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Natural Radioactivity In Some Borehole Water in Ogbia Local Government Area, Bayelsa State, Nigeria

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ABSTRACT: Measurement of Natural Radioactivity in some Borehole Water in Ogbia Local Government Area, Bayelsa State, Nigeria was carried out using High Purity Germanium Detector. The aim was to identify the radionuclides present in the water samples with their respective concentration. The activity of ^{40}K ranged from 0.47 ± 0.04 to $14.90 \pm 1.14 \text{ BqL}^{-1}$. The activity concentration of ^{226}Ra ranged from DBL to $8.55 \pm 1.63 \text{ BqL}^{-1}$ while that of ^{232}Th ranged from BDL to $4.45 \pm 0.35 \text{ BqL}^{-1}$. In three locations ^{226}Ra activity was not detected. Also in three locations activity concentration of ^{232}Th was below detectable level. The mean values of ^{40}K , ^{226}Ra and ^{232}Th activities were 7.51 ± 0.56 , 2.99 ± 0.57 and $1.78 \pm 0.14 \text{ BqL}^{-1}$ respectively. Generally, these values were above reference values, 0.1 BqL^{-1} for alpha and 1.0 BqL^{-1} for beta. Therefore further investigation is required to evaluate radiological health implications of the results.

KEYWORDS: Borehole water, Detector, Measurement, Natural radioactivity.

I. INTRODUCTION

Life depends on water; therefore the knowledge of contaminants in drinking water is of utmost importance to human healthy living. All Living creatures are exposed to naturally occurring radioactive materials (NORMs) and technological enhanced naturally occurring radioactive materials (TENORMs). According to [1], living organisms are continuously exposed to a wide range of ionizing radiations from naturally occurring radioactive materials (NORMs) and radionuclides generated from human activities. naturally occurring radionuclides are of Natural origin are normally present in different amounts in drinking water [2]. Terrestrial radiations are given out from natural radioactive elements present in varying amounts in all types of water, soil, air, rocks, food in the human body and other environmental materials [3]. The processes of erosion and dissolution bring radioactive elements from the rocks into the ground water [4]. In environmental studies, water is considered very important because of its daily domestic use, human consumption and its ability to transport contaminants [5]. The main sources of drinking water in the area of study included tap (borehole) water and river water. However, only borehole water sources were considered. These sources are constantly subjected to contamination from radiation sources especially the natural radioactivity of radionuclides such as ^{40}K , ^{238}U , and ^{232}Th [6]. Human internal exposure due to radioactive decay of the isotopes taken into the body through ingestion, inhalation and incorporation into food chain is never desirous.

This study basically measured the activities in underground water pumped to the surface. The radioactivity in ground water comes mainly from radionuclide of natural decay series of ^{238}U and ^{232}Th and ^{40}K in soil and bedrock. Access to safe drinking water is essential to health a basic human right and a component of effective policy for health protection [7] and for this reason its quality must be strictly controlled. Drinking water may contain radionuclides that could be present a risk to human health. Radiation exposure through drinking water could results from naturally occurring radionuclides in drinking water sources, through alpha radiation emitting radon. Alpha and beta particle emission emanating from oil spill could also elevate these radionuclides in water [8]. Some radionuclide can easily dissolve in water depending on mineralogical and geochemical composition of the soil and rock, time of ground water in the soil and bedrock, basically on their interaction [9]. The occurrence of natural radionuclide in drinking water poses a problem of health hazard, when these radionuclides are taken into the body by ingestion. The radionuclides contribute significantly to the ingestion dose via consumption of water contaminated with radium. Radium is a naturally occurring isotope found in the earth's crust, a member of uranium, ^{238}U decay series. The predominant radium isotopes in ground and surface water are ^{226}Ra , an alpha emitter with a half- life of 5.8 years [10]. Many salts of radium are soluble in water

and therefore underground water maybe enriched in radium and its descendent radon in surface water. ²²⁶Ra is an earth alkaline element sharing the metabolic pathways of calcium in the human body. Due to their radiotoxicity, a contamination hazard for humans exists even at low concentration levels [11].

