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Determination of Radionuclide Levels in Soil and Water around Cement Companies in Port Harcourt

AVWIRI, G O

Department of Physics, university of Port Harcourt, P. M. B. 5323, Port Harcourt, Nigeria

ABSTRACT: The study of the radionuclide concentration levels in soil and water samples in Eagle, Atlas and rock cement companies in Port Harcourt was carried out. Soil and water samples collected from the respective premises were analyzed using the gamma -ray spectrometry. The average absorbed dose rates of the soil samples were 49.27nGy/h, 45.21nGy/h and 42.33nGy/h for Eagle, Atlas and Rock cements respectively while the water values were 22.16nGy/h, 20.75nGy/h and 19.37nGy/h for the respective companies. Mean dose rate equivalents of 0.18mSv/y and 0.39mS/y were obtained for the water and soil samples. These results are lower than the International Commission on Radiological Protection (ICRP) maximum permitted limit and therefore, have no significance radiological health burden on the environment and the populace. @JASEM

Industrial and domestic activities such as oil exploration and exploitation, manufacturing and process industries may lead to the perturbation of the natural ecosystem and the environment that ultimately occurs as pollution. Increase in the background ionization radiation from numerous sources has various health side effects on the populace. Some of the sources of radiations are cosmic rays and natural radionuclide in air, food and drinking water (NCRP, 1976). Radiation exposure can be external: natural radionuclides and cosmic rays and internal: food, drinking water and the mineral contents of the body. The natural radionuclides in the earth or soil and water of an environment are present as daughters of uranium (^{238}U), thorium (^{232}Th) isotopes distributed by natural geological and geochemical processes in addition to potassium (4%) and small quantities of fission-product residues ^{137}Cs from atmospheric weapon test (Trimble, 1968). Exposure to excess level of background ionization radiation causes somatic and genetic effects that tend to damage critical and/or radiosensitive organs of the body, which ultimately can lead to death (Ajayi, 1999). The major raw materials for the production of cement are limestone ($CaCO_3$), shale ash and ion oxide. They also contain some elements like gypsum, which contains silicates and aluminates that have ionization tendency (White, 1981).

The natural radionuclide levels have been studied in surface soils in Ijero-Ekiti (Ajayi, et, al. (1995)), in soil and water around a cement company in Ewekoro by Jubiri et, al. (1999) and in rocks found in Ekiti by Ajayi et, al(1999). Results from these studies revealed non-significant levels of radionuclides in the environment. Port Harcourt, a major seaport in the Niger-Delta, plays host to a number of companies that are involve in manufacturing, packaging, processing and oil activities. The various rivers criss-crossing the city encourage the sitting of industries in the hinterland. Three cement companies, sited at Onne and Rumuolumeni exist in the city. They are Eagle, Rock and Atlas cements. Their main operations involve the bulk importation of the cement (dust) and then packaging into various sizes for domestic and industrial usages. Part of the operations take place in the ship berthed in the river such as the New Calabar River for Eagle cement and River Nmu Ngololo for Rock and Atlas cements. The locations of these companies are shown in Figures 1 and 2.

The awareness of the potential degradation of the environment by the activities of these companies is on the increase and there have been various claims and counterclaims of degradation of the surface soil and rivers by the host communities. This study, therefore, determine the level of natural radionuclide concentrations in the soil and water in around the plants, estimates the level of degradation of the radioactive equilibrium of the areas and ascertain the radiological health side effects on the populace and the environment.

EXPERIMENTAL METHODS

Sample Collection and Preparation: Nine soil samples of about 500g were collected from the respective cement company's premises and three samples were collected from the host community as indicated in Table 1to serve for comparative assessment. The samples were kept in polyethene bags and were properly labeled as shown in Table 1 and taken to the laboratory for gamma (γ) ray analysis. The water samples were collected from the rivers where the ships are berthed. About 6 litres of water were collected at three points in each river. They are the berthing position of the ship, 500m upstream and 500m downstream. The water samples were stored in a refrigerator and kept for 30 days for secular equilibrium to be established before the γ-ray analysis.

