes or in the air he breathes (internal exposure) (Larmash, 1983). The major part of the radioactive materials which enter the body are usually contained in foodstuffs reaching it mainly through complex biological mechanisms or food chains, an example of which is illustrated in Fig 1 for natural sources. And contamination of the terrestrial food chain with radionuclides is normally considered for human radiation dose assessments. The Earth's surface has been contaminated by nuclear fallout produced by atmospheric test explosions since 1954 (Lowe, 1978). Some of such explosions were carried out in the 1960's in the Sahara desert close to Northern Nigeria and they have resulted in the presence of fission products; in particular ^{137}Cs in some soil samples analysed by Olomo et al. (1994).

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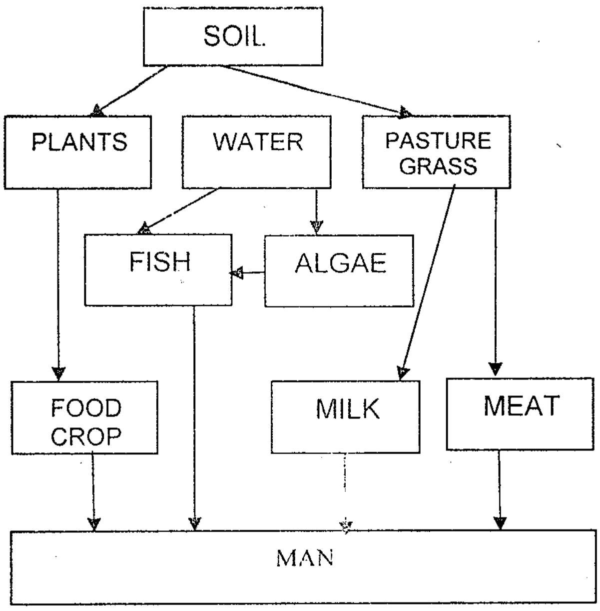

Fig. 1: Food chain from soil to man from natural radiation sources

All radioactive materials which are present in the environment may enter foodstuffs to an extent which depends on their chemical and physical characteristics and on the sites at which they are introduced into the environment (Pentreath, 1980; NCRP, 1985).

The environmental fields are made up of soil, surface and underground water, sediments and vegetation, and these constitute the immediate pathways, leading to the contamination of food. Vegetation samples usually consist of the leafy or above ground portions of vegetation. The radionuclide contents of vegetation thus arise from natural sources through transfer from the soil and from fallout from thermonuclear explosions via direct deposition on the leaves (NCRP, 1985).

Vegetation such as forage is one of the pathways of radionuclide to man through meat and or milk. Therefore, the radionuclide content of vegetation can provide a basis for deciding whether cattle, sheep, goat, etc. can be permitted to graze in a given area. They could also constitute a source of external outdoor radiation exposure of man.
In this work the radionuclide contents of some grasses in the environment of nuclear research facilities in the Obafemi Awolowo University (OAU), Ile-Ife campus were determined.

The OAU, Ile-Ife has been identified as a nuclear site as it plays host to two nuclear research laboratories (Akinloye and Olomo, 1995). These laboratories house nuclear research facilities which have tendencies to release radioactive effluents to the environment during normal operations and at a higher level in emergency situations. The radionuclide contents of other environmental fields such as soil, surface water and sediments in the OAU environment have been measured (Olomo et al., 1994; Akinloye and Olomo, 2002). Measurements of the radionuclide contents of some common food samples as well as poultry and meat obtained from the environment have also been undertaken (Akinloye and Olomo, 2002; Akinloye et al., 1999; Olomo, 1990). The data in vegetation obtained from the present work would further contribute to the existing data on radioactivity levels of the various sources (i.e. food and environmental) in the OAU environment.

Sampling

The study was conducted over the entire environment of the OAU which covers a total field area of 28 km^2. Within the study site, thirteen sampling locations were selected as shown in Fig. 2. Our choice of sampling locations was based on the various exposure pathways leading to exposure of the local inhabitants. Some of the measurement sites were located near populated areas (NCRP, 1985) since the dose to man is the quantity of interest (NCRP, 1985; Akinloye and Olomo, 1995). The locations shown in Fig. 2 are as listed in Table 1. Locations 1 and 7 are the CERD and DOP which host the nuclear research facilities, and they constitute sources of ionizing radiation to be released into their immediate physical environment, and through which man could be exposed. Locations 4, 9, 10 and 13 represent the food and water sources whose radionuclide contamination can represent a direct route of exposure of the local inhabitants. Locations 3, 5, 6, 8, 11 and 12 are residential and recreational areas where there are multitudes of people for at least 18h daily. Location 2 is the religious ground which also includes agricultural farmlands in the vicinity of CERD (Olomo, 1990).

