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Assessment of the Natural Radionuclides and Its' Potential Radiological Hazards in Commonly Used Incense in Anambra State, Nigeria

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Abstract **Original Research Article**

Background: The increasing use of incense for spiritual, domestic, and cultural purposes raises concern over possible exposure to naturally occurring radioactive materials (NORMs) such as Potassium-40 (K-40), Radium-226 (Ra-226), and Thorium-232 (Th-232). The research aimed to identify radionuclides present in selected incense brands, determine their activity concentrations, and assess associated health risks.

Materials and Methods: A prospective cross-sectional design was adopted, and nineteen incense samples comprising both spiritual and domestic types were randomly collected from major incense shops in Onitsha markets. The samples were analyzed at the Centre for Energy Research and Training, Zaria, using NaI (Tl) gamma spectrometry, and data were processed with SPSS version 21.

Results: revealed that all incense samples contained K-40, Ra-226, and Th-232, with mean activity concentrations of 51.70 ± 20.02 Bq/kg, 14.82 ± 3.90 Bq/kg, and 25.33 ± 17.02 Bq/kg, respectively. K-40 exhibited the highest activity across all samples, while Ra-226 recorded the lowest. Most samples fell below the UNSCEAR-2000 safety limits, except Shalimar Magnet and Excess Grace incense sticks, which showed Th-232 levels exceeding 40 Bq/kg, indicating potential radiological health risks. ANOVA results confirmed significant differences among the radionuclides ($p < 0.001$). The findings suggest that while the majority of incense brands are radiologically safe for use, certain brands pose elevated exposure risks, particularly from Th-232. It is recommended that regulatory bodies such as the Nigerian Nuclear Regulatory Authority (NNRA) conduct routine monitoring of incense products and raise public awareness on safe usage practices.

Conclusion: The study concludes that regular surveillance of consumer goods containing natural radionuclides is vital to minimizing long-term health risks.

Keywords: Background radiation, hazards, radionuclides

INTRODUCTION

The world Nuclear Association noted that all minerals and raw materials contain radionuclide(s) of natural origin (World Nuclear Association[1]. The level of exposure to these radionuclides from natural background is significantly greater than the radiation levels from artificial source. Long-lived radioactive elements such as Uranium, Thorium and Potassium-40 and any of their decay products, such as Radium and Radon are examples of Naturally Occurring Radioactive Material (NORM) [1], thus there is concern for radiation protection [1]. However, certain industrial activities can give rise to significantly enhanced exposures that may need to be controlled by regulation [1]. The major source of terrestrial NORM is Potassium 40 (K-40). The long half-life of K-40 (1.25billion years) means that it still exists in measurable quantities today [1]. After the decay of K-40, their beta decay products, mostly Calcium-40 forms 0.012% of natural potassium which is otherwise made up of stable K-39 and K-41. They are found in soil, water, foodstuffs and in the air and can end up in human body through ingestion of food and water; inhalation of contaminated air/ radioactive gas like during incense burning, injection of radiopharmaceuticals during radiotherapy and absorption through open skin/wounds[2].

Incense burning had been an age-long global traditional and common practice for various purposes in Africa and especially in South-Eastern, Nigeria[3]. There has been an extensive practice of incense burning in Temples, Monasteries, Mosques, Shrines, Churches and Household settings for divine worship and ancestor veneration[3]. Furthermore, the burning of incense has been adopted into human daily life activities for other purposes such as deodorant, aromatherapy and meