Sept 2013. Vol. 4, No. 3 ISSN2305-8269
International Journal of Engineering and Applied Sciences

www.eaas-journal.org

EVALUATION OF NATURAL OCCURRING RADIONUCLIDE VARIATION WITH LITHOLOGY DEPTH PROFILE OF UDI AND EZEAGU LOCAL GOVERNMENT AREAS OF ENUGU STATE, NIGERIA.

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ABSTRACT

The assessment of selected natural radionuclide concentration with lithology depth profile of two drilled borehole in Enugu State Nigeria have been carried out using gamma spectroscopy detector. Samples were collected at 20meters depth interval down the boreholes with a well depth of about 200m and 140m for Well 1 (Amagu-Umuene) and well 2 (Ogulogu-Olo) respectively. The average values of ^{40}K, ^{226}Ra and ^{232}Th obtained is 57.17±13.06Bqkg^{-1}, 13.71±6.27Bqkg^{-1} and 10.49±3.72Bqkg^{-1} respectively for well 1 and 59.77±16.67Bqkg^{-1}, 11.49±4.43Bqkg^{-1} and 8.83±2.93Bqkg^{-1} respectively for well 2. Laterite, sand stone and silty sand show relative high activity concentration while other rock formations in the lithology were moderate in radioactivity level. The computed absorbed dose and annual gonnadal equivalent dose has a mean value of 15.20ηGyhr^{-1} and 0.10mSvy^{-1} for well 1 and 13.30ηGyhr^{-1} and 0.09mSvy^{-1} for well 2 respectively. These values obtained, other health hazard indices and excess life cancer risk examined are well within the world average value and may not constitute any health effects to human and environmental hazard. The variation of the radionuclides for both wells is irregular down the depth of the boreholes profile. The irregular distribution pattern down the lithology/aquifer is attributed to the mineralogy and the geology of the study area.

Key words: *Natural radioactivity variation, soil depth profile, Enugu, Nigeria*

1.0 INTRODUCTION

The environment is a complex ecological system and adverse impact on one part can ultimately affect other parts (Ezeh, 2008). Natural radioactivity is widespread in the earth environment and it exists in various geological formations such as earth crust, rocks, soils, plants, water and air (UNSCEAR, 2000).The environment when exposed to deleterious substance can become polluted thus having harmful effect to man and other biotic organisms in the environment. Radionuclides is one of the sources of pollution in the environment if allow to build up due to natural occurrence or anthropogenic activities. Radionuclides which emit radiation are found naturally in air, water and soil. Natural radioactivity is common in rocks formations and soil that make up our planet, in waters and oceans, and in building materials. Monitoring of radioactive materials are therefore of primary importance to human kind and environmental protection (El-Bahi, 2004).

Studies on radionuclide concentration variation with geological formation, soil type and depth profiles are relatively new in the field of radiation and radioactivity concentration studies in the environment especially in Nigeria. Studies have shown that in soil and water, terrestrial radiations and radioactivity are highly dependent on the soil type and mineral content of the environment Nevas et al., (2002a), however, reports on activity variation with rock formation and soil depth profile are scanty. Nevas et al., (2002b) determined the distributions of natural gamma-emitting radionuclide in three soil profiles developed on tertiary sedimentary materials in mountain landscapes of the Central Spanish Pyrenees and

reported a depletion of activity with depth, and concluded that the variation in radionuclide activities of soil may be due to differences in carbonate content, organic matter and/or grain size. Nevas et al. (2002a) reported that soil properties differently affected mobilization of natural radionuclide and the association of some radiologic properties with soil layers suggests a relationship between soil processes and radionuclide distribution.

Vukašinović1 et al., (2009) measured the radionuclide variation from a series of soil cores between 13 and 40 cm depth collected in different lithology and reported that radionuclides show variations in the depth profile as well as in the different morphoedaphic environments studied. They further reported that variability in some radionuclides seems to be related to mineralogy derived from parent materials as well as with cryogenic and soil processes affecting the depth distribution of the granulometric fractions and organic matter Nevas et al., (2002b). Avwiri et al., (2010) measured radionuclide concentration with depth in lithology of Port Harcourt, Nigeria and reported that radionuclide concentration reduced with depth from 0- 40meters in a significant manner down the aquifer depth. This present study is aimed at assessing the variability of the three natural radionuclides with depth in Enugu lithology up to 200meters depth and assesses the health hazard associated with these geological formations. The result obtained from the study will form a baseline data of radionuclide earth profile of the study area. It will also reveal the variation in behavior of the radionuclides at further depth profile from previous studies and will add to the world data base of radionuclide variation with depth profile. The findings of the study will be useful for geologist exploiting solid minerals and authorities in charge of implementing radiation protection standards for the public. During borehole drilling, drillers literally bath with the mud drilled out of the reservoir and other sediments associated with the process. The need to ascertain the radiological health hazard content also laid credence to this work.