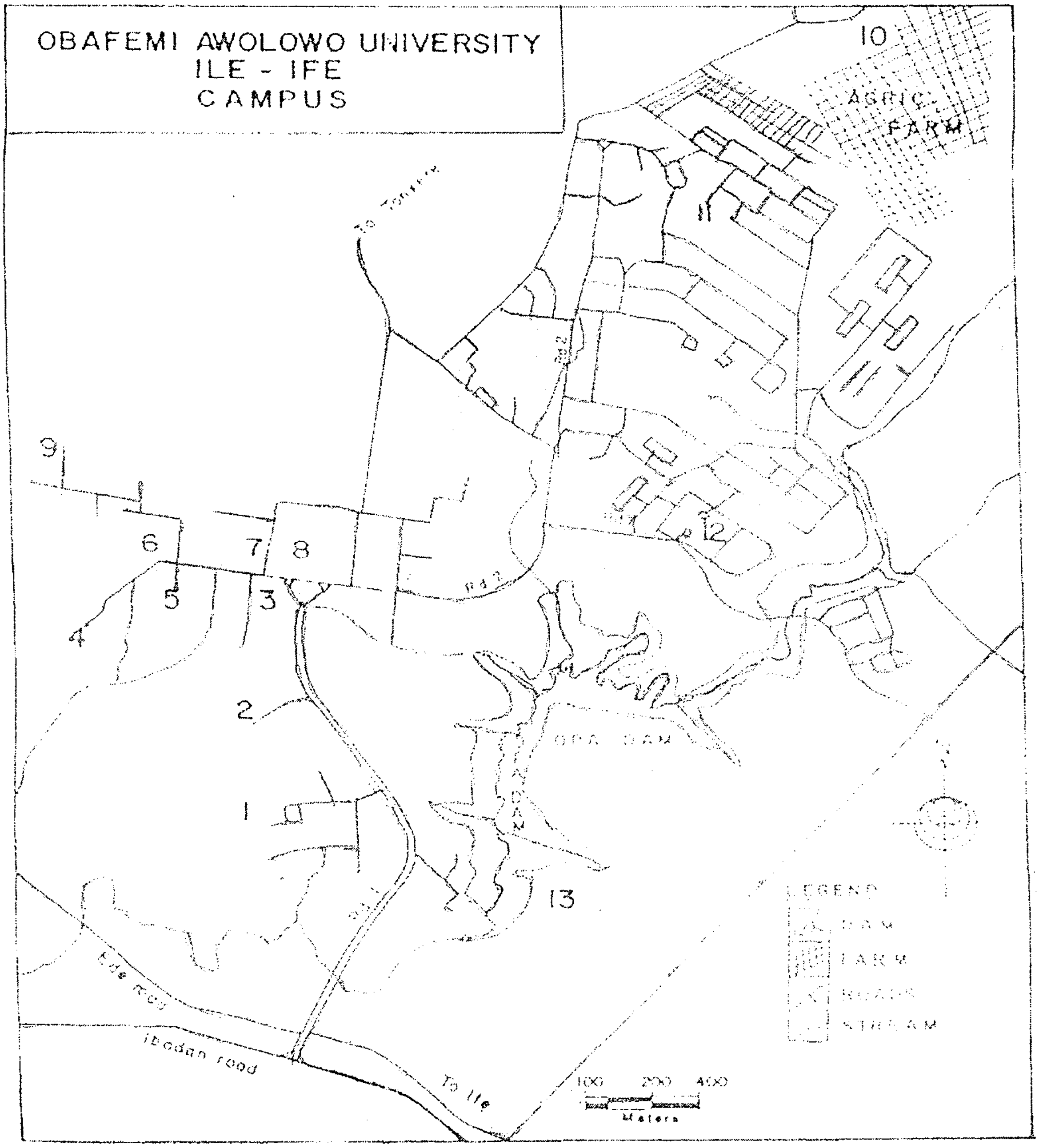

Fig. 2: The campus of Obafemi Awolowo University, Ile-Ife.

Materials and Methods

The vegetation samples analysed in this work consisted mainly of those that are consumed by stock animals. The samples consisted of giant star grass (*cynodon plectostachum*), centro (*centrosema pubescens*), gliricidia (*gliricidia sepium*) leucaena (*leucaena leucocephala*) guinea grass (*panicum maximum*) siam's weed (*chromolaena odorata*) and elephant grass (*penisetum purpureum*). The vegetation samples were obtained from all the locations within the study site (see Table 1).

