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Determination and Comparative analyses of Radionuclide Concentration Levels of some Imported and Local bathing Soaps Used in Nigeria

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ABSTRACT

In this paper, we investigated the concentration of natural radionuclide levels of five imported bathing soaps in Nigeria and five local soaps. The specific activities of 40K, 238U and 232Th, of both were determined using gamma-ray spectroscopy. Calculations of radiological parameters were made to estimate associated radiation hazards in both imported and local soaps for comparative study. The activity concentrations in the imported soap samples ranged from $78 \pm 27.7\ to\ 244.5 \pm 26.5,\ 9.1 \pm 8.7\ to\ 128.6 \pm 10.0\ and\ 45.3 \pm 12.0\ to\ 144 \pm 6.8\ Bq/kg$ with corresponding mean concentration of $154 \pm 24.8, 44.4 \pm 9.2\ and\ 83.0 \pm 14.0$ Bq/kg for 40K, 238U and 232Th respectively. The activity concentration in the local soap samples ranged $from\ 55.9 \pm 23.0 - 633.5 \pm 29.5, 6.9 \pm 8.2 - 64.6 \pm 10.3\ and\ 32.9 \pm 13.8 - 107.8 \pm 15.2\ Bq/kq$ with corresponding mean activity concentration of 97.0 ± 24.5,$29.7 \pm 9.1\ and 40.4 \pm 13.9\ for$ 40K, 238U and 232Th respectively. The radium equivalent activities in the imported soap samples ranged from ($9.5 \pm 19.1 - 235.7 \pm 26.2$) Bq//kg with a mean of 174.9±16.4 Bq/kg while for local soap samples, the radium equivalent activities ranged from ($93.1 \pm 21.1 - 246.0 \pm 24.1$) Bq/kg with a mean of 134.7±22.8 Bq/kq. The mean external hazard index in the imported soap samples was 0.5 and 0.4 in the local soap samples. The mean internal hazard index obtained from the imported soap samples was 0.6 while for the local soap samples, it was found to be 0.4. The mean activity concentration, radium equivalent activities, external and internal hazard indices are less than the safe limits as recommended by ICRP and

UNSCEAR. Therefore, it suffices to say that both imported and local bathing soaps used in Nigeria are safe and may not pose any significant radiological health risks to users.

Keywords: Radionuclides, radiological hazard, bathing soap, health risk

1.0 INTRODUCTION

In physics, radiation is a process in which energetic particles or energy waves travel through a vacuum or through matter- containing media that are not required for their propagation. Radiation can be classified as either ionizing or non- ionizing. Ionizing radiation is known to have sufficiently high energy required to ionize atom. In Non- ionizing radiation, the kinetic energy of particles is too small to produce charged ions when it passes through matter. For non-ionizing electromagnetic radiation, the associated particles (photons) have only sufficient energy to charge the rotational, vibrational or electronic valence configuration of molecules and atoms.

Soaps are naturally radioactive, primarily because of their raw materials content.

Soaps are the oldest cleaning products. They are usually potassium or salts of water − soluble of fatty acids. From chemistry point of view, they are manufactured by saponification of fats and oils or their fatty acids, chemically treated with a strong alkali. It has good ability to emulsify oils and be suspended on water. Though it has a disadvantage of forming insoluble calcium salts that are deposited on fabrics, when used with hard water.

Naturally, all minerals and raw materials are radionuclides .However, some certain human activities may result to an increase in the exposures of Naturally Occurring Radioactive Materials (NORM) and they need to be controlled by regulations. Primordial radionuclides have been deposited in the earth ever since it was created. They are typically long- lived with half-lives of the order of 109 years. They include 235U, 238U, 226Ra, 222Rn and 40K [1]. Radium and uranium may be taken up by different cleaning materials such as soap and powder detergents which are usually used by human beings. Therefore there is need to estimate the radiological hazards in the soaps that are from the local and foreign markets.

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The radioactivity measurements in the cleaning materials have been studied by very few researchers. Radium -226, Uranium-238 and Radon-222 in certain samples of toothpastes which are available in the Iraqi local markets using CR-39 plastic nuclear tract detector is illustrated in [2] while the investigation of the radioactivity levels in powder detergent samples by gamma spectroscopy in [3].