1.1 Study Area

The study area Ogulogu-Olo, E007°08'12.2'' N06°24'44.5" in Ezeagu Local Government Area and Amagu-Umuene, E007°25'15.4" N06°34'03.7" in Udi Local Government Area both in Enugu State shows two major types of landforms which consist of a high relief zone with undulating residual hills, valleys and the lowland areas. The residual hills are the remnants of the Nsukka formation which constitute the surface layers. These layers are highly weathered and eroded and overly the Ajali Sandstone. The lowlands are most profound in the northwestern part of the study area and serve as the collecting centre of the run offs during the rainy season. Drilling of borehole for water in Nigeria especially in the urban areas has become a regular activity. Water exploration through the drilling of boreholes in Enugu State is a hectic task because of the lithology and structure of the environment. Depth of about 150m to 200m is required to get to water table and this can take several weeks to achieve. The area is also noted for the exploration of solid minerals especially coal. The geology of the area has been reported (Ezeh and Ugwu, 2010; Ezeh, 2008).

2.0 MATERIALS AND METHODS

2.1 Sampling and Sample Preparation

Sampling was carried out in two deep boreholes during the process of well drilling located at Ogulogu-Olo in Ezeagu L.G.A and Amagu-Umuene, Ibete Opkatu, Udi Local Government Areas of Enugu State, between January and April 2012. Samples were collected at the depth interval of 20meters during the drilling process. The wells are of various depth with well 1 having a depth of 200meters and well 2 been 140meters to the aquifer.

The samples were collected using a steel hand geological auger attached to a drawing rope, which was cleaned with acid, detergent and rinsed with tap water. Samples of about 450g wet- weight of soil were collected in new aluminum foil labeled and placed in polythene bags during the drilling process. Water content in samples were separated from samples by decantation. The samples were then oven dried at temperature of 60^0 to 80^0C for about 24 hours. The dried samples were grounded with mortar and pestle and then allowed to pass through a 100-mesh sieve. Sample of 250g dry-weight were packed in air tight cylindrical plastic container which is of the detector geometry, and stored for a period of four weeks before counting, so that secular equilibrium can be attained between ^{226}Ra and its short lived progeny (Zarie and Al Mugren, 2010).

2.2 Sample analysis

The samples were analyzed using a thallium activated Canberra vertical high purity 3"x 3" Sodium iodide [NaI(TI)] detector connected to ORTEC 456 amplifier. The detector was connected to a computer program MAESTRO window that matched gamma energies to a library of possible isotopes. The cylindrical plastic containers holding the samples were put to sit on the high geometry 7.6cm x 7.6cm NaI(TI) detector. High level shielding against the environmental background radiation was achieved by counting in the Canberra 100mm thick lead castle. Spectrum were accumulated for background for 29000s at 900volts to produce strong peaks at gamma emitting energies of 1461keV for ^{40}K; 609keV of ^{214}Bi and 911keV of ^{228}Ac, which were used to estimate the concentration of ^{238}U and ^{232}Th, respectively. The energy resolution of the detector using Cs-137 from International Atomic Energy agency (IAEA) is 8% at 662keV Cs-137 line, while the activity of the standard at the time of calibration is 25.37KBq. The background spectrum measured under the same conditions for both the standard and sample measurements, were used to correct the calculated sample activities concentration in accordance with Arogunjo, et.al. 2005. The activity concentration (C) in Bqkg^{-1} of the radionuclides in the samples was calculated after decay correction using the expression:

$$Cs \quad (Bqkg^{-1}) = \frac{Ca}{\varepsilon\gamma \times Ms \times tc \times P\gamma} \quad (1)$$

Where C_s = Sample concentration, $Ca_=$ net peak area of a peak at energy, ε_y= Efficiency of the detector for a γ-energy of interest, M_s =Sample mass, t_c= total counting time, P_γ=Emission probability of radionuclide of interest.