Table 1: Sampling locations

Serial number	Sampling location
1	CENTRE FOR ENERGY RESEARCH AND DEVELOPMENT (CERD)
2	RELIGIOUS CENTRE
3	STUDENTS' UNION BUILDING
4	NEW BUKATERIA
5	FAJUYI HALL
6	HEALTH CENTRE
7	DEPARTMENT OF PHYSICS (DOP)
8	ODUDUWA HALL
9	COMMERCIAL FARM
10	TEACHING AND RESEARCH FARM
11	ROAD 22B IN OAU STAFF QUARTERS
12	ROAD 7B IN OAU STAFF QUARTERS
13	OPA DAM

Each vegetation type while being collected was cut within a height of about 50 mm from ground level in order to simulate the height at which grazing takes place. Large quantities of each vegetation type were dried in an oven at a temperature of 378 K to constant weight. The dried vegetation samples were ground to smaller particle size to pass through a 2-mm sieve. The sieved samples were then tightly sealed in 1-l Marinelli beakers and left for 28 d to attain a state of secular equilibrium (Cember, 1983). Three samples were formed from each vegetation type, thus a total of 21 samples were prepared from the 7 vegetation types. The dry weight of the samples ranged from 0.122 to 0.320 kg.

Having attained secular equilibrium the sealed samples were each counted in a well-shielded and accurately calibrated HPGe detector for 36,000s. An empty Marinelli beaker under identical geometry was also counted for the same time as the sample i.e. 36,000 s. Analyses of the spectra obtained from the samples were carried out as described by some authors (Akinloye et al, 1999; Akinloye and Olomo, 2000) using energy and efficiency calibration data obtained with the standard source supplied by International Atomic Energy Agency (IAEA). The photopeaks observed with some regularity in the vegetation samples were identified to belong to the natural radioactive decay series headed by ^{238}U and ^{232}Th and a third non-series natural radionuclide ^{40}K. Other radionuclides if present appeared rather infrequently and at low levels below the minimum detectable limit (MDL) statistically determined at two-standard deviation analytical error. The activity concentrations of ^{226}Ra in the ^{238}U and ^{228}Ra in the ^{232}Th were determined indirectly from gamma rays emitted by their progenies while that of ^{40}K was determined by its γ-line of 1460.8 keV. Bismuth-214 concentration was used as an indicator of ^{226}Ra concentration by using the measured concentration of the 609.3 keV γ-line. Similarly, the average of 911.2 keV γ-ray of ^{228}Ac and 583.0 keV of ^{208}Tl were used to estimate the activity concentrations of ^{228}Ra since they have similar errors. The values of energies and emission probabilities applied in this work were obtained from IAEA (1989) and NCRP (1994).

Results and Discussion

The mean specific activities determined from the measurements of the 3 samples formed from each vegetation type are as presented in Table 2. The data recorded in this work show that the radionuclides detected in the vegetation samples belong to the natural radionuclide series headed by ^{238}U and ^{232}Th and the ^{226}Ra and ^{228}Ra concentrations as well as the concentrations of the ubiquitous singly-occurring long-lived natural radionuclide ^{40}K were determined.

Table 2: Average concentrations of radionuclides in OAU grasses (Bq kg^{-1})

Vegetation type	Radionuclide			
	Concentration	^{226}Ra	^{228}Ra	^{40}K
Giant star grass	Mean	-	-	84.00±10.80
	Range	-	-	80.40 – 86.50
	Mean	3.12±1.38	-	78.83±10.42

Centro	Range	3.01 – 3.24	-	76.91 – 81.26
Gliricidia	Mean	3.45±0.58	-	69.42±13.81
	Range	3.12 – 3.48	-	65.91 – 72.61
Leucaena	Mean	14.40±1.57	-	62.50±11.01
	Range	12.51 – 15.41	-	60.41 – 65.22
Guinea grass	Mean	3.30±0.57	2.86±0.38	56.06±5.07
	Range	3.16 – 3.62	2.75 – 2.92	50.21 – 59.18
Siam's weed	Mean	10.39±1.24	3.97±0.55	75.58±19.07
	Range	10.19 – 10.95	3.74 – 4.10	72.41 – 78.61
Elephant grass	Mean	4.23±0.92	1.82±0.35	65.60±10.40
	Range	4.02 – 4.95	1.64 – 2.59	54.45 – 76.19

From these results, it is seen that ^{226}Ra and ^{228}Ra contents in giant star grass were not detectable, and that the ^{40}K concentrations in this grass range from 80.40 to 86.50 Bq kg^{-1} with a mean value of 84.00±10.80 Bq kg^{-1}. For centro, the ^{226}Ra concentrations vary between 3.01 and 3.24 Bq kg^{-1} with a mean value of 3.12±1.38 Bq kg^{-1}, the ^{228}Ra contents were not detectable in this grass type and the concentrations of ^{40}K range from 76.91 to 81.26 Bq kg^{-1} with a mean value of 78.83±16.42 Bq kg^{-1}. The ^{226}Ra contents in gliricidia range from 3.12 to 3.48 Bq kg^{-1} with a mean value of 3.45±0.58 Bq kg^{-1}, but the ^{228}Ra contents were not detectable, and the concentrations of ^{40}K range from 65.91 to 72.61 Bq kg^{-1} with a mean value of 69.42±13.81 Bq kg^{-1}. In leucaena, the radionuclide concentrations recorded for ^{226}Ra varied between 12.51 and 15.41 Bq kg^{-1}, with a mean value of 14.40±1.57 Bq kg^{-1} while the ^{228}Ra content was not detectable and the ^{40}K concentrations range from 60.41 to 65.22 Bq kg^{-1} with a mean value of 62.50±11.01 Bq kg^{-1}.

