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Radiation dose to the eyes of readers at the least distance of distinct vision from Nigerian daily newspapers

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Abstract: *This work reports the measurements of the radionuclide contents in some widely read daily newspapers published in Nigeria, using gamma spectrometry. The radionuclides detected in the newspapers measured consisted of the natural radionuclides belonging to the series headed by* ^{228}Ra *and* ^{226}Ra *as well as the singly occurring radionuclide* ^{40}K*. The mean activity concentrations obtained for* ^{40}K, ^{226}Ra *and* ^{228}Ra *respectively in the newspapers were 183.41±135.43, 9.06±3.64 and 6.11±1.36* $Bqkg^{-1}$*, 139.10±90.38, 7.58±1.87 and 5.29±1.33* $Bqkg^{-1}$ *and 152.10±114.32, 9.62±1.40 and 5.76±1.29* $Bqkg^{-1}$ *respectively from* P_1, P_2 *and* P_3*. The doses to the eyes due to the measured activity concentrations in the newspaper samples were determined for a distance of 0.25 m (least distance of distinct vision) from the eyes. The annual effective doses to the eye resulting from the activities of the radionuclides identified with observed regularity in all the newspaper samples, obtained in this study are 0.012±0.010, 0.010±0.009, 0.010±0.009* $\mu Sv\ y^{-1}$ *respectively for the newspapers. These values show that the doses to the lens of the eye from the Nigerian newspapers assessed in this work are very low compared to the annual dose limit of 15* $mSv\ y^{-1}$*.*

Keywords: newspapers, radioactivity, least distance of distinct vision, effective dose, eyes

I. INTRODUCTION

Environmental radiation comes from the sky, the earth and the air we breathe and the sources can be categorized as natural or man-made. The natural radionuclides, such as ^{40}K, ^{228}Ra and ^{226}Ra, constitute the bulk of the radionuclides present in the earth's crust [1]. Gamma rays emitted by ^{40}K and the members of the decay series of ^{232}Th and ^{238}U thus constitute the main source of external exposure to man.

This work is set to examine some Nigerian newspapers as single product in everyday circulation. Thousands of everyday products and materials containing radioactive materials are surfacing around the world. Common kitchen cheese graters, reclining chairs, bathroom tiles, women's handbags and tableware manufactured with contaminated metals have been identified, some after having been in circulation for a considerable period of time [2, 3, 4, 5, 6]. Others are fencing wire and fence posts, shovel blades, elevator buttons, airline parts and steel used in construction. While some include food, personal cosmetics, inclusive of soaps, shampoos, deodorants, toothpaste, mouthwash, body wash; furniture and bedsprings. Thousands of consumer goods and millions of grams of unfinished metal and its by-products have been found to contain low levels of radiation [7].

The effect of low-level ionizing radiation on the human population is considered to be a subject matter of contradictions; some researchers believe that all levels of ionizing radiations, no matter how low, are hazardous to health: whereas, the other says that an adaptive mechanism is formed within the human body due to a certain level of exposure below which the health effects on organisms are negligible [8].This study is not intended to give any affirmation of either view. Succinct discussions on these are available in literatures.The divergence of opinion among stakeholders may impact whether health protection criteria expressed in terms of exposure to radioactive contamination, for instance as radiation dose or intakes of radionuclides, are acknowledged as representative of a particular level of protection expressed in terms of risk. Granted explicit consideration, we suggest that different views among stakeholders about such issues should be recognised. This study is set to quantify the level of radiation in one of the materials found in the environment, especially those in daily use so as to estimate the biological hazard that could be posed by them. A study of this sort will definitely add to our knowledge of radioactivity in materials around us, thereby increasing the available data.