2.3 Radiation Hazard Indices Calculation

Different known radiation health hazard indices analysis is been used in radiation studies to arrive at a reliable conclusion on the health status of a radiated or irradiated person and environment in recent studies (Diab *et al.*, 2008; Kabir *et al.*, 2009; Zarie and Al Mugren, 2010; Senthilkumar *et al.*, 2010; Agbalagba and Onoja, 2011). To assess the radiation hazards associated with the study samples, six quantities have been defined (Zarie and Al Mugren, 2010)

Radium Equivalent Activity (Ra_{eq})

Radium equivalent (Ra_{eq}) is a common index used to compare the specific activities of materials containing ^{226}Ra, ^{232}Th and ^{40}K by a single quantity, which takes into account the radiation hazards associated with them (Baratta, 1990). The activity index provides a useful guideline in regulating the safety standard dwellings.

The radium equivalent activity represents a weighted sum of activities of the above mentioned natural radionuclides and is based on the estimation that 1Bq/kg of ^{226}Ra, 0.7Bq/kg of ^{232}Th, and 13Bq/kg of ^{40}K produce the same radiation dose rates.

The radium equivalent activity index is given as (Beratka and Mathew 1985);

$$Ra_{eq} = C_{Ra} + 1.43C_{Th} + 0.077C_k \quad (2)$$

Where; C_{eq}, C_{Th}, C_k are the radioactivity concentration in Bq/kg of ^{238}U, ^{232}Th, and ^{40}K.

The use of a material whose Ra_{eq} concentration exceeds 370Bq/kg is discouraged to avoid radiation hazards (Sam and Abbas, 2001)

Annual Gonnadal Equivalent Dose (AGED)

The gonads, the activity bone marrow and the bone surface cells are considered as organs of interest by UNSCEAR (1988). The AGED for the resident of a building using a material with given activity concentration of ^{226}Ra, ^{232}Th and ^{40}K is calculated using the equation;

$$\text{AGED (Sv/yr)} = 3.09C_{Ra} + 4.18C_{Th} + 0.314C_k \quad (3)$$

Where C_{Ra}, C_{Th}, and C_k are the radioactivity concentration of ^{226}Ra, ^{232}Th and ^{40}K.

External Hazard Index (H_{ex})

Many radionuclides occur naturally in terrestrial soils and rocks and upon decay, these radionuclides produce an external radiation field to which all human beings are exposed. In terms of dose, the principal primordial radionuclides are ^{232}Th, ^{238}U and ^{40}K. Thorium and uranium head series of

radionuclides that produce significant human exposure.

The external hazard index (H_{ex}) is defined as (Beretka and Mathew 1985)

$$H_{ex} = C_{Ra}/370 + C_{Th}/259 + C_k/4810 \quad (4)$$

Where C_{Ra}, C_{Th}, C_k are the radioactivity concentrations in Bq/Kg of ^{238}U, ^{232}Th and ^{40}K respectively. The value of this index must be less than unity for the radiation hazard to be negligible (Beretka and Mathew, 1985).

H_{ex} equal to unity corresponds to the upper limit of Raeq (370Bq/Kg) (Berekta and Mathew, 1985).

Internal Hazard Index (H_{in})

The internal hazard index (H_{in}) is given as (Beretka and Mathew 1985).

$$H_{in} = C_{Ra}/185 + C_{Th}/259 + C_k/4810 \quad (5)$$

H_{in} should be less than unity for the radiation hazard to be negligible. Internal exposure to radon are very hazardous, this can lead to respiratory diseases like asthma and cancer.

Representative Gamma Index (I_{yr}):

This is used to estimate the γ- radiation hazard associated with the natural radionuclide in specific investigated samples. The representative gamma index as (Ashraf *et al.*, 2010)

$$I_{yr} = C_{Ra}/150 + C_{Th}/100 + C_k/1500 \quad (6)$$

This gamma index is also used to correlate the annual dose rate due to the excess external gamma radiation caused by superficial materials. It is a screening tool for identifying materials that might become health of health concern when used for construction (Tufail et al., 2007).

Values of $I_{yr} \leq 1$ corresponds to an annual effective dose of less than or equal to 1mSv, while $I_{yr} \leq 0.5$ corresponds to annual effective dose less or equal to 0.3mSv (Turham et al 2008).

