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Computation of the Percentage Risk Levels of Radioisotopes of ²²⁶RA, ²³²TH, And ⁴⁰K in Hydrocarbon Degraded Soil Environment.

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ABSTRACT:Computation of the percentage Risk contributions of the radioisotopes²²⁶Ra, ²³²Th, and ⁴⁰K in typical hydrocarbon degraded oil field environment was conducted using Pearson excel sheet correlation coefficients. The plot of the average radium equivalent (R_{eq}) activity in fields 1,2,3,4, and 5 versus average activity concentration of radium-226, thorium-232 and potassium-40 produced correlation coefficients of [0.2066, 0.8346, 0.8482], [0.8001, 0.7907, 0.5281], [0.6151, 0.0494, 0.2019], 0.7068, 0.3909, 0.0630], [0.7643, 0.3432, 0.0243] respectively. The percentage risk contributions of ²²⁶Ra in Fields 1,2,3,4 and 5 are 11%, 38%, 71%, 61%, and 57% respectively. The percentage risk contributions of ²³²Th in Fields 1,2,3,4 and 5 are 44%, 37%, 6%, 34%, and 25% respectively. Similarly the percentage risk contributions of ⁴⁰K in Fields 1,2,3,4 and 5 are 45%, 25%, 23%, 5%, and 18% respectively. The study revealed that ²²⁶Ra has high percentage contributions in three out of the five oil spilled sites, and was low in Field 1. Erection of post signs is therefore recommended as a warning to deter people from farming on the affected soil or bathing in a nearby stream where the crude oil may have flowed into.

KEYWORDS: Computation, Correlation coefficients, Environment, Radioisotopes, Risk

I. INTRODUCTION

Environmental pollution may emanate through oil spill and many researchers have shown that there are hazards associated with crude oil spill. Anything that can cause elevation of radioisotopes in the human environment can be termed pollutant. This study used correlation between two very important health hazard parameters to ascertain hazard levels. Basically environmental pollution occurs on land, in air and in water. These are the receiving media through which animals and human beings can feel the impact of the environmental degradation.

Natural environmental radioactivity arises mainly from premordal radionuclides such as ²²⁶Ra, ²³²Th, ⁴⁰K and their decay products [1].Oil spills have posed a major threat to the environment of the oil producing areas, which if not effectively checked can lead to the total destruction of ecosystems [2]. Niger Delta is commonly being affected by the slow poisoning of the waters and the destruction of vegetation and agricultural land by oil spills which occur during petroleum exploration and exploitation [3]. Oil spilled on land often reaches lakes, rivers, and wetlands, where it can also cause damage. The environmental impact of crude oil spill on land and marine biodiversity has been proven to be devastating, for example, the case of Ogoni land as stated in the UNEP report [4]. The spillage could also occur or spread to the soil surface and thereby contaminating the soil with a gross effect upon the terrestrial life. Oil vapours can cause damage to the animal's central nervous system, liver, and lungs. Animals are also at risk from ingesting oil, which can reduce the animal's ability to eat or digest its food by damaging the cells in the intestinal tract [5].The activity levels and availability of naturally occurring radioactive radionuclides can be significantly altered by processes in the oil and gas, and mining industries [6]. The effect of radiation on the human body depends mainly on the dose of radiation taken, duration of radiation, type of radiation and the sensitivity of the part of the body exposed to it [7], [8],



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[9]. According to [10], other factors include type of radiation, age of individual, total dose, type of cell, tissue volume exposed, state of cell division, duration of exposure. In the case of spill on water, the oil spreads immediately on the surface of the water and sometimes travels a very long distance depending on the magnitude of oil spillage and rate of dispersion. The rate at which an oil spill spreads will determine its effect on the environment [5]. Most oils tend to spread horizontally in water into a smooth and slippery surface, called a slick, on top of the water. Factors which affect the ability of an oil spill to spread include surface tension, specific gravity, and viscosity [5]. While some components of the hydrocarbon could get evaporated into the atmosphere, some dissolve in the water body and impact negatively on the aquatic body.

Terrestrial outdoor radiation usually comes from naturally occurring radioactive isotopes. These isotopes have long half-lives present in the environment. They can be elevated through the action of man on planet earth. Shipment of oil from the Nigerian coast in commercial quantities started as far back as 1958, it was not until some thirty years later that attention was drawn to the havoc being wreaked on the environment by the oil companies, [11]. In this study correlation coefficients were used to evaluate the relationship between the radium equivalent activity and nuclides activity concentration. The result yielded percentage distributions of the radionuclides of ²²⁶Ra, ²³² Th, and ⁴⁰K to health risk.