Human beings come in contact with soap virtually everyday in the process of bathing, washing and so forth. Therefore, there is a need to determine the potassium, uranium and thorium levels in different types of bathing soaps. The objectives are to determine the activity concentration in the bathing soaps and also the radiological hazard indices of different types of bathing soaps available in Nigeria. Exposure to these radioactive elements can lead to respiratory diseases such as, asthma, cancer and etc.

2.0 BACKGROUND OF STUDY

2.1 Radium Equivalent (Ra_{eq})

This is a weighted sum of the activity concentrations of ^{40}K, ^{238}U, and ^{232}Th, usually calculated to estimate the radiological hazards associated with the three radionuclides. While defining Ra_{eq} activity, it is assumed that 10 Bq/kg of ^{238}U, 7 Bq/kg of ^{232}Th, and 130 Bq/kg of ^{40}K produce equal gamma-ray dose. Its empirical relation is defined in [3] as

$$Ra_{eq} = C_U + 1.43C_{Th} + 0.077C_K \tag{2}$$

Where C_U, C_{Th}, and C_K are the specific activities of ^{40}K, ^{238}U, and ^{232}Th respectively. The maximum value of Ra_{eq} must be less than the acceptable safe limit of 370 Bq/Kg.

2.2 External Hazard Index (H_{ex})

Regarding dose, the principal primordial radionuclides are ^{40}K, ^{238}U, and ^{232}Th that produce significant human exposure. The external hazard index is given in [3] as

$$H_{ex} = \frac{1}{370}C_U + \frac{1}{259}C_{Th} + \frac{1}{4810}C_K \quad (3)$$

WhereC_U, C_{Th}, and C_K are the specific activities of ^{40}K, ^{238}U, and ^{232}Th respectively. The value of this index must be less than unity for negligible radiation hazard.

2.3 Internal Hazard Index (H_{in})

Internal exposure to radon is very hazardous and this can lead to respiratory diseases like asthma and cancer. The internal hazard index is given in [3] as

$$H_{in} = \frac{1}{185}C_U + \frac{1}{259}C_{Th} + \frac{1}{4810}C_K \quad (4)$$

WhereC_U, C_{Th}, and C_K are the specific activities of ^{40}K, ^{238}U, and ^{232}Th respectively. The internal hazard index should be less than unity for a negligible radiation hazard.

3.0 MATERIALS AND METHODOLOGY

3.1 Sample Collection

Twenty different soaps that are commonly used were bought from the Agbeni market, Oyo state, Nigeria. The details of products that were collected for this study are presented in Table 1.

3.2 Sample Preparation

The samples were dried at 70^{0}C in a temperature-controlled oven to remove all the moisture. The samples were passed through 1.8 mm sieve to ensure homogeneous particles. The samples were then packed in cylindrical plastic containers (about 70mm height by 60mm diameter) made from polyethylene. The containers were then sealed using adhesive to avoid any possibility of radon leakage and left to cure for 30 days. This was done in other to achieve radioactive secular equilibrium between 238U and its gaseous daughters [4]. An empty container with the same geometry was then sealed and left for 30 days for background measurement. The mass of samples analyzed ranged between 50g and 110g.

Table 1: Types of imported soaps and manufacturers

No	Samples code	Name of samples	Country of Origin
1	A1	Tura	England
2	A2	White classic	Indonesia
3	A3	Merico	England
4	A4	Cairo white	Abidjan, Cotd'voire
5	A5	Fun-beut A	England

Table 2: Types of local soaps and manufacturers

No	Samples code	Name of samples	State of Manufacture
1	B1	Lux	Agbara, Lagos
2	B2	Septol	Kano
3	B3	Premier	Ilupeju,Lagos
4	B4	Dettol	Yaba, Lagos
5	B5	Dudu osun	Lagos

3.3 Determination of Activity Concentration

The sample containers were placed symmetrically on top of the detector and measured for a counting period of 36,000 s (10 h). The activity concentration of the radionuclides in a sample is determined by applying the full energy photo-peak corresponding to the energy of the gamma ray(s) of each radionuclide and integrated to obtain the number of counts C in each defined region of interest.

