Natural Activity Concentrations and Assessment of Radiological Dose Equivalents in Medicinal Plants around Oil and Gas Facilities in Ughelli and Environs, Nigeria

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Abstract

The natural radionuclide contents in some medicinal plants commonly found around oil and gas facilities in Ughelli and nearby communities have been investigated. A class of such medicinal plants are those that are regarded as grasses and are usually taken for healing purposes. The plants investigated are lemon grass *(Cymbopogan citrates)*, Spear grass *(Imperata cylindrical)* and Carpet grass *(Eleusin indicageartin)*. The plants were assayed for their radionuclide contents by means of gamma spectrometry using a shielded and well calibrated NaI(Tl) detector coupled to a computer interfaced multichannel analyser, quantum^{Tm} MCA 2100R. Results of the analysis showed that the radionuclides detected in the grasses around the oil and gas facilities belong to the primordial radionuclide series of ^{238}U and ^{232}Th as well as non serial ^{40}K. On the average, the values for lemon grass has ^{238}U (15.3 $\pm$ 1.7 Bqkg^{-1}), ^{232}Th (1.1 $\pm$ 2.7 Bqkg^{-1}) and ^{40}K(67.9 $\pm$ 7.4 Bqkg^{-1}). In spear grass, ^{238}U (15.8 $\pm$ 2.4 Bqkg^{-1}), ^{232}Th (1.7 $\pm$ 4.3 Bqkg^{-1}) and ^{40}K(69.3 $\pm$ 9.4 Bqkg^{-1}) were determined while carpet grass recorded ^{40}K (70.2 $\pm$ 11.6 Bqkg^{-1}) with ^{238}U(16.0 $\pm$ 1.9 Bqkg^{-1}) and ^{232}Th(1.6 $\pm$ 4.2 Bqkg^{-1}). The measured levels of the radioactivity in the samples translated to very low values of the annual effective dose equivalent, implying safe level of radiological health consequences. No significant difference was determined between radionuclide contents of samples of medicinal plants around oil and gas facilities and samples of the same species of medicinal plants from an undisturbed and virgin location in Nigeria where industrial activities, waste dump nor is farming practised. However, no trace of artificial radionuclide was determined in all the samples assayed in both areas, hence, measurements can be taken as representing baseline values of the radionuclides in medicinal plants in the areas.

Keywords: Radionuclide concentration, Medicinal plants, Niger Delta, Oil and gas

1. Introduction

Human exposure to radiation in the environment is from sources that are widely used in industry, agriculture, as well as for scientific and medical purposes. Traditional medicine involving use of grasses and herbs is the most ancient method of curing diseases (Iwu, 1993). The use of plants for the treatment of various diseases is universal and its acceptance by a population largely depends on cultural factors and therefore not easily transferable form one culture to another (Akerele, 1987; Kokwaro, 1993). For more than two decades now, the World Health Organisation (WHO) has encouraged the use of traditional medicine globally by promoting the incorporation of its useful elements into national health care systems.

Africa despite significant strides made in certain areas of social and economic development, has been identified to have the potential to achieve even more if it can overcome the large burden of disease which continues to be a barrier to faster development. This ever increasing disease burden, despite good plans and strategies, calls for concern of the policy makers. This has prompted the African Union Ministers of Health to harmonize all the existing health strategies by drawing this Africa Health Strategy which Regional Economic Communities (RECs) and other regional entities and Member States can use to enrich their strategies, depending on their peculiar challenges. The strategy has however been adopted by the third session of the African Union conference of Ministers of Health. (Africa Health Strategy, 2007).

In Nigeria, there is shift of interest to the use herbal medicine for the cure of diverse diseases. Apart from the high cost of procuring available allopathic medicines for treating even common health disorders, other reasons for this shift are inaccessibility of health institutions in the rural or remote locations in the country and growing awareness of adverse reaction to some allopathic drugs. Besides, Nigeria being in the tropics, has forest that are full of cheap, easily available and sustainable medicinal plants which can be used and have always been used for the treatment of various diseases.