Paper is the number one material that is thrown away. For every 100 kg of trash, 35 kg is paper [9]. Newspapers take up about 14 percent of landfill space, and paper used in packaging accounts for another 15 to 20 percent [9]. This shows how much of paper products are in daily use. Amidst other factors, the origin of the radiation hazard in newspapers may be the materials from which the newspapers are made [10]. Uptake of radionuclides in the environment by trees may be the source of radioactivity in the newspapers. Hence, the types of radioactivity in the newspapers depend on the environment of the place where the raw material is taken from.

Newspapers may be considered, though at low level, as a contributor to radioactivity in libraries, offices, homes and other places where they may be stored. Various studies have been carried out on books produced from different parts of the world; while recording certain levels of natural and artificial radionuclides in books [8, 10, 12, 13], data on newspapers are seemingly scare if available at all.

The purpose of this study is to determine the radioactivity levels of some Nigerian Daily Newspapers, by taking precise measurements of their radionuclide contents and calculating the dose rate due to the activity of the radionuclides found in them. Hence this work will afford one of the preliminary information in the archive of environmental radiation. The data was used to investigate the level of radiological hazards due to exposure to these newspapers at the least distance of distinct vision for the eye (LDDV).

II. MATERIALS AND METHODS

The samples analysed in this study were newspapers from three different publishers, designated as P_1, P_2 and P_3. These three dailies were chosen because they are the most preferred newspapers by the Nigerian populace. Several copies of the newspapers were collected directly from the respective publishers as well as from major vendors and some individuals. Future research may consider the effect of this sampling approach on the overall result. The papers were kept at room temperature; 27^{o}C and relative humidity of about 70%, for more than three months. The papers were then shredded into small sizes and packed into standard cylindrical plastic cans. Prior to packaging, the cans were thoroughly washed with dilute HNO_3 (0.5M) and rinsed with distilled water. This ensured dissolution of residual particles on the surface (internal and external) of the cans. Ten samples from each of the dailies were prepared, to make a total of thirty samples. The mass of each sample was carefully measured using a digital weighing balance (ADAM^{R} model) with 0.01 g accuracy. The cans were tightly sealed and kept in the laboratory for more than 28 days to ensure there was secular radioactive equilibrium. The samples were then analysed for radionuclide concentrations at the Gamma Laboratory of the Centre for Energy Research and Development, ObafemiAwolowo University, Ile-Ife.

The spectrometer consists of a high efficiency NaI(Tl), 3m3/3 Canberra model enclosed in a 100 mm thick lead shield, coupled to a versatile 2048-channel multichannel analyser (MCA) which uses S100 Canberra software. The detector was placed in the centre of the shield in order to minimize the effect of scattered radiations. The detector was calibrated to display photopeaks within the energy range of interest (60 to 2,000 keV), using a mixed multi-nuclide standard source from IAEA, Vienna. The choice of gamma-ray peaks of the radionuclides used for measurements was made taking into account, the modest energy resolution of the NaI(Tl) detector used in the present study. The activity concentrations of ^{228}Ra and ^{226}Ra were determined indirectly from the gamma-rays emitted by their progenies: ^{228}Ac (911.07 keV, 29.0%) and ^{208}Tl (583.19 keV, 86.0%) for ^{228}Ra, ^{214}Bi (1764.49 keV, 15.1%; 1120.30 keV, 15.7%; 609.31 keV, 46.1%) and ^{214}Pb (351.92 keV, 37.1%) for ^{226}Ra while that of ^{40}K was determined by its gamma-line of 1460.75 keV (10.5%). Each sample was placed on the detector and counted with a counting time of 36,000 s. The background measurements were taken with an empty can of the same geometry as the samples for 36,000 s and the average subtracted from the spectrum of the sample. In plants, the radioactivity of ^{232}Th and ^{238}U are lesser than the radioactivity of ^{228}Ra and ^{226}Ra because plants absorb radium preferentially to thorium and uranium [10]. The activity A_i, for radionuclide i, in each newspaper sample was determined using the relation:

$$A_i = \frac{C_i}{\varepsilon \times I_\gamma} \quad (1)$$

whereC_i is the net peak area in cps, ε is the counting efficiency of the detector at energy E (keV) and I_γ is abundance of gamma emissions per radioactive decay.