*Corresponding author: Email: goavwiri@yahoo.com

Table 1: Sampling Points of Soil and Water Samples

Location Index	Locations
S_{11}	Entrance Gate of Eagle Cement Co.
S_{12}	Storage/Bagging Area of Eagle Cement Co.
S_{13}	Admin Block Area of Eagle Cement Co.
S_{21}	Entrance gate of Atlas Cement Co.
S_{22}	Bagging Area of Atlas Cement Co.
S_{23}	Onne Community, hosting Atlas Cement Co.
S_{31}	Loading Area of Rock Cement Co.
S_{32}	Bagging Area of Rock Cement Co.
S_{33}	Admin Block of Rock Cement Co.
W_{11}	500m upstream of Eagle Cement Co along New Calabar River
W12	Berthing Station of Ship/vessel
W13	500m downstream of Eagle Cement along New Calabar River
W_{21}	500m upstream of Atlas Cement Co along Nmu Ngololo River (FOT)
W_{22}	Berthing Station of Ship/vessel
W_{23}	500m downstream of Atlas Cement Co. a long Nmu Ngololo Rivers (FOT)
W_{31}	500m upstream of Rock Cement Co. along Nmu Ngololo River (FOT)
W_{32}	Benthing Station of Ship/vessel
W_{33}	500m downstream of Rock Cement Co. along Nmu Ngololo River (FOT)

Legend: 1st digit indicates sample Number, 2nd digit indicates company i.e Eagle = 1, Atlas = 2, Rock = 3
Letter indicates type of sample – S = Soil, W = Water

Gamma (γ) ray Analysis: The method of γ-ray spectrometry as has been severally reported (Ajayi et, al. (1990)), Jubiri, et, al. (1999) was adopted in the analysis. The spectrometer consists of a Canberra 7.6cm by 7.6cm NaI (Tl) (Model No 802 – series) detector coupled to a Canberra series 10 plus Multichannel Analyzer (MCA) through a pre-amplifier base. The transition lines of 1.460 MeV of ^{40}K, 1764.5 KeV of ^{214}Bi and 2614.7Kev of ^{208}Tl were used to determine the concentrations of ^{40}k, ^{238}U and ^{232}Th respectively. The soil samples were sieved through a 2mm mesh screen and then placed in a container for 28 days to enable them reach secular equilibrium before the analysis. The spectral for the soils were measured by counting for 2 hours and the area under the photo peaks were computed using the algorithm of the MCA. The water samples were transferred to a one-litre Marinelli sample container, which fits into the detector. Counting was done for 10 hours because of the natural low activities of radionuclides in water. The areas under the photopeaks were similarly computed as in the soil samples. Environmental shielding for the water was achieved using a Canberra 10cm thick lead castle and 5cm thick lead castle was used for the soil (Farai and Sanni, 1992).

The specific activity concentrations A_{ck}, A_{cu} and A_{cTh} for ^{40}K, ^{238}U and ^{232}Th respectively were computed using the relation (Beck, et. al, 1972).

$$Ac = \frac{AA^{S}cm^{s}}{A^{s}m.} \quad (1)$$

Where Ac = activity of sample, A = full peak area of samples, A^sc = activity concentration of standard sample, m^s= mass of standard sample, A^s = full peak of the standard sample and m = mass of sample.

The absorbed dose rates D, at 1.0m above the ground were calculated using the Beck, et al. (1972) relation.

$$D = 0.042\, Ac_K + 0.429 Ac_U + 0.666 Ac_{Th}. \quad (2)$$

Where 0.042 = Dose constant for ^{40}K, 0.429 = dose constant for ^{238}U and 0.666 dose constant for ^{232}Th. Using the conversion factor of 0.70Sv/Gy (UNSCEAR), 1988), the dose equivalents in mSv/y were computed.

