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Assessment of Natural Radioactivity in a Decommissioned Fertilizer Plant Complex in Onne, Rivers State, Nigeria

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ABSTRACT

Phosphate ore is the major raw material for the production of phosphate fertilizers and contain significant amount of natural radioactivity of mainly uranium-238(^{238}U), thorium-232 (^{232}Th) and potassium-40(^{40}K) due to geological reasons. The mean activity concentration of radionuclides in the soil samples within the decommissioned fertilizer plant complex for ^{226}Ra was 58 ± 2.8 Bqkg^{-1} (range 34.5 ± 5.3 to 61.67 ± 4.1 Bqkg^{1}), for ^{232}Th, 34.3 ± 1.0 Bqkg^{-1} (range 19.67 ± 1.6 to 43.27 ± 3.7 Bqkg^{-1}) and for ^{40}K was 25.58 ± 8 Bqkg^{-1} (range 5.9 ± 3.1 to 49.7± 0.6 Bqkg^{-1}). The mean activity concentration of ^{226}Ra, ^{232}Th and ^{40}K radionuclides in the control soil samples were 8.3 ± 1.5 Bqkg^{-1}, 2.9 ± 1.1 Bqkg^{-1} and 85 ± 9.2 Bqkg^{-1} respectively. The mean activity concentration of ^{226}Ra, ^{232}Th and ^{40}K radionuclides in vegetation samples were 22.8 ± 2.5 Bqkg^{-1}, 12.4 ± 1.2 Bqkg^{-1} and 253.8 ± 2.3 Bqkg^{-1} respectively. The mean activity concentration of ^{226}Ra, ^{232}Th and ^{40}K radionuclides in the control grass samples were BDL, 2.7 ± 1.3 Bqkg^{-1} and 236 ± 8.1 Bqkg^{-1} respectively. There is need for remediation if a decommissioned fertilizer plant complex will be used for residential purposes.

Introduction

Phosphate ore is the major raw material for the production of phosphate fertilizers. Phosphate ore contain significant amount of natural radioactivity of mainly uranium-238(^{238}U), thorium-232 (^{232}Th) and potassium-40(^{40}K) due to geological reasons (Halbert et al.,1990; Banzi et al.,2002). Due to the natural presence of ^{238}U and its decay products in the phosphate rock, they are present in all the products and wastes associated with the processing of phosphate ore into fertilizer (Perianez andGarcia-Leon, 1992; Erdem et al., 1995; Marovic and Sencar, 1995). Phosphate ore dusts generated during the processing fall in the immediate vicinity of the fertilizer plant and the wastes from the fertilizer plant are discharged as effluents into the environment (World Bank, 1996). These discharges havebeenshowntocontainlarge quantitiesofprimordial radionuclides (Scholten andTimmermans, 2005, Okeji et al., 2012).These radionuclides introduced into the environment constitute great source of human exposure to the natural occurring radioactive materials (NORM). There is therefore need to assess the releases of these NORM in a decommissioned fertilizer plant complex especially if the fertilizer complex is to be applied for residential or other human activities. The aim of this study was to assess the radionuclides present in soil and vegetations in the premises of a ten-year old decommissioned fertilizer plant in Nigeria.

Materials and method

The study was conducted in a ten-year old decommissioned fertilizer plant complex (1998-2008) located in Onne, Rivers State, Nigeria on latitude 4.45`35` and longitude $7^0$26`34` East of Greenwich Meridian and about 30km away from Port Harcourt. The fertilizer plant had two sections. One for the production of phosphate fertilizer and the other for the production of ammonium based brands. The entire fertilizer complex was surveyed. The fertilizer complex was divided into ten grids or zones for sampling purposes. Three soil samples were collected from each of the grids or zones. Thesampleswerecollected at 5cmdepth,toexcludedeadorganicmatter(IAEA, 1989), in different clean and dry containers. Control samples were collected from uncultivated land 50 kmfrom the fertilizer complex. All the samples were air-dried at 33^{o}C to avoid loss of radionuclides (IAEA 1989). The dried samples each were pulverizedand made to pass through a 2 mm sieve. The samples were distinctly packed in plastic containers measuring 8.0 cm in diameter by 6.5 cm in height made to fit into the sodiumiodide (NaI) gamma spectrometer counting chamber and labelled with codes 1, 2, 3 for each sample. They were left for 28 days for short-lived radionuclides to attain secular equilibrium.The same treatment was applied to the control samples.The activity counting was carried out using a sodiumiodide (NaI) gamma spectroscopy system. The system consists of a 76 9 76 mm NaI (TL) detector [Model 802series] by Canberra Inc. connected to an Ortec series multichannel

analyzer (MCA) through a preamplifier base and coupled to a personal computer. The computer has anuninterrupted power supply connection (UPS) to maintain regular voltage and safeguard the data in the system. There is also an attached printer to the computer.