Annual Effective Dose Equivalent (AEDE): The annual effective dose equivalent received outdoor by a member is calculated from the absorbed dose rate by applying dose conversion factor of 0.7Sv/Gy and the occupancy factor for outdoor and indoor was 0.2(5/24) and 0.8(19/24) respectively (Veiga et al., 2006). AEDE is determined using the following.

AEDE (Outdoor) (μSv/y) = Absorbed dose (nGy/h) × 8760h × 0.7Sv/Gy × 0.2 × 10^{-3} (7)

AEDE (Indoor) (μSv/y) = Absorbed dose (nGy/h) × 8760h × 0.7Sv/Gy × 0.8 × 10^{-3} (8)

2.4 Excess Lifetime Cancer Risk (ELCR)

This deals with the probability of developing over a lifetime at a given exposure level. It is presented as a value representing the number of extra cancers expected in a given number of people on exposure to a carcinogen at a given dose.

Excess lifetime cancer risk (ELCR) is given as (Taskin et al., 2009)

$$ELCR = AEDE \times DL \times RF \quad (9)$$

where, AEDE is the Annual Effective Dose Equivalent (outdoor), DL is average Duration of Life (estimated to be 70years), and RF is the Risk Factor (S/v), i.e. fatal cancer risk per Sievert. For stochastic effects, ICRP uses RF as 0.05 for the public (Taskin et al., 2009).

3.0 RESULTS AND DISCUSSION

3.2 DISCUSSION

Tables 1 and 2 present the three (^{40}K, ^{226}Ra and ^{232}Th) natural radionuclide isotopes present in the two boreholes lithology profile. In well 1, ^{40}K activity concentration ranged from 46.60±15.43Bqkg^{-1} in sharp sand at 180meters depth to 68.18±19.53Bqkg^{-1}in laterite at 20meters depth. Radium-226 values ranged from 6.45±2.78Bqkg^{-1} in sharp sand at 180meter depth to 18.64±6.98Bqkg^{-1} in sand stone at 140meters depth, while Thorium- 232 activity concentration ranged from 5.06±1.82Bqkg^{-1} in sand stone at 160meters depth to 15.47±5.35Bqkg^{-1} in silty sand at 120meters depth. The average value of ^{40}K, ^{226}Ra and ^{232}Th is 57.17±13.06Bqkg^{-1}, 13.71±6.27Bqkg^{-1} and 10.45±3.72Bqkg^{-1} respectively. In well 2, ^{40}K activity concentration ranged from 42.67±16.02 Bqkg^{-1} in shale at 80meters depth to 79.12±19.53Bqkg^{-1}in laterite at 20meters

depth. Radium-226 values ranged from 7.65±3.22Bqkg^{-1} in sand at 140meter depth to 16.75±65.21Bqkg^{-1} in laterite at 20meters depth, while Thorium-232 activity concentration ranged from 6.20±3.02Bqkg^{-1} in sand at 140meters depth to 11.17±2.25Bqkg^{-1} in laterite at 20meters depth. The average value of ^{40}K, ^{226}Ra and ^{232}Th is 59.77±16.67Bqkg^{-1}, 11.49±4.43Bqkg^{-1} and 8.83±2.93Bqkg^{-1} respectively. From tables 1 and 2, the relatively high values of ^{40}K obtained are comparable with the values reported by Jankovic et al., (2011) and maybe as a result of its relative abundance in the earth crust (Tchokossa et al., 1999). The high values obtained in laterite shows the level of radioactive material in laterite which may be attributed to the presents of radioactive minerals in it. Sand stone is known to contain some levels of natural radionuclides, thus the values obtained for sand stone is in agreement with other values reported in related studies (Jankovic et al., 2011; Vukašinović1 et al., 2009; Avwiri et al., 2010). The observed high activity concentration in silty sand indicated the present of a radioactive induced mineral in that lithology, since silty sand is not known to contain high radioactive materials. Clay, clay/ silt and share are known to contain moderate levels of radioactive elements (Mokobia, 2011), this is evident in the values obtained for these samples. The average concentrations of ^{226}Ra in the boreholes are higher compared to that of ^{232}Th. This may be attributed to the fact that ^{226}Ra is moderately soluble in water and is found more abundantly than ^{232}Th in atmosphere (Ashraf et at., 2001; Nevas et al., 2002b). These radioactivity concentration values obtained in these two boreholes are below the world average value of 400Bqkg^{-1} for ^{40}K, 35Bqkg^{-1} for ^{226}Ra and 30Bqkg^{-1} for ^{232}Th (UNSCEAR, 2000). It was observed from figures 1 and 2 that the variation of the radioisotopes down the aquifer depth was not in a definite order. The distribution pattern of the radionuclide for both well 1 and well 2 is irregular (neither ascending nor descending uniformly), but has a pattern which could divide the lithology profile of the study areas into segmented layers. The change in the characteristic pattern was observed at a periodic depth interval of about 60meters for well 1 and 25meters for well 2.