2.1 Estimation of Dose and Annual Effective Dose at LDDV

The doses to the eyes due to the measured activity in the newspaper samples were calculated while making the following assumptions:

- That the newspaper was held at a distance of 0.25 m (LDDV) from the eyes.
- That the activity in newspaper was uniformly distributed in the material of the newspaper.
- That the newspaper was kept open for reading at approximately half the number of pages, e.g., at page 20 of a 40 page newspaper, to keep the source evenly distributed.

The dose, D (µSv h^{-1}), to the eyes at LDDV from the source was calculated by using Equation 2 [8]:

$$D = 4\pi\varphi k_\gamma S_A \; \mu Sv h^{-1} \quad (2)$$

whereφ is a constant whose value corresponds to the surface area of the measuring can, k_γ is the specific gamma ray constant and S_A is the specific activity of newspaper (i.e. activity divided by surface area of the can) in Bqm^{-2}. The values of k_γ were calculated using Equation 3 [14].

$$k_\gamma = 0.5 \sum_i E_i f_i \frac{(C/kg)m^{-2}}{MBq\, h} \quad (3)$$

whereE_i is the energy of the ith radionuclide in MeV, f_i is the intensity of energy of interest. The annual effective dose, H_E (µSv y^{-1}), resulting from the three different newspapers assessed in this study were calculated using equation 4.

$$H_E = D \times T \quad (4)$$

where D is the calculated dose rate (in µSv h^{-1}) and T is the total number of hours in a year. We did not however consider the intervening air between the eye and the newspaper.

III. RESULTS AND DISCUSSION

The mean values obtained from measurements of activity of the radionuclides found in the three newspapers are presented in Table 1. The activity concentrations obtained ranged from 23.46±2.14 $Bqkg^{-1}$ to 392.80±35.63 $Bqkg^{-1}$, 3.85±0.23 $Bqkg^{-1}$ to 15.28±2.19 $Bqkg^{-1}$ and 3.71±0.21 $Bqkg^{-1}$ to 9.52±2.53 $Bqkg^{-1}$ in all the samples, with an average of 158.20±112.22 $Bqkg^{-1}$, 8.75±2.56 $Bqkg^{-1}$ and 5.72±1.30 $Bqkg^{-1}$ for ^{40}K, ^{226}Ra and ^{228}Ra respectively. Considering the mean activity obtained in this work for ^{40}K, ^{226}Ra and ^{228}Ra, it is reasonable to conclude, as expected, that the dominant source of γ-radiation measured in all the newspaper samples was ^{40}K (Figure 1).

As at the time of reporting this study, there are no data for radioactivity in newspapers produced in Nigeria and the world at large.

The radiation doses to the eye at the LDDV obtained from the activity of radionuclides found in each of the samples of the three newspapers assessed in this work are presented in Table 2. The dose levels obtained in all the samples using equation 2, for ^{40}K, ^{226}Ra and ^{228}Ra respectively varied from 0.08 to 1.06 pSv h^{-1}, 0.14 to 0.59 pSv h^{-1} and 0.42 to 0.88 pSv h^{-1} in P_1, 0.15 to 0.81 pSv h^{-1}, 0.15 to 0.36 pSv h^{-1} and 0.35 to 0.63 pSv h^{-1} in P_2 and 0.06 to 0.65 pSv h^{-1}, 0.21 to 0.39 pSv h^{-1} and 0.26 to 0.56 pSv h^{-1} in P_3. Approximate value of the total radiation dose from these three radionuclides is 1.32±0.10 pSv h^{-1}, 1.19±0.12 pSv h^{-1} and 1.16±0.09 pSv h^{-1} respectively from P_1, P_2 and P_3 newspaper. The highest dose rate occurred in P_1 newspaper, while P_3 newspaper recorded the lowest dose rate. The values obtained from this study show that the net activities of these natural radionuclides in the overall material (the pulp and the additives, and the equipment) used in the production of these newspapers are reasonably low when assessed at LDDV.