Following the acceptance of this alternative measures in medicine, comments on calculated dosages and hygienical condition of the drugs from this alternative method are been raised and addressed at various fora. Despite various measures to ensure compliance with the safety conditions and standards of the products, based on improper disposal or accidental discharge of waste or by-products at the location of the materials, radioactive substances of natural and artificial sources may be present in higher quantity in these raw materials. It has been reported (IAEA, 2003) that products from oil and gas facilities contain naturally occurring radioactive materials (NORM). Analyses of NORM from many different oil and gas fields have been reported (Jonkers *et al*., 1997) to include radionuclides from ^{238}U and ^{232}Th series. These natural radionuclides have been found in different production and installation parts of oil and gas facilities and have been detected and measured to be more significant than other elements of the NORM in oil and gas products (IAEA, 2003). Since, the medicinal products are mostly rubbed on the skin and ingested, the radioactive substances, if present in higher quantity may lead to both internal and external exposure of radiation to the individuals concerned, thereby leading to deleterious consequences of radiation exposure to human.

Over the years, much work on radioactive food contamination in the environment and its pathway to plants, animals and human population has been reported, (Gaso *et al.*, 2002; Akinloye & Olomo, 2000; Till & More, 1988; ICRP, 1993; Mitchell, 1974). In Nigeria, apart from medical facilities, the oil and gas sector is a major importer and most identified user of radionuclides in both upstream and downstream operations (Elegba, 1993). For example, about 150 non-destructive service companies use Iridium-192 and Cobalt-60 gamma sources. Not less than 35 nuclear well-logging service companies use Americium - Beryllium neutron sources, Cobalt-60 and caesium-137 gamma sources. Unknown number of service companies use radiotracers while thousands of tonnes of naturally occurring radioactive material (NORM) scales and sludges containing Radium- 226 and Radium-228 which are radioactive are in use in the petroleum industry in Nigeria. For over four decades of oil exploration and exploitation in Nigeria, Delta State of Nigeria has been playing host to various oil and gas facilities of major petroleum companies. The quality control centre of a prominent petroleum company (Shell petroleum) situated at Ughelli is an example.

Despite various measures to ensure safety in the application of these radionuclides, accidental discharge and improper disposal are possible means by which these radionuclides may find their way to the immediate environment. These phenomena may thereby contaminate various compartment of the environment which plants, mostly grasses are susceptible to receive large amount of the contaminants.

A survey of commonly accessible and used plants for medicinal purposes in Delta State has pointed to three types of medicinal grasses. The radio-analysis of the plants have been necessitated by the need to adequately assess the radionuclide content in the medicinal grasses following finite possibility of radionuclide in different sources and strength finding their way in to the environment and based on series of complaints of environmental pollution by the inhabitants of the communities hosting these oil and gas facilities. This work therefore aims to ascertain the level of radionuclide content in medicinal plants commonly used by people living around the oil and gas facilities, in a bid to determine the effect of oil and gas operations of these environmental samples and invariably assess the radiological health implication on human consuming the samples.

2. Materials and Methodology

Sampling of lemon grass *(Cymbopogan citrates)*, Spear grass *(Imperata cylindrical)* and Carpet grass *(Eleusin indicageartin)* was conducted around oil and gas facilities in Ughelli and neighbouring communities, Nigeria. The study areas lie within longitude 5° 56′ E and 6° 04′ E. The latitude of the area is between 5° 30′N and 5° 38′ N (Avwiri *et al*., 2007). Sampling was carried out at twenty stations studied (Table 1).

The samples were collected at locations within a distance not exceeding 1 km from oil and gas facilities. In order to ensure uniformity of sample matrix, the roots of the plants, having been uprooted, are rid of soil before drying at room temperature for a period of 30 days (Jibiri & Ajao, 2005) to constant weight. The dried samples were later pulverised, packed in a sealed container, labelled and left for 28 days to attain secular equilibrium. In all, a total of 100 samples of each type of plants were obtained in this study area.

Following the same method of collection and preparation, samples each of the same specie of medicinal plants were obtained from Ogbomoso (Fig. 1), southwestern Nigeria, which is non oil and gas producing. These samples are to serve as control. However, conscious efforts were made to ensure that the collection was done at locations not falling within a distance of 1km or less from residential area, waste dump or farming. This is in a bid to ensure that grasses are from their natural and undisturbed habitat.