II. METHOD

There are many types of correlation coefficient formulae but Pearson's correlation coefficient formula was used. The basic theory in the formula is represented as

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$$
(1)

where x and y are the variables and n the number of reading. The formula returns a value between -1 and 1, where:

- 1 indicates a strong positive relationship.
- -1 indicates a strong negative relationship.
- A result of zero indicates no relationship at all.



Fig. 1: Graphs showing a correlation of -1, 0 and +1



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Vol. 7, Issue 7, July 2018

The relationship between radium equivalent activity and each activity concentration of radioisotopes was considered. Radium equivalent activity index (Ra_{eq}) is a radiological index which represents the activity levels of ²²⁶Ra, ²³²Th and ⁴⁰K by a single quantity and also takes into account the radiation hazards associated with them [12]. Radium equivalent activity is mathematically defined by [13] as $Ra_{eq} = C_{Ra} + 1.43C_{Th} + 0.077C_{K}$ (2)

activity is mathematically defined by [13] as $Ra_{eq} = C_{Ra} + 1.43C_{Th} + 0.077C_{K}$ (2) where C_{Ra} , C_{Th} and C_{K} are the activity concentrations of ²²⁶Ra, ²³²Th and ⁴⁰K respectively. In the above relation, it has been assumed that 10 Bqkg⁻¹ of ²²⁶Ra, 7 Bqkg⁻¹ of ²³²Th and 130 Bqkg⁻¹ of ⁴⁰K produce equal gamma dose. The maximum value of Ra_{eq} in soil must be less than 370 Bqkg⁻¹ [14] otherwise it is regarded as being above permissible level. The activity concentrations (C) in Bqkg⁻¹ of the radionuclides in the samples could be calculated after decay correction using the expression:

$$C_{s} = \frac{N_{Ey}}{\varepsilon_{Ey} x M_{s} x t_{c} x P_{y}} \quad (Bqkg^{-1}) \tag{3}$$
Where C = Sample concentration, N_P, net peak area of a peak at energy, $\varepsilon_{P} = \text{Efficiency of th}$

Where $C_s =$ Sample concentration, $N_{Ey=}$ net peak area of a peak at energy, $\varepsilon_{Ey} =$ Efficiency of the detector for a γ -energy of interest, $M_s =$ Sample mass, $t_c =$ total counting time, $P_{\gamma} =$ Emission probability of radionuclide of interest.

These values were then subjected to Pearson Excel Sheet plotting. Correlation is a measure of the relationship or association between two variables. The relationship may indicate both the direction and the degree to which they covary with one another from case to case. The implication may be that one is causing the other or that one is not causing the other.

III. RESULTS AND DISCUSSION

RESULT

Radium Equivalent Activity and Average Activity concentrations are presented in Table 1 while Table 2 shows the correlation coefficients. The degree to which the radium equivalent activity co-varied with radionuclides of radium, thorium and potassium activities are presented in Figures 2 to 6. The percentage risk contributions and distributions of Radioisotopes of ²²⁶Ra, ²³² Th, and ⁴⁰K are shown in Figure 7.

S/N	Location	²²⁶ Ra Bq/kg	²³² Th Bq/kg	⁴⁰ K Bq/kg	Raeq Bq/kg
1	Field 1	29.30±4.40	58.10±2.14	185.70±9.54	126.66±8.97
2	Field 2	31.03±4.19	60.51±3.87	145.66±6.02	128.68±9.69
3	Field 3	62.06±3.38	61.15±1.78	177.81±7.80	161.77±7.03
4	Field 4	28.25±4.20	56.27±2.34	170.37±8.77	119.48±8.22
5	Field 5	54.83±3.15	53.63±2.68	193.37±8.53	146.12±7.69
World Standard		35	30	400	≤370

Table 1: Radium Equivalent Activity and Average Activity concentrations.

Table 1 above shows values of Radium equivalent activity concentrations



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S/N	Location	²²⁶ Ra	²³² Th	⁴⁰ K
1	Field 1	0.2066	0.8346	0.8482
2	Field 2	0.8001	0.7907	0.5281
3	Field 3	0.6151	0.0494	0.2019
4	Field 4	0.7068	0.3909	0.063
5	Field 5	0.7643	0.3432	0.02429

Table 2: Correlation coefficients

The values of correlation coefficients are shown if table 2 above





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Fig. 2:Correlation of Ra-226, Th-232, K-40 activity concentration and radium equivalent at Field 1.

The degree to which the radium equivalent activity co-varied with radionuclides of radium, thorium and potassium activities are presented in Figure 2 above.





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Fig. 3:Correlation of Ra-226, Th-232, K-40 activity concentration and radium equivalent at Field 2.

The degree to which the radium equivalent activity co-varied with radionuclides of radium, thorium and potassium activities are presented in Figure 3 above.





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Fig. 4: Correlation of Ra-226, Th-232, K-40 activity concentration and radium equivalent at Field 3.