Using equation (4), the estimated annual effective dose value is 0.012±0.001 µSv y^{-1} for P_1 newspaper, 0.010±0.009 µSv y^{-1} for P_2 newspaper and 0.010±0.009 µSv y^{-1} for P_3 newspaper (Figure 2). The estimated value obtained for P_2 and P_3 are the same, while P_1 recorded the highest value. People who spend long hours reading newspaper P_1 are likely to accumulate more doses of radiation than those with P_2 and P_3 (Figure 2). However, these results are obviously much lower than the annual dose limit of 15 mSv y^{-1} to the lens of the eye as recommended by the ICRP [15] (1991). In view of this it is reasonable to state that the doses resulting from the radionuclides contained in the newspapers analysed in this study may not result in significant exposure to the eyes of the readers at LDDV.

IV. CONCLUSION

The measurements of the radionuclide contents of some Nigerian Daily Newspapers have been carried out using gamma-ray spectrometry system in this work. The mean activity concentrations obtained in this work showed that the dominant source of γ-radiation measured in all the newspaper samples was ^{40}K. The doses resulting from the activity of the radionuclides obtained in the newspapers at 0.25 m, which is the least distance of distinct vision for the eye, were determined.

The annual effective dose values of 0.012±0.001 µSv y^{-1} for P_1 newspaper, 0.010±0.009 µSv y^{-1} for P_2 newspaper and 0.010±0.009 µSv y^{-1} for P_3 newspaper obtained from the present study are much lower than the annual dose limit of 15 mSv y^{-1} to the lens of the eye. Hence the radiological hazard from these newspapers can be considered to be negligible.

In the subsequent study, a more representative sampling approach will be employed. Also needful to be determined is the effect of the intervening air on the result obtainable at such a distance to the eye of the readers.

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Table 1: Radionuclide Concentrations ($Bqkg^{-1}$) in the Newspaper Samples Analysed

		^{40}K	^{226}Ra	^{228}Ra
P_1	Range	35.41±5.32 – 392.80±35.63	3.85±0.23 – 15.28±2.19	4.90±1.58 – 9.52±2.53
	Mean	183.41±135.43	9.06±3.64	6.11±1.36
P_2	Range	54.18±7.64 – 333.90±30.25	4.33±1.44 – 10.44±2.51	3.77±0.11 – 7.60±3.20
	Mean	139.10±90.38	7.58±1.868	5.29±1.33
P_3	Range	23.46±2.14 – 324.12±30.19	7.37±2.51 – 12.70±2.14	3.71±0.21 – 7.98±3.08
	Mean	152.10±114.33	9.62±1.40	5.79±1.29