Analysis of the results pattern showed that for well 1, the process of infiltration (layers acting as filter and buffer) was observed down the laterite zone until a sudden and sharp increase was observed at the clay/silt layer. At the sandstone region, infiltration process continued dawn to the sand region where the concentration of the radionuclide increased because of the sandstone. For well 2, there is also reduction of radionuclide concentration down the well at the laterite region. This may also be as a result of infiltration process down the lithology profile. But in the shale zone, the radionuclide concentration was retained and it fluctuated at irregular order. This indicated that shale has the ability to retain and conserve minerals and radionuclide. At the sand zone, there was decrease in the radionuclide concentration which further shows the process of infiltration down the well. Following from these observations, one may infer that the radionuclide concentration down the well of an aquifer is affected by the process of infiltration (ie reduces down the well) except at some layers like shale, clay and silt where the concentration is either retained or increased due mineral content of the layer. These results obtained compared and agreed satisfactorily with the work of Nevas et al., (2002a) where the ^{238}U, ^{226}Ra, ^{210}Pb, ^{232}Th and ^{40}K exhibited very irregular pattern down the aquifer depth. Variation in radionuclide seems to be related to mineralogy derived from parent materials as with soil processes.

Tables 3 and 4 show the estimated health hazard indices computed from equations 2- 9. The computed absorbed dose rate (ADR) and annual gonnadal equivalent dose (AGED) has a mean value of 15.20ηGyh^{-1} and 0.10mSvy^{-1} for well 1 (Amagu-Umuene) and 13.30ηGyh^{-1} and 0.09mSvy^{-1} for well 2 (Ogulogu-Olo) respectively. The obtained values are lower compared with the values obtained by Avwiri et al., (2010) in lithology of Port Harcourt, Nigeria. These values are well within the world average value of 60ηGyh^{-1} for absorbed dose and 1.0mSvy^{-1} annual effective dose equivalent rate (ICRP, 1991 and UNSCEAR 2000). Also, external hazard index, internal hazard index and representative gamma index and AEDE (indoor and outdoor) are all less than the world permissible value of unity (Orgun et al., 2007). This indicates that the values will not lead to respiratory diseases such as asthma and cancer and external diseases such as erythema, skin cancer and cataracts. Average excess lifetime cancer risk (ELCR) for all samples is less than the world average of 0.29× 10^{-3}) (Taskin et al., 2009).

CONCLUSION

The study on the natural radionuclide present in lithology profile of two borehole aquifer in Enugu, Nigeria has been carried out. 40k was observed to be

relatively high compare to other two natural radionuclides. Laterite and sand stone contain relatively high concentration of the natural radionuclides, while clay, sharp sand, clay/silt and share were moderately concentrated. The radionuclides were observed to be distributed at an irregular pattern down the aquifer, which could be attributed to the mineralogy, carbonate content in the lithology. The average radionuclide levels of the aquifer are lower than the world standards for such environment and as such exposure to the drilling mud by the drillers and other workers will pose no significant health threat to human lives and the environment is said to be safe radiologically. Therefore, the irregularities in the distribution pattern observed in this study may be attributed to the irregular distribution of the minerals in Enugu State. The health hazard indices examined show that drilling operations and use of laterite, sand and any other rock materials in the lithology as building material in these areas poses no health hazard effect on the populace of Enugu.