The sealed samples were each assayed in a well calibrated and well shielded NaI (Tl) detector coupled to a computer resident quantum™ Multichannel analyser produced by Princeton Gamma Tech., USA, for 10 h. The NaI (Tl)detector, produced by ScintiTech Instruments, USA, has a resolution of about 6.2% for 0.662MeV of ^{137}Cs, capable of distinguishing the gamma ray energies in environmental samples. The photopeak at 1.460 MeV was used for ^{40}K measurement while 1.760 MeV peak from ^{214}Bi and peak at 2.614 MeV from ^{208}Tl were respectively used for the measurement of ^{238}U and ^{232}Th. The count rate, N_t, under each photopeak due to the radionuclides at fixed geometry and matrix of the samples was obtained after the counting time of 10 h. The radioactivity concentrations of each radionclide was calculated using the equation (IAEA, 1989; Jibiri & Ajao, 2005)

$$A_c = \frac{N_t}{\varepsilon P_\gamma M_s}$$

where A_c is the specific activity of the each radionuclide in the grass (Bq.kg^{-1}), ε is the detector efficiency of the specific γ–ray and pg the absolute transition probability of the specific γ-ray, while M_s is the mass of the sample (kg). The values of the activity concentrations in the grass samples for the areas translated to the effective dose equivalents following methods and conversion factors for ^{238}U and ^{232}Th described in Till and Moore (1988) as used by Jibiri and Ajao (2005) in a related work.

3. Results and Discussion

The concentrations of ^{40}K, ^{238}U and ^{232}Th in the samples of *Cymbopogan citrates*, *Imperata cylindrical* and *Eleusin indicageartin* around oil and gas facilities in the study areas (Ughelli and environs) and control area (Ogbomoso and environs) have been measured. The mean of the specific activities for the two regions for the species of grass is shown in table 2. The values of the radionuclide concentrations in soils of the two regions have been ealier presented in the work of Farai and Jibiri (2000) and Avwiri *et al*. (2007).

However, data obtained in this work showed that the radionuclide contents in the grass samples belong to the primordial radionuclide series of ^{238}U and ^{232}Th concentrations. Potassium-40 was obtained to have the highest concentration in all the samples assayed. From these results it is observed that the average activities in *Cymbopogan citrates* for the oil and gas facilities area range between 12.7 Bq kg^{-1} and 17.9 Bq kg^{-1} for ^{238}U; Values below detectable limit of detector (BDL) and 8.5 Bq kg^{-1} for ^{232}Th while for ^{40}K the values are between 55.3 Bq kg^{-1} and 77.4 Bq kg^{-1}. For the control area the range are 48.7 Bq kg^{-1} and 85.5 Bq kg^{-1}; 12.8 Bq kg^{-1} and 19.0 Bq kg^{-1} and BDL and 8.3 Bq kg^{-1} for ^{40}K, ^{238}U and ^{232}Th, respectively.

In *Imperata cylindrical* for Ughelli and environs, the ranges of the activities are: ^{238}U (11.3 Bq kg^{-1} and 17.9Bqkg^{-1}); ^{223}Th (BDL and 13.6Bq kg^{-1}) while 40K (55.1 Bq kg^{-1} and 85.2 Bqkg^{-1}). The range of the radionuclide concentrations in Ogbomoso and environs are (55.7 Bq kg^{-1} and 85.2 Bq kg^{-1}), (11.2 Bq kg^{-1} and 18.2 Bq kg^{-1}), (BDL and 8.3 Bq kg^{-1}) respectively for ^{40}K, ^{238}U and ^{232}Th. The *Eleusin indicageartin* in the oil and gas area recorded values of ^{40}K (55.2 Bq kg^{-1} and 77.4 Bq kg^{-1}); ^{232}Th (BDL and 13.2 Bq kg^{-1}) and for ^{238}U value are (12.3 Bq kg^{-1} and 19.1 Bq kg^{-1}).Values of the range in Ogbomoso and its environ in this specie of grass are (48.8 Bq kg^{-1} and 85.5 Bq kg^{-1}), (12.8 Bq kg^{-1} and 19.0 Bq kg^{-1}), (BDL and 12.0 Bq kg^{-1}) for ^{40}K, ^{238}U and ^{232}Th.

The difference of the radionuclide concentrations in the sample of the grasses from the two regions was statistically analysed using student's t-test statistical tool. The result of the analysis showed no significant difference in the sample from the two areas. For ^{40}K in *Cymbopogan citrates,* ($t_{calc.}$ = 0.43; $t_{tab.}$ = 1.73, n = 20). In *Imperata cylindrical* the t-test for ^{40}K shows ($t_{calc.}$ = 0.77; $t_{tab.}$ = 1.73, n = 20) while it is ($t_{calc.}$ = 1.05; $t_{tab.}$ = 1.73, n = 20) for *Eleusin indicageartin*. The test for other radionuclides followed the same pattern and all showed no significant difference between the radionuclide concentration in medicinal plants from Ughelli and environs and same species of plants collected from Ogbomoso and environs. This observation thus implied that the radioactive materials in use in the oil and gas activities have not contaminated the environment where the plants were collected and that the radioactivity levels found in the plants are not due to the application of the radioactive materials usually use in the oil and gas operations in the Niger Delta; moreso that no artificial radionuclide was detected in any of the samples.