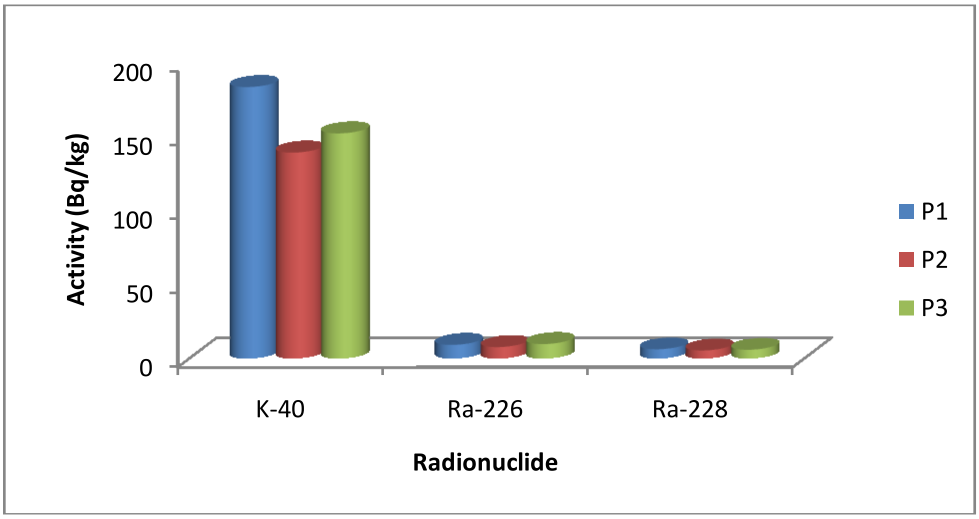

Figure 1: Radionuclide Concentrations in P_1, P_2 and P_3 Newspapers

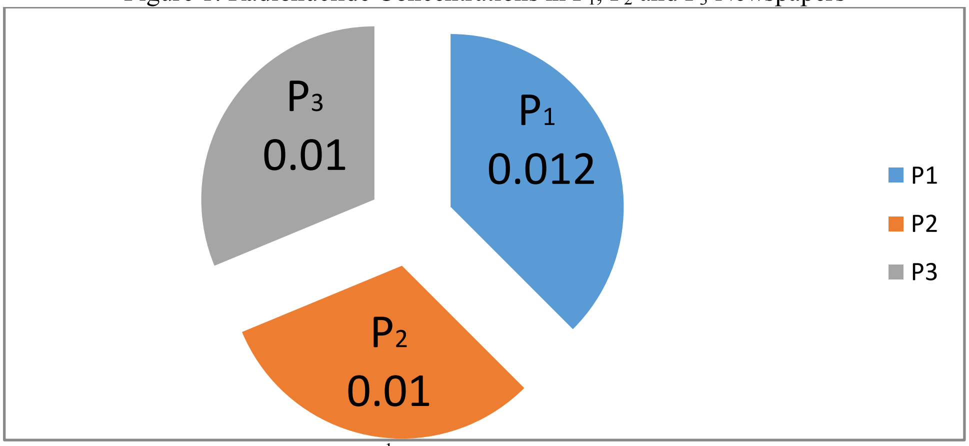

Figure 2: Annual Effective Dose (μSv y^{-1}) to the eye of the reader at least distance of distinct vision

Table 2: Radiation Dose to the Eye of Readers ($Sv\ h^{-1}\ X\ 10^{-11}$)

Sample	^{40}K	^{226}Ra	^{228}Ra
P_1-1	1.0548	0.3370	0.5566
2	0.1457	0.2055	0.4234
3	0.5763	0.2853	0.4516
4	0.2770	0.3794	0.4263
5	0.2485	0.4769	0.5902
6	0.5844	0.5845	0.8746
7	0.9606	0.3139	0.4950
8	0.4845	0.4132	0.4513
9	0.1976	0.1394	0.4887
10	0.0820	0.1547	0.5432
Mean	**0.4611**	**0.3290**	**0.5301**
P_2-1	0.2928	0.2540	0.4638
2	0.6417	0.2110	BDL
3	0.8125	0.1513	0.3473
4	0.4718	0.3392	0.5687
5	0.2893	0.2780	0.5906
6	BDL	0.3068	0.5215
7	0.1517	0.2167	0.3639
8	0.4307	0.2784	0.6139
9	0.3214	0.3619	0.6326
10	BDL	0.2704	0.3914
Mean	**0.3412**	**0.2668**	**0.4494**
P_3-1	0.5068	0.2593	0.4727
2	0.1104	0.3091	0.5569
3	BDL	0.3154	0.4659
4	0.3899	0.2989	0.5751
5	0.2770	0.3794	0.4297
6	BDL	0.3078	0.5238
7	0.0595	0.3862	0.4882
8	0.6035	0.2427	0.5123
9	0.6417	0.2130	BDL
10	0.5068	0.2651	0.2593
Mean	**0.3096**	**0.2977**	**0.4284**