The net count of the photopeak of each of the radionuclide was found by subtracting the count due to background from the gross count of each of the photopeak.

The activity concentration which is the activity per unit mass of the radionuclide in the sample was calculated using a relation given in [3]:

$$A = \frac{C_N}{\varepsilon t Y M} \qquad (1)$$

Where C_N is the net count, ε is the detector efficiency, t is the counting life time in seconds, γ is the gamma yield per disintegration of the nuclide, and M is the mass of the sample measure in kg.

Table 3: Activity concentration of the imported soap samples

Sample Code	^{40}**K**(Bq/kg)	^{238}**U**(Bq/kg)	^{232}**Th**(Bq/kg)
A1	78.0±27.7	23.73±10.2	144.0±16.8
A2	103.7±24.9	48.30±9.7	89.9±14.5
A3	244.5±26.5	9.1±8.7	87.0±14.5
A4	174.1±22.3	12.1±7.5	48.6±12.2
A5	173.7±22.6	128.6±10.0	45.3±12.0
Mean	154.8±24.8	44.4±9.2	163.0±14.0

Table 4: Activity concentration of the local soap samples

Sample Code	^{40}K(Bq/kg)	^{238}U(Bq/kg)	^{232}Th(Bq/kg)
B1	55.9±23.2	6.9±8.2	57.2±13.6
B2	84.3±24.3	50.2±9.6	32.9±13.8
B3	112.4±21.1	9.5±7.3	31.6±11.7
B4	71.3±23.5	50.0±9.3	30.9±13.3
B5	161.1±30.3	31.7±10.9	49.5±16.9
Mean	97.0±24.5	29.7±9.1	40.4±13.9

4.0: Results and discussion

The specific activities of 40k, 238U and 232Th in the imported soap samples are presented in Table 3. The results showed that the activity concentration of imported soap samples ranged from 78 ± 27.7 - 244.5 ± 26.5, 9.1 ± 8.7 - 128.6 ± 10.0 and 45.3 ± 12.0 – 144 ± 16.8 Bq/kg with corresponding mean concentration of 154.8 ± 24.8, 44.4 ± 9.2 and 83.0 ± 14.0 for 40K, 238U and 232Th respectively. The specific activities of 40k, 238U and 232Th in the local soap samples are presented in Table 4. The results showed that the activity concentration of soap samples ranged from 55.9 ± 23.0 - 633.5 ± 29.5, 6.9 ± 8.2 - 64.6 ± 10.3 and 32.9 ± 13.8 - 107.8 ± 15.2 with corresponding means of 97.0 ± 24.5,29.7 ± 9.1 and 40.4± 13.9 for 40k, 238U and 232Th respectively.

The highest activity Concentration for 40K was observed in B5(Dudu osun) made in Lagos while the least was observed in B1(lux) made in Lagos. The highest activity concentration for 238U was observed in A5(Fun-beaut A) made in England while the least was observed in A3(merico) made in England. The highest activity concentration for 232Th was observed in A1(Tura) made in England while the least was observed in B5(Dudu osun) made in Lagos.

The calculated Radium equivalent activity for the imported soap samples are shown in fig 1 which was calculated using (2) , the Raeq for imported ranged from (95 ± 19.1) to (235.7 ± 26.2). Bq/kg with an average value of (174.9 ± 16.4) Bq/kg while the Radium equivalent for local soap samples are shown in fig1, the Raeq for local ranged from (93.1

± 21.1) to (246 ± 24.1) with an average value of (134.7 ± 22.74) Bq/kg. It can also be seen that Raeq values for both imported and local studied samples are lower than the recommended maximum value of 370 Bq/kg in [5]. Thus, these samples are within recommended safety limits. The external hazard indices for imported and local were calculated using (3) and it can be seen that they vary from 0.3-0.6 Bq/kg with an average value of 0.5 for imported soaps while in the local soap samples, they vary from 0.3- 0.7 with an average value of 0.4. These values are lower than the acceptable value of unity as stated in [6]. The internal hazard for both imported and local soap samples were calculated using (4) and it can be seen that they vary from 0.3 - 0.9 Bq/kg with an average value of 0.4 in the imported soaps while they vary from 0.3 - 0.8 Bq/kg with an average ssvalue of 0.4 in the local soap samples. Therefore, the value of the internal hazard for both imported and local soap samples are less than unity and is in line with the benchmark stated in [6].