The radionuclides are naturally present in the earth and can get into these water bodies through the process of seepage and run-off. These radionuclides transported by the ground water can enter the food chain through irrigation water wells[12]. Ingestion of radionuclide can result to cancer of the skin, kidney, lungs, bones and other diseases such as sterility, leukaemia[13], or to death [16]. Consequently radionuclides in the radioactive decay chain starting from ²³⁵U are highly radiotoxic [14]. Radium is the most radiotoxic and a known carcinogen and exists in several isotopes forms. Considering the high radio toxicity of ²²⁶Ra and ²²⁸Ra , their presence in ground water and the associated health risks require particular attention. When radium is ingested into the body, an appreciable proportion is deposited in the bone, and the remaining fraction is distributed to soft tissue [15]. The exposure to high levels of radium for a long period of time, could lead to cancer of the bone and nasal cavity [16].

The large proportion of human exposure to radiation comes from natural sources which includes cosmic and terrestrial radiations. The United Nations scientific committee on effect of atomic radiation [17] has estimated that exposure to natural sources contributed about 70% the population radiation exposure dose and global average human exposure from natural source is 2.4mSvy⁻¹ [18]. Several studies have been carried out on Radioactivity concentration in various water samples (tap river and well) collected from cities in Nigeria and other countries [19]. However, the systematic data on the radioactivity of public water supplies in Ogbia Local Government Area of Bayelsa State is not available in the literature. Hence, the need for this study which aims at determining the natural radioactivity of borehole water.

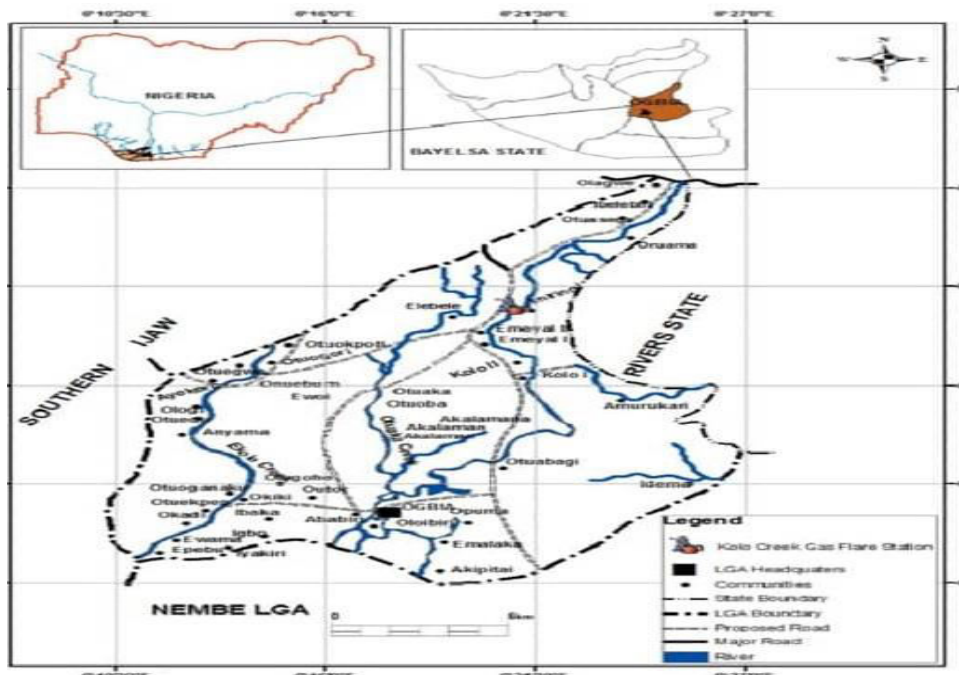


Fig. 1: Map of Ogbia LGA showing the study area.

II. STUDY AREA

The study area is Ogbia local Government Area in Bayelsa State which is located in the Niger Delta region of Nigeria. It lies between longitude 6°15'E and 6°45'E, Latitude 4°39' and 5°02'N. Figure 1 shows the map of Ogbia local Government Area, Bayelsa State, Nigeria. This area is located in the southern part of Niger Delta. Ogbia local Government Area has an area of 100km² and a population of 179,926 [20].