Sequel to the determination that the oil and gas activities have not contributed to the level of the activity concentrations in the samples from both regions, and that the use of the medicinal grass is oral, the values of the radionuclide concentrations from both regions were therefore pooled together. The pooled average of the activity concentrations thereafter translated through ingestion path to very low values of annual effective dose equivalent of 17.9 µSv y^{-1}, 16.7 µSv y^{-1} and 17.4 µSv y^{-1} respectively for ^{238}U in *Eleusin indicageartin, Cymbopogan citrates and Imperata cylindrical.* For ^{232}Th in the respective species of the sample, the annual effective dose equivalents were determined to be 124.5 µSv y^{-1}, 97.1 µSv y^{-1} and 125.9 µSv y^{-1} for *Eleusin indicageartin, Cymbopogan citrates and Imperata cylindrical.* This finding thus indicated that the ingestion of the medicinal plants is of very low radiological health risk.

4. Conclusion

The natural radionuclide contents of three medicinal grasses (*Cymbopogan citrates*, *Imperata cylindrical* and *Eleusin indicagaertin*) have been analysed by means of gamma spectrometery. The results obtained from this work indicated that no artificial radionuclide was found in samples assayed. The effective dose equivalent corresponding to the measured concentrations in the medicinal plants was found to be lower than the recommended limit of 1 mSv in a year, despite clear evidence from the data obtained that the dominant radionuclide in the grasses is ^{40}K.

In order to assess the contribution of the radioactive materials used in the oil and gas activities hosted by Ughelli and environs, same samples of plants collected from another region that is not using radioactive materials was also assayed for their radionuclide contents. The result showed no significant difference.

The findings in this work has however pointed to the fact that Ughelli and environs which has hosted the use radioactive materials of different strength and sources, for over four decades, has not contributed adversely to the radioactivity levels of natural radionuclides found in the medicinal plants and thus pose no radiological health risk.

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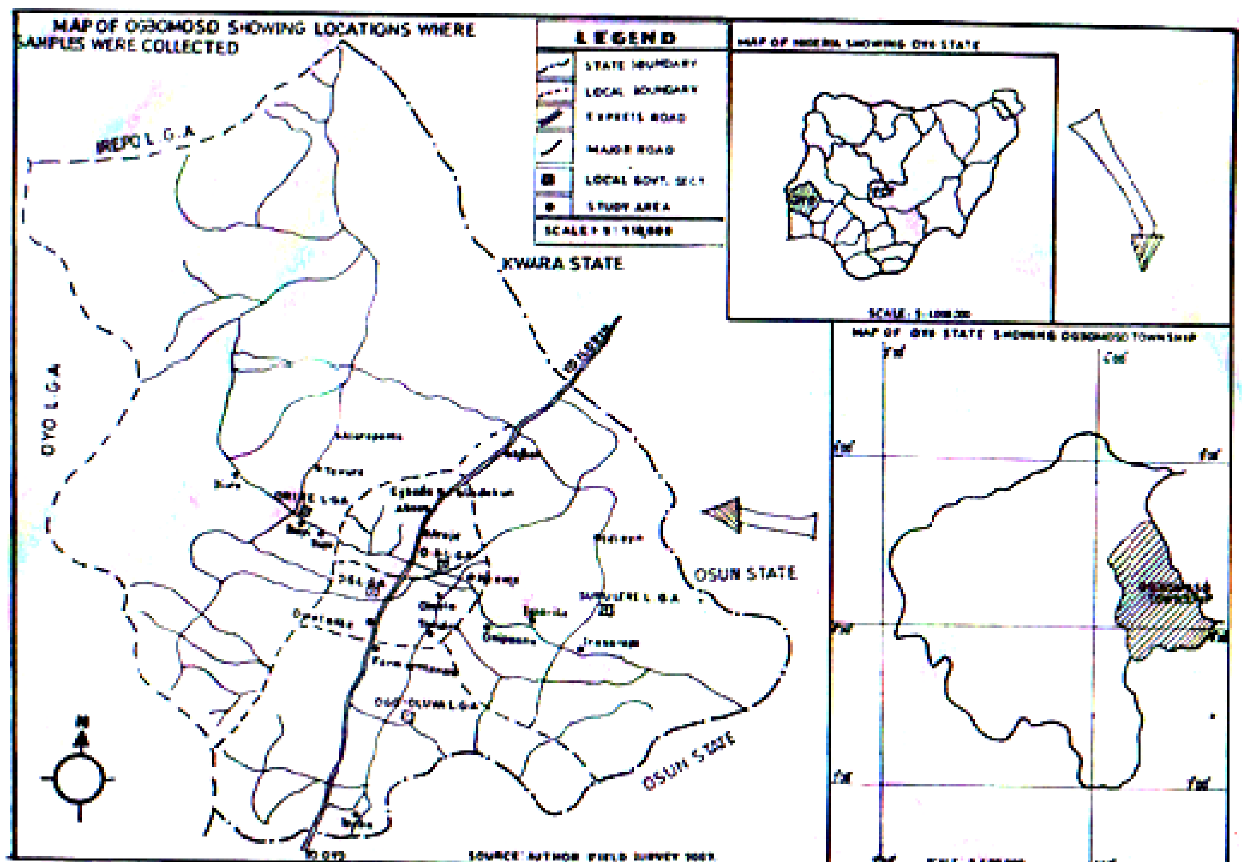