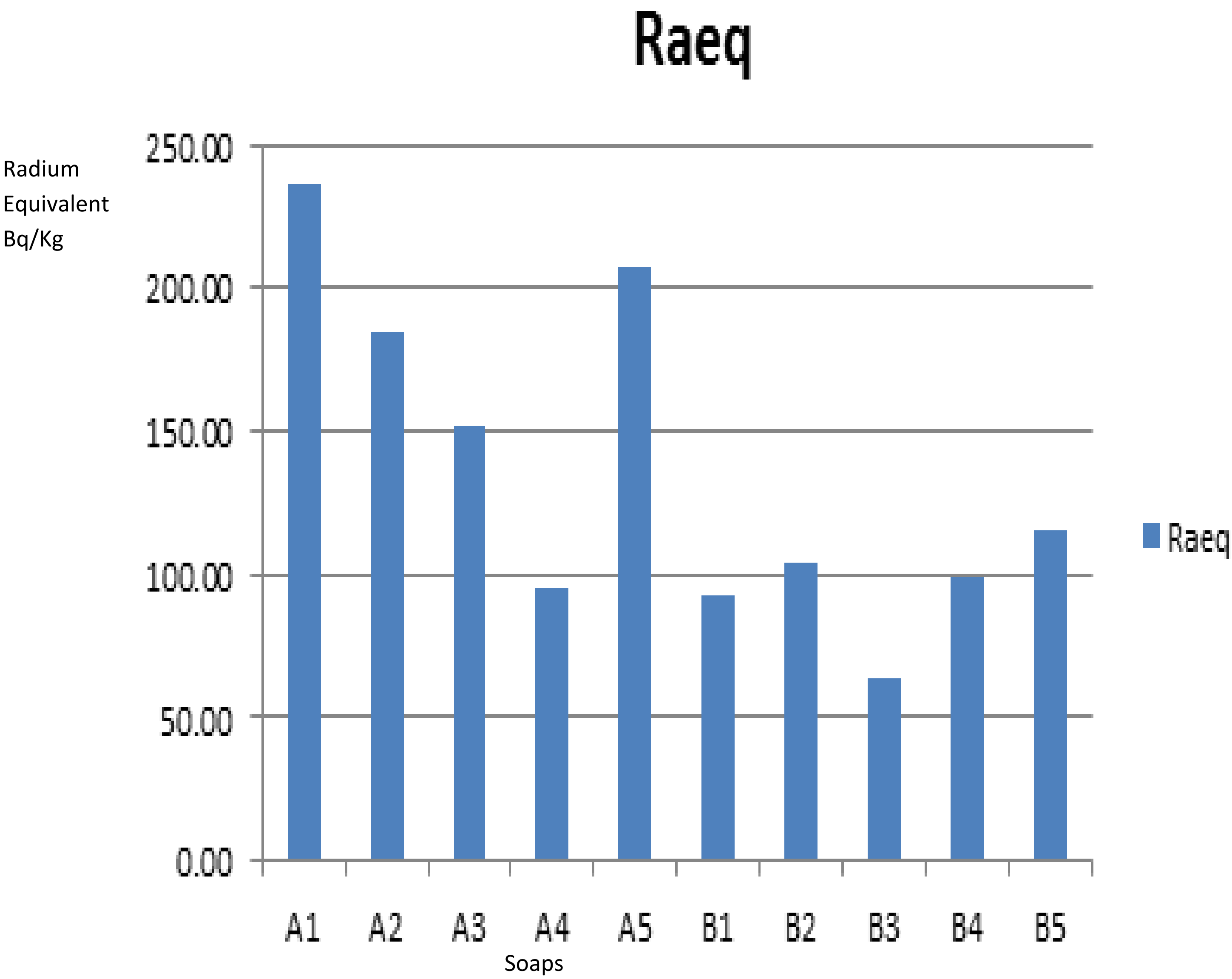

Figure 1: The Distribution of Radium Equivalent Activity for both imported and local Soap Samples