The detector has a resolution of about 8 % at 662 keV of ^{137}Cs and is capable of distinguishing the gamma ray energies likely to be encountered in the measurements of the samples. The system was calibrated and the quality control carried out using a standard reference material soil IAEA-226 and IAEA-375 whose concentration of natural radioactivity has been certified by the IAEA. The spectral analysis was carried out using MAESTRO Software which identifies the photo peak, deducts the background and gives the total area under the peak.

Result and discussion.

The mean activity concentration of radionuclides in the soil samples within the decommissioned fertilizer plant complex for ^{226}Ra was 58±2.8 Bqkg^{-1}(range 34.5 ± 5.3 to 61.67 ± 4.1 Bqkg^{1}), for ^{232}Th, 34.3 ± 1.0 Bqkg^{-1}(range 19.67 ± 1.6 to 43.27 ± 3.7 Bqkg^{-1}) and for ^{40}K was 25.58 ± 8 Bqkg^{-1} (range 5.9 ± 3.1 to 49.7± 0.6 Bqkg^{-1}).The mean activity concentration of ^{226}Ra, ^{232}Th and ^{40}K radionuclides in the control soil samples were 8.3 ± 1.5 Bqkg^{-1}, 2.9 ± 1.1 Bqkg^{-1} and 85 ± 9.2 Bqkg^{-1} respectively. The mean activity concentration of ^{226}Ra, ^{232}Th and ^{40}K radionuclides in vegetation samples were 22.8 ± 2.5 Bqkg^{-1}, 12.4 ± 1.2 Bqkg^{-1} and 253.8 ± 2.3 Bqkg^{-1} respectively. The mean activity concentration of ^{226}Ra, ^{232}Th and ^{40}K radionuclides in the control grass samples were BDL, 2.7±1.3Bqkg^{-1} and 236±8.1Bqkg^{-1} respectively.

The mean activity concentration of ^{226}Ra in soil samples is 1.7 times more than the world average of 35 Bqkg^{-1}, while that of ^{232}Th, 34.3 ± 1.0 Bqkg^{-1} and ^{40}K, 25.58 ± 8.0 Bqkg^{-1} respectively were below the world average in normal soil (UNSCEAR, 2000). The finding from our study is similar to that of Bolca et al (2006) in their study of radioactivity in soil amended with phosphate fertilizer in Gediz River Basin in Western Turkey. They found the range for ^{226}Ra, ^{232}Th and ^{40}K to be 46.05 - 68.83 Bqkg^{-1}, 9.29 – 50.5 Bqkg^{-1} and 325.89 – 530.52 Bqkg^{-1} respectively.

Table 1:Mean activity concentration of soil and vegetation samples

		Mean activity concentration (Bqkg^{-1})		
S/No	**Sample**	**^{226}Ra**	**^{232}Th**	**^{40}K**
1	Soil samples	58 ± 2.8	34.3 ± 1.0	25.58 ± 8.0
	Control soil samples	8.3 ± 1.5	2.9 ± 1.1	85 ± 9.2
	World average values	35	35	370
2	Vegetation samples	22.8 ± 2.5	12.4 ± 1.2	253.8 ± 2.3
	Control vegetation sample	BDL	2.7±1.3	236±8.1

Table 2: Calculated absorbed dose rate in air

Soil sample	Mean absorbed dose rate in air
Soil sample	79.1nGyh^{-1}
Control soil sample	9.06nGyh^{-1}
World average values	59nGyh^{-1}

The mean absorbed dose rate in air for the soil samples was 79.1nGyh^{-1}. This value is 1.3 times of world averageof 59 nGyh^{-1}. It is however 2.5 times the mean dose rate from soil samples around phosphate fertilizer plant in Egypt, which was 31.1nGyh^{-1} (Hamdy*et al.,* 2007).

Conclusion

The assessment of release of radionuclides in the immediate environment of a decommissioned phosphate fertilizer plant was conducted. The concentrations of the natural radionuclides in the soil samples were observed from our study to be above the world average in normal soil. From our finding, there is need for remediation if the complex housing a decommissioned fertilizer plant will be used for residential purposes.

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