III. MATERIALS AND METHODS

Sampling and Sample Preparation:

In measuring the natural Radioactivity in drinking, water samples were collected from Ogbia Local Government Area of Bayelsa State. A total of twenty water samples were randomly collected from the borehole water in some communities. All water samples were collected into carefully washed 2 litre linear polypropylene bottles. The collected water samples were acidified with 1ml of concentrated hydrochloric acid (HCl) to avoid adsorption of radionuclide into the walls of the containers [14] and also to avoid microbial activities. Evaporation was allowed in an oven at 70°C. About 120ml of the residue was transferred into a 120 ml marinelli bottles. These were sealed with thick vinyl tape and stored for 28days to reach secular equilibrium between ²³⁸U and ²³²Th and their respective daughters before analysis [19].

Experimental Setup:

The gamma spectrometric measurement was carried out using gamma ray spectrometry analysis. Each of the 20 prepared samples was placed under the influence of a low background gamma spectrometer of High Purity germanium (HPGe), P – type detector system. The detector was connected through a preamplifier, model 2002CSL and serial number 13000742 to a PC – based Multichannel Analyzer. CANBERRA Multi Gamma ray, MGS6M315 was used as standard source. Energy calibration of the detector was performed using standard sources of known radionuclides with well – defined energies. The ²²⁶Ra and ²³²Th (228Ra) activity concentrations were determined indirectly through their activities of their decay products, while ⁴⁰K content of the water samples was also determined by measuring the 1460.8 KeV gamma rays emitted

during the decay of ⁴⁰K. The detection limits of radionuclides ²²⁶Ra, ²³²Th and ⁴⁰K are given as 0.03, 0.0013 and 0.002 Bql-1 respectively. Also efficiency calibrations was done using 1.33MeV gamma line of ⁶⁰Co resulting to energy resolution of 2.3 KeV which was taken to be good enough to differentiate the gamma ray energies.

Background count was determined by counting the empty plastic container volume for 10 hours. This was followed by counting water samples, each 120 ml, in the HPGe detector for a period of 10 hours to identify the radioisotopes. The energy spectrum showed corresponding photo peaks of each of the isotopes. This was computed by subtracting counts due to Compton scattering of higher peaks and the background sources from the total area of the peaks. Activity concentration and uncertainty in activity Gamma probability, Efficiency and uncertainty in efficiency were used to determine the radionuclide concentration in each sample [21]. Activity concentrations were then computed from the following relation.

$$A(Bql^{-1}) = \frac{C_n}{\epsilon_y P_y t_c V}$$

where C_n is the net peak area at gamma ray energy, ϵ_y is the efficiency of the detector, P_y is the emission probability of the radionuclides of interest, t_c is the total count time(s) and V is the sample volume in litres.

IV. RESULTS AND DISCUSSION

The activity concentrations of natural radionuclides of ⁴⁰K, ²²⁶Ra and ²³²Th in the collected water samples were presented in table 1 below.

Table 1

S/N	Location	Latitude (degree)	Longitude (degree)	Elevation (m)	⁴⁰ K (Bql ⁻¹)	²²⁶ Ra (Bql ⁻¹)	²³² Th (Bql ⁻¹)
1	Abobiri	4.690594	6.346430	-6.70	11.59±0.84	4.85±0.88	2.33±0.21
2	Akipelai	4.631006	6.338827	-22.40	0.47±0.04	0.26±0.05	1.08±0.09
3	Amorekeni	4.770262	6.402325	-3.50	16.20±1.13	6.57±1.20	4.45±0.35
4	Anyama	4.759551	6.229732	-11.90	3.70±0.28	BDL	BDL
5	Elebele	4.856307	6.344791	-7.50	4.50±0.35	2.76±0.49	1.60±0.14
6	Emekalaka	4.650440	6.349701	-0.40	7.02±0.53	2.61±0.54	BDL
7	Emeyal 2	4.839074	6.350002	6.90	11.59±0.88	BDL	3.30±0.28
8	Imiringi	4.891768	6.372003	17.70	7.36±0.51	6.94±1.33	1.29±0.11
9	Kolo 3	4.810038	6.376089	6.20	2.79±0.22	3.29±0.71	1.92±0.16
10	Ogbia Town	4.689922	6.316899	-9.40	8.87±0.67	8.55±1.63	0.590.05

11	Okiki	4.720291	6.258814	-5.60	14.90±1.14	1.67±0.37	0.90±0.08
12	Okodi	4.676393	6.221625	-3.90	6.05±0.50	4.38±0.90	2.17±0.18
13	Oloibiri	4.670915	6.312865	2.20	6.08±0.44	1.25±0.24	1.08±0.11
14	Onuebum	4.805502	6.259044	-1.20	21.51±1.58	2.09±0.40	0.52±0.05
15	Opume	4.679380	6.399171	-4.80	0.91±0.08	7.67±1.37	3.34±0.28
16	Oruma	4.915971	6.418283	1.40	5.21±0.37	0.16±0.03	BDL
17	Otuabula 1	4.730946	6.299751	-0.41	3.36±0.27	BDL	2.69±0.23
18	Ewoi	4.790184	6.313882	-5.10	2.86±0.21	1.10±0.23	2.96±0.25
19	FUO	4.792694	6.322980	2.70	3.26±0.26	0.57±0.12	1.18±0.10
20	Otuasega	4.918310	6.399650	10.80	11.96±0.93	1.67±0.37	2.46±0.20
		Mean			7.51±0.56	2.99±0.57	1.78±0.14

Discussion

Activity concentrations of radionuclides of potassium, radium and thorium were measured and results presented in table 1 above. The values were in agreement with those obtained in similar environment. The activity of ^{40}K ranged from 0.47 ± 0.04 to $16.20\pm 1.13 \text{ Bq l}^{-1}$. The activity concentration of ^{226}Ra ranged from BDL to $8.55\pm 1.63 \text{ Bq l}^{-1}$ while that of ^{232}Th ranged from BDL to $4.45\pm 0.35 \text{ Bq l}^{-1}$. The mean values of ^{40}K , ^{226}Ra and ^{232}Th were 7.51 ± 0.56 , 2.99 ± 0.57 and $1.78\pm 0.14 \text{ Bq l}^{-1}$ respectively. The mean value of ^{40}K was 27.51 ± 0.56 with a maximum at Amorekeni ($16.20\pm 1.13 \text{ Bq l}^{-1}$) community whereas the minimum ^{40}K was recorded at Akipelai ($0.47\pm 0.04 \text{ Bq l}^{-1}$). Maximum ^{226}Ra was recorded at Ogbia town ($8.55\pm 1.63 \text{ Bq l}^{-1}$) while at Anyama, Emeyal2 and Otuabula1 activity concentrations were below detectable limit, BDL. The value of ^{232}Th was a minimum at Emekalaka and Oruma (BDL) and the maximum was at Amorekeni (4.45 ± 0.35). These values were in consonance with values reported by [12] which recorded that for the borehole water samples, the activity concentrations ranged from BD to $185.72\pm 16.61 \text{ Bq}\cdot\text{L}^{-1}$, 0.51 ± 0.02 to $6.77\pm 0.23 \text{ Bq}\cdot\text{L}^{-1}$ and 0.87 ± 0.05 to $2.59\pm 0.13 \text{ Bq}\cdot\text{L}^{-1}$ for ^{40}K , ^{226}Ra and ^{232}Th respectively. Ogbia is located in hydrocarbon bearing formation and it is possible that artificial isotopes used in crude oil drilling may affect the natural constituents of aquifer.

V. CONCLUSION

The natural activity concentrations of radionuclides of ^{40}K , ^{226}Ra , and ^{232}Th have been estimated in various borehole water resources in some communities in Ogbia local Government Area of Bayelsa using high purity Germanium based on gamma spectroscopy. This study showed elevation of activity concentration of ^{40}K , ^{226}Ra , and ^{232}Th in most of the water samples and undetected in a few samples. These values of activity concentrations would serve as base line data for future study that would estimate the health risk implications of the borehole water in the area.

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