The radionuclide concentrations for guinea grass vary between 3.16 and 3.62 Bq kg^{-1} for ^{226}Ra with a mean value of 3.30±0.57 Bq kg^{-1} while the ^{228}Ra contents range from 2.75 to 2.92 Bq kg^{-1} with a mean value of 2.86±0.38 Bq kg^{-1} and the ^{40}K concentrations range from 50.21 to 59.18 Bq kg^{-1} with a mean value of 56.06±5.07 Bq kg^{-1}. The range of radionuclide concentrations recorded for siam's weed were from 10.19 to 10.95 Bq kg^{-1} with a mean while of 10.39±1.24 Bq kg^{-1} for ^{226}Ra while ^{228}Ra concentrations range from 3.74 to 4.10 Bq kg^{-1} with a mean value of 3.97±0.55 Bq kg^{-1} and ^{40}K concentrations range from 72.41 to 78.61 Bq kg^{-1} with a mean value of 75.15±19.07 Bq kg^{-1}. The concentrations of the radionuclides in elephant grass range from 4.02 to 4.95 Bq kg^{-1} with a mean value of 4.23±0.92 Bq kg^{-1} for ^{226}Ra, while the concentrations of ^{228}Ra vary between 1.64 and 2.59 Bq kg^{-1} with a mean value of 1.82±0.35 Bq kg^{-1} and those of ^{40}K range from 54.45 to 76.19 Bq kg^{-1} with a mean value of 65.60±10.40 Bq kg^{-1}.

None of the vegetation samples analysed indicated the presence of any man-made radionuclide; in particular ^{137}Cs whose presence was indicated in some of the soil samples analysed from the study site, but was found below the minimum detectable limit (MDL) (Olomo et al., 1994) did not occur in any of the vegetation samples. The reason for the presence of this radionuclide at levels below the MDL could be attributed to the fact it had gone through more than one half-life (its half-life being 30 yr) since the atmospheric tests took place in the 1960s.

The data obtained for the concentrations of ^{226}Ra and ^{228}Ra in beef and goat meat obtained from stock animals raised in this environment were found to be higher than those obtained in pork (Akinloye et al., 1999). This result could be attributed to the fact that cattle and goats are ruminants which consume all the vegetation types that were analysed in this work, but pigs are omnivorous and their feed is only supplemented by centro whose content of ^{226}Ra is the lowest of all the vegetation types. The average radionuclide concentrations obtained for both free-range and intensive poultry raised in this environment however indicated no significant difference between the ^{226}Ra and ^{40}K contents in the two poultry types (Akinloye et al., 1999).

Estimates of the daily radionuclide intakes of poultry and meat obtained from poultry and stock animals respectively raised in the study site (Akinloye et al., 1999) indicated that the daily dietary intakes of ^{226}Ra, ^{228}Ra and ^{40}K were well within the range of values obtained for normal background areas (Holtzman, 1980; Petrow et al., 1968). Also measurements of the γ-radiation exposure rate at the various locations from which the grasses were collected indicated a low-level natural radiation background area (Olomo and Akinloye, 1995).

Conclusion

In this study the radionuclide contents of some grasses obtained in the environment of nuclear research facilities located in the Obafemi Awolowo University, Ile-Ife campus have been determined. The results obtained showed that the radionuclides detected in the grasses analysed belong to the natural radionuclide series headed by ^{226}Ra and ^{228}Ra as well as the singly-occurring ubiquitous radionuclide ^{40}K. No man-made radionuclide was detected in any of the grasses even though previous measurements indicated the presence of ^{137}Cs in soil samples analysed (Olomo et al., 1994).

It is also evident from the data obtained in this work that the dominant contributor to the radionuclide contents of the grasses is ^{40}K with values ranging from 50.21-86.50 Bq kg^{-1}. The data obtained in this work would contribute to the data on radionuclide contents of the various fields in this environment.

Acknowledgements

The authors express their gratitude to the Physics Department, OAU, Ile-Ife for the use of the research facilities in the pollution laboratory and to the IAEA, Vienna, Austria who donated the counting equipment.

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