The degree to which the radium equivalent activity co-varied with radionuclides of radium, thorium and potassium activities are presented in Figure 4 above.





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Fig. 5: Correlation of Ra-226, Th-232, K-40 activity concentration and radium equivalent at Field 4.

The degree to which the radium equivalent activity co-varied with radionuclides of radium, thorium and potassium activities are presented in Figure 5 above.





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Fig. 6: Correlation of Ra-226, Th-232, K-40 activity concentration and radium equivalent at Field 5.

The degree to which the radium equivalent activity co-varied with radionuclides of radium, thorium and potassium activities are presented in Figure 6 above.





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Vol. 7, Issue 7, July 2018



Fig. 7: Percentage risk contributions of 226 Ra, 232 Th, and 40 K to health hazard in field 1, 2, 3, 4, 5

The percentage risk contributions of radionuclides of ²²⁶Ra, ²³²Th and ⁴⁰K in fields 1,2,3,4,5 are in the order of [11%,

44% and 45%], [38%, 37% and 25%], [71%, 6% and 23%], [61%, 34% and 5%], [57%, 25% and 18%] respectively.

IV. DISCUSSION

In Field 1 crude oil spill site, the correlation coefficient of radionuclides ²²⁶Ra, ²³²Th, ⁴⁰K and Ra_{eq} activity concentration are 0.2066, 0.8346, 0.8482 respectively. In Field 2 crude oil spill site, the correlation coefficient of radionuclides ²²⁶Ra, ²³²Th, ⁴⁰K and Ra_{eq} activity concentration are 0.8001, 0.7907, 0.5281 respectively. In Field 3 crude oil spill site the correlation coefficient of radionuclides ²²⁶Ra, ²³²Th, ⁴⁰K and Ra_{eq} activity concentration are 0.8001, 0.7907, 0.5281 respectively. In Field 3 crude oil spill site the correlation coefficient of radionuclides ²²⁶Ra, ²³²Th, ⁴⁰K and Ra_{eq} activity concentration are 0.6151, 0.0494, 0.2019 respectively. In Field 4 crude oil spill site the correlation coefficient of radionuclides ²²⁶Ra, ²³²Th, ⁴⁰K and Ra_{eq} activity concentration are 0.7068, 0.3909, 0.0630 respectively. In Field 5 crude oil spill site the correlation coefficient of radionuclides ²²⁶Ra, ²³²Th, ⁴⁰K and Ra_{eq} activity concentration are 0.7643, 0.3432, 0.2429 respectively. The expression y = 1.2436x + 90.22 for example is the correlation equation. 90.222 is the intercept while 1.2436 is the gradient. R² is the correlation coefficient. The same is applicable to the other equations. Radium showed weak relation with Equivalent activity in Fields 3, 4, 5 but strong in Fields 1 and 2. Potassium-40 showed weak relation with Equivalent Activity in Fields 3, 4, and 5.

In Field1, risk contributions of ²²⁶Ra, ²³²Th, and ⁴⁰K are in the order of 11%, 44% and 45% respectively. The percentage risk contributions of radionuclides of ²²⁶Ra, ²³²Th and ⁴⁰K in Field 2 are in the order of 38%, 37% and 25% respectively. In Field 3 ²²⁶Ra, ²³²Th and ⁴⁰K contributed 71%, 6% and 23% respectively. In Field 4 ²²⁶Ra, ²³²Th and ⁴⁰K contributed 71%, 6% and 23% respectively. In Field 4 ²²⁶Ra, ²³²Th and ⁴⁰K contributed 71%, 6% and 23% respectively. In Field 4 ²²⁶Ra, ²³²Th and ⁴⁰K contributed 61%, 34% and 5% respectively. The percentage risk contributions of radionuclides of ²²⁶Ra, ²³²Th and ⁴⁰K in Field 5 are in the order of 57%, 25% and 18% respectively. These values are comparable to those obtained by [16], which showed the percentage contribution of each of these radionuclides as; 64.77% for radium-226, 3.13% for thorium-232 and 32.10% for potassium-40.

V. CONCLUSION

Correlation coefficients of activity of nuclides of ²²⁶Ra, ²³²Th, and ⁴⁰K and Radium Equivalent activity has provided the hazard each identified radioisotope contributed to the total percentage ionizing radiation health risk in the oil fields investigated. The percentage risk contributions of radionuclides of ²²⁶Ra, ²³²Th and ⁴⁰K in fields 1,2,3,4,5 are in the order of [11%, 44% and 45%], [38%, 37% and 25%], [71%, 6% and 23%], [61%, 34% and 5%], [57%, 25% and 18%]



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Vol. 7, Issue 7, July 2018

respectively. In general these radioisotopes have low risk impact in the degraded Oil Fields. On the other hand, no amount of elevation should be neglected therefore the areashould be environmentally remediated.

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