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Table 1: Activity Concentration of Well 1 (Amagu-Umuene, Ibite Okpatu) Site Location

Depth (M)	SOIL TYPE	Activity concentration (Bqkg^{-1})		
		^{40}K	**^{226}Ra**	**^{232}Th**
20	Laterite	68.18±19.53	12.32±9.21	14.97±5.65
40	Laterite	54.98±18.75	14.32±7.65	12.65±4.69
60	Clay	46.73±13.00	17.17±6.98	8.56±2.87
80	Clay/silt	49.56±16.08	9.64±4.45	9.17±2.53
100	Silt	62.79±17.28	13.36±6.76	9.87±3.78
120	Silty sand	84.54±23.73	15.09±5.76	15.47±5.35
140	Sand stone	44.75±13.48	18.64±6.98	11.42±3.65
160	Sand stone	65.16±14.24	16.38±6.98	5.06±1.82
180	Sharp Sand	46.60±15.43	6.45±2.78	7.34±2.98
200	Sharp sand	48.41±19.13	13.71±5.19	10.36±3.83
Average		57.17±13.06	13.71±6.27	10.45±3.72
Worldwide Background Soil Standard		30 (10-50)	35 (10-50)	400 (100-700)

Table 2: Radionuclide Concentration of well 2 (Ogulogu-Olo, Ezeagu) Site Location

Depth (M)	SAMPLE CODE	Activity concentration ($Bqkg^{-1}$)		
		^{40}K	^{226}Ra	^{232}Th
20	Laterite	79.12±19.46	16.75±5.21	11.17±2.25
40	Laterite/shale	39.68±14.39	13.39±5.76	7.49±2.73
60	Shale	56.15±17.51	9.54±4.64	11.04±3.14
80	Shale	42.67±16.02	8.56±2.74	9.07±4.01
100	Shale	67.17±14.92	12.79±4.30	9.64±1.79
120	Shale/sand	62.74±12.85	11.75±5.02	7.21±3.54
140	Sand	70.86±21.54	7.65±3.22	6.20±3.02
Average		59.77±16.67	11.49±4.43	8.83±2.93
Worldwide Background Soil Standard		30 (10-50)	35 (10-50)	400 (100-700)

Table 3: The hazard indices and excess lifetime cancer risk for well 1

S/N	Depth (m)	ADR ($nGyh^{-1}$)	AGED (μSvy^{-1})	Ra_{eq} ($Bqkg^{-1}$)	H_{ex}	H_{in}	I_{yr}	AEDE (outdoor)	AEDE (indoor)	ELCR $\times 10^{-3}$
1	20	18.03	122.05	38.98	0.105	0.138	0.28	22.11	88.45	0.077
2	40	16.80	114.39	36.64	0.099	0.137	0.26	20.60	82.41	0.072
3	60	14.98	103.51	33.00	0.089	0.078	0.23	17.17	73.48	0.060
4	80	12.27	69.67	26.53	0.072	0.098	0.19	15.05	60.19	0.052
5	100	14.88	102.25	32.25	0.087	0.123	0.23	18.25	72.99	0.064
6	120	20.23	137.84	43.72	0.118	0.159	0.31	24.81	99.24	0.087
7	140	17.41	119.38	38.42	0.103	0.154	0.27	21.35	85.41	0.075

8	160	13.10	92.22	28.63	0.077	0.123	0.20	16.06	64.23	0.056
9	180	9.57	65.24	20.53	0.055	0.073	0.15	11.74	46.95	0.041
10	200	14.75	100.87	33.25	0.087	0.124	0.23	18.08	72.35	0.063
Average		**15.20**	**102.74**	**34.19**	**0.089**	**0.1053**	**0.21**	**18.08**	**74.57**	**0.065**

Table 4: The hazard indices and excess lifetime cancer risk for well 2

S/N	Depth (m)	ADR ($nGyh^{-1}$)	AGED (μSvy^{-1})	Ra_{eq} ($Bqkg^{-1}$)	H_{ex}	H_{in}	I_{yr}	AEDE (outdoor)	AEDE (indoor)	ELCR $\times 10^{-3}$
1	20	17.88	123.29	38.82	0.105	0.150	0.28	21.92	87.71	0.077
2	40	12.35	85.14	27.16	0.073	0.109	0.19	15.15	60.58	0.053
3	60	13.73	93.26	29.65	0.080	0.106	0.21	16.84	67.35	0.058
4	80	11.46	77.82	24.84	0.067	0.090	0.18	14.05	56.22	0.049
5	100	14.67	100.90	31.75	0.085	0.120	0.15	17.99	71.96	0.063
6	120	12.41	86.15	26.83	0.073	0.104	0.19	15.22	60.88	0.053
7	140	10.45	71.80	21.97	0.059	0.080	0.16	12.81	51.26	0.045
Average		**13.30**	**91.19**	**28.72**	**0.077**	**0.108**	**0.19**	**16.28**	**65.14**	**0.057**