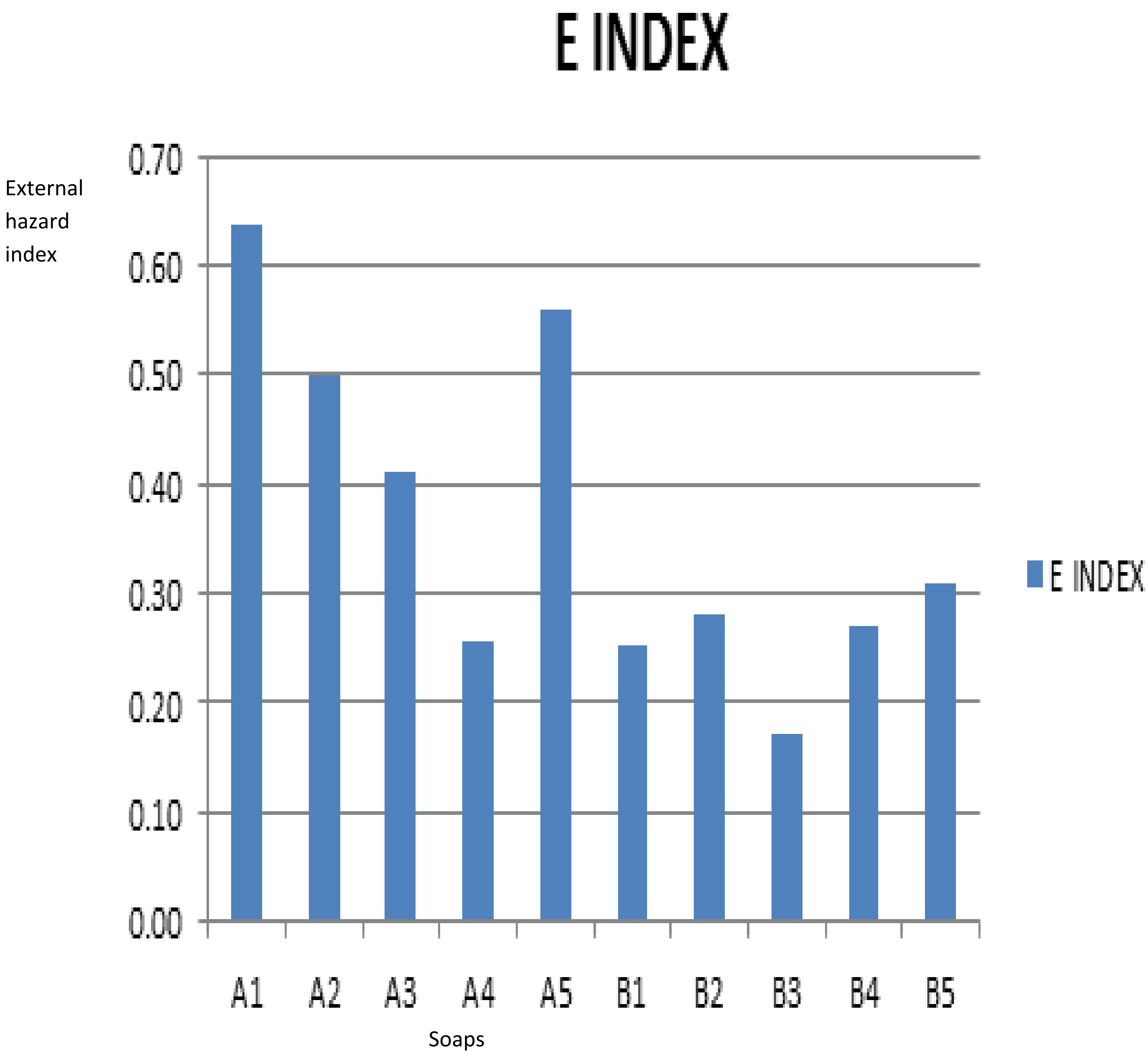

Figure 2: The Distribution of External Hazard index for both imported and Local soap Samples