Figure 1. Map of Ogbomoso indicating locations of sample collection

Table 1. Sampling locations

Serial Number	Location *Ughelli and environs*	Location *Ogbomoso and environs*
1.	Ughelli quality control centre 5^o 30.3$^/$N; 5^o 55.9$^/$ E	Olaroponla
2.	Ughelli East UPS manifold 5^o 30.7$^/$N; 5^o 56.2$^/$ E	Tewure
3.	Ughelli East flow station 5^o 30.8$^/$N; 5^o 56.9$^/$ E	Ikoyi
4.	Ughelli East gas plant 5^o 30.8$^/$N; 5^o 56.2$^/$ E	Iluju
5.	Ughelli East flare site 5^o 30.9$^/$N; 5^o 56.3$^/$ E	Ladokun
6.	Ughelli East buster station 5^o 31.0$^/$N; 5^o 55.9$^/$ E	Idi-Ayin
7.	Kokori flow station 5^o 38.6$^/$N; 6^o 04.2$^/$ E	Aroje
8.	Kokori flare site 5^o 39.1$^/$N; 6^o 04.2$^/$ E	Ile-Ewe
9.	Kokori flare knock-out drum 5^o 39.0$^/$N; 6^o 04.1$^/$ E	Oke-Ola
10.	Afisere compressor station 5^o 32.8$^/$N; 6^o 00.9$^/$ E	Igbo-Ile
11.	Afisere flare knockout vessel 5^o 32.8$^/$N; 6^o 00.7$^/$ E	Ologbon
12.	Afisere manifold 5^o 32.8$^/$N; 6^o 00.9$^/$ E	Onipaanu
13.	Afisere NGC station 5^o 32.6$^/$N; 6^o 01.1$^/$ E	Farm settlement
14.	Afisere well location 4 5^o 32.5$^/$N; 6^o 02.4$^/$ E	Iresa-Apa
15.	Eriemu well location 19 5^o 32.1$^/$N; 6^o 02.2$^/$ E	Ipeba
16.	Eriemu NGC station 5^o 31.2$^/$N; 6^o 03.4$^/$ E	Egbeda
17.	Eriemu flow station 5^o 31.2$^/$N; 6^o 03.4$^/$ E	Abaa
18.	Eriemu flare knock-out vessel 5^o 31.2$^/$N; 6^o 03.5$^/$ E	Buro
19.	Eriemu flare site 5^o 31.1$^/$N; 6^o 00.9$^/$ E	Owolaake
20.	Eriemu pigging manifold 5^o 31.5$^/$N; 6^o 01.1$^/$ E	Temidire

Table 2. Mean of the specific activities of the species of samples for the two areas

Specie/ Area	^{40}K	^{238}U	^{232}Th
Eleusin indicageartin			
Ughelli	70.2 ±11.6	16.0 ± 1.9	11.1 ± 2.1
Ogbomoso	66.8 ± 9.4	16.2 ± 2.0	7.0 ± 1.9
Cymbopogan citrates			
Ughelli	67.9 ± 7.4	15.3 ± 1.7	7.2 ± 1.8
Ogbomoso	66.6 ± 8.6	14.7 ± 1.6	7.1 ± 2.1
Imperata cylindrical			
Ughelli	69.3 ± 9.4	15.8 ± 2.4	11.4 ± 2.2
Ogbomoso	67.1 ± 9.2	15.5 ± 2.4	7.4 ± 1.8