ISSN2305-8269
International Journal of Engineering and Applied Sciences

www.eaas-journal.org

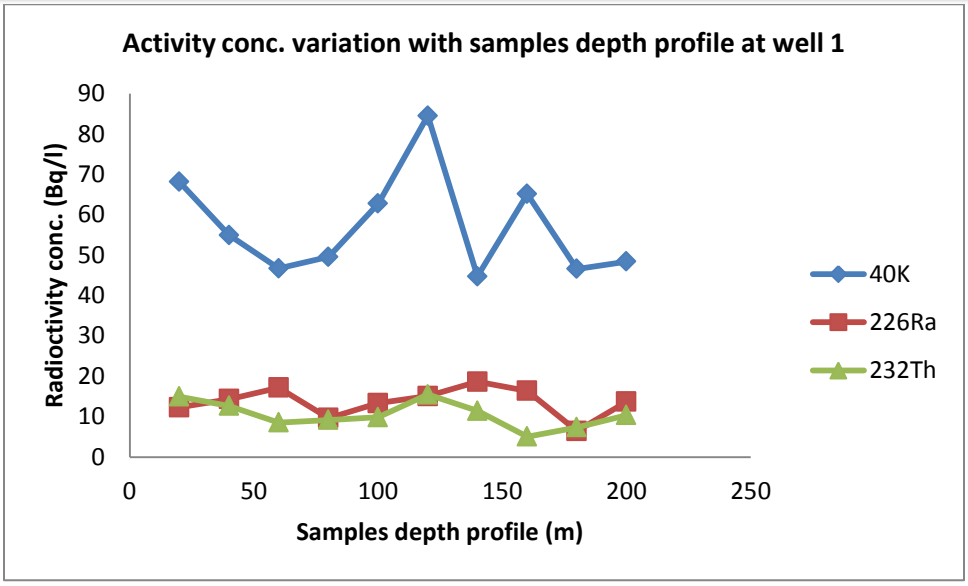

Fig 1: Radioactivity concentration variation with soil profile depth of well1

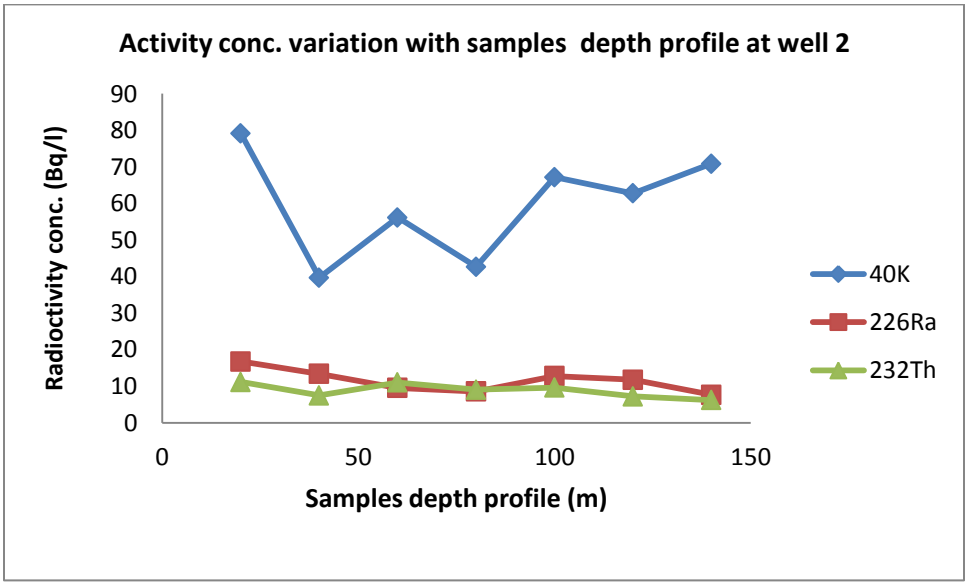

Fig 2: Radioactivity concentration variation with soil profile depth of well 2