RESULTS AND DISCUSSION

The mean specific activities of the radionuclides concentration levels are presented in Tables 2 and 3 for soil and water samples respectively. Table 4 shows the calculated absorbed dose rates for all samples. The average absorbed dose rates of soil samples range from 49.27 nGy/h for Eagle Cement to 42.35nGy/h for the Rock cement and from 22.16 nGy/h to 19.37 nGy/h for the Eagle cement and Rock Cement's water samples respectively. The values of the dose equivalents of the soil samples for all the companies are lower than the average world soil average of 0.7mSv/y (ICRP, 1991). The dose equivalents of all samples are comparable with those reported in literature (Myrick, et al (1983) and Jubiri et, al. (1999). The results show that the Eagle cement company, with longer period of operation has higher absorbed dose rates than the newly established Atlas and Rock Cements. The trend of the results in the soil samples shows that the specific activities of the radionuclides are higher in the storage/baggage area for the companies compared to the other areas within the premises. Also, the radionuclides activities are higher than that of the host community. These results suggest that the sitting of the companies may have degraded the immediate environment minimally. The water samples revealed that the dose rates are highest at the berthing/baggaging stations with a gradual decrease downstream. Though the dose equivalents are within the acceptable values for water, the toxicity of cement will naturally perturb the chemical equilibrium of the riverbanks thus making them unsuitable for natural fish breeding.

Table 2: Mean Specific Activities of the radionuclides in the Soil Samples

SL	Radionuclides concentration (Bg/kg)			Abs. Dose rate nGy/h
	^{40}K	^{238}U	^{232}Th.	
S_{11}	241.21	82.02	6.41	49.60
S_{12}	654.12	61.41	4.50	56.92
S_{13}	463.23	43.33	4.91	41.31
S_{21}	389.21	51.21	7.53	43.32
S_{22}	542.02	56.55	6.81	51.52
S_{23}	315.64	45.54	3.01	34.79
S_{31}	564.2	25.14.	3.32	36.68
S_{32}	772.19	23.31	8.22	47.91
S_{33}	315.24	6061	4.85	42.47
MEAN	473.9S± 165.27	49.90 ± 17.34	5.51 ± 1.72	44.95 ± 6.75

Table 3. Mean Specific Activities of the Radionuclides In Water Samples

SL	Radionuclides concentration (Bg/l)			Abs. Dose rate nGy/h
	^{40}K	^{238}U	^{232}Th.	
W_{11}	0.1210	41.20	0.0342	17.70
W_{12}	0.1614	60.31	0.0480	28.91
W_{13}	0.1412	53.23	0.0582	22.87
W_{21}	0.3143	32.11	0.0312	13.81
W_{22}	0.6631	71.21	0.0901	30.63
W_{23}	0.5214	41.34	0.0622	17.80
W_{31}	0.2978	35.27	0.0021	15.18
W_{32}	0.4321	56.38	0.0070	24.21
W_{33}	0.610	43.56	0.0081	18.72
MEAN	0.3624± 0.19	48.29 ±12.07	0.0379± 0.0296	20.76 ± 5.18

Generally, these results show that the radiological health burden due to the operations of these companies on the human populace is very insignificant and has neither health implications nor affect the background ionization radiation and the results obtained could therefore be that due to natural ionization radiation of the environment.

Conclusion: The study of the radionuclide concentration levels in soil and water in/around Eagle, Rock and Atlas cement companies in Port Harcourt has been carried out. The average dose rates equivalent of 0.18mSv/y and 0.39 mSv/y were obtained for the water and soil samples respectively. These values are lower than the MPL and therefore do not pose health problems to the populace of the host communities and do not affect the background ionization radiation of the environment. However, these values may increase with longer period of operation.

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Table 4. Absorbed Dose Rates in Soil and Water In mSv/y

Sample location	Absorbed dose rate (nGy/h)	mSv/y
S_{11}	49.60	0.42
S_{12}	56.92	0.48
S_{13}	41.31	0.35
S_{21}	43.32	0.39
S_{22}	51.52	0.44
S_{23}	34.79	0.30
S_{31}	36.68	0.31
S_{32}	47.91	0.41
S_{33}	42.47	0.36
W_{11}	17.70	0.15
W_{12}	25.91	0.22
W_{13}	22.87	0.19
W_{21}	13.81	0.12
W_{22}	30.63	0.26
W_{23}	17.80	0.15
W_{31}	15.18	0.13
W_{32}	24.21	0.21
W_{33}	18.72	0.16

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