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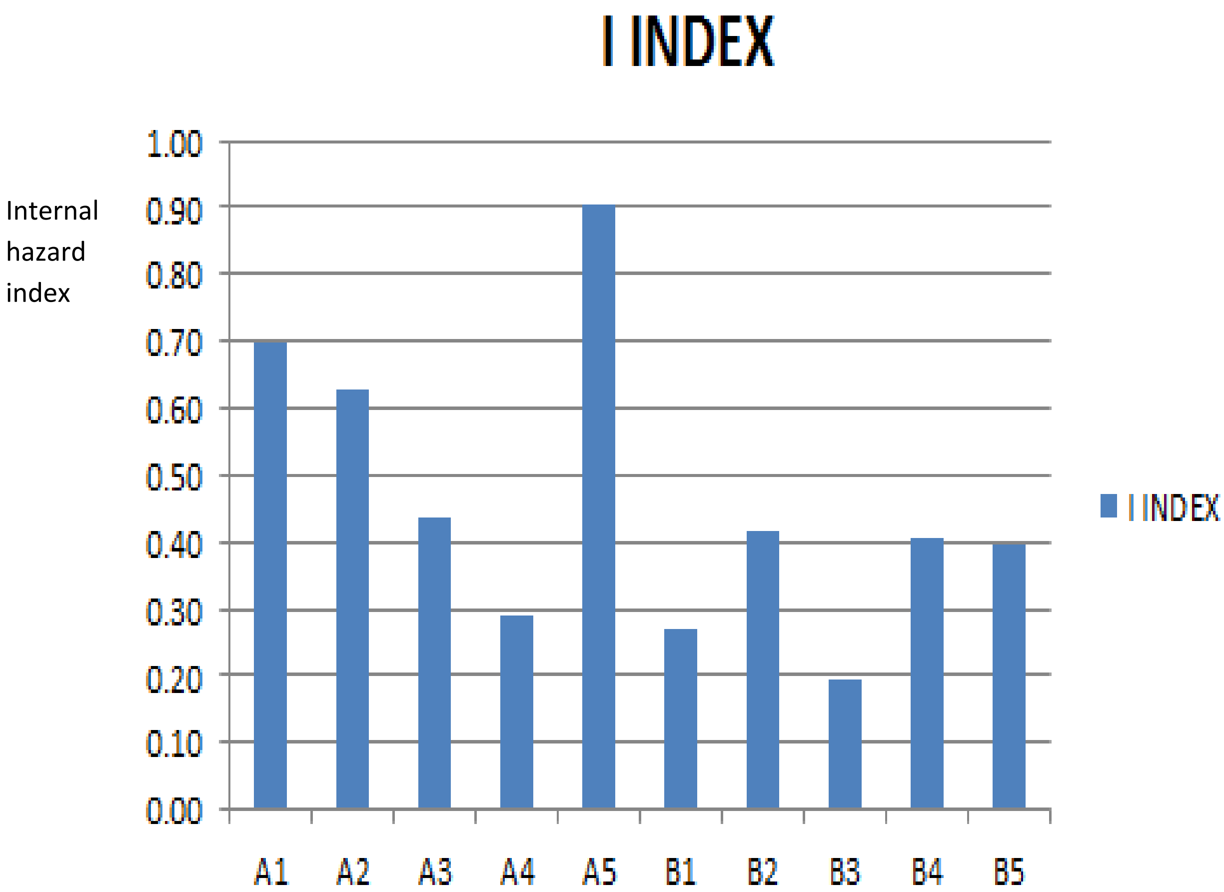

Figure 3: The Distribution of Internal Hazard index for both imported and Local soap Samples

Soaps

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5.0 CONCLUSION

The natural concentrations in some imported and local bathing soaps used in Ibadan, Nigeria have been determined. The mean activity concentration, radium equivalent activities, external and internal hazard indices are less than the safe limits recommended by [5-7]. Therefore, it suffices to say that the selected imported and local bathing soaps used in Nigeria are safe and may not pose any significant radiological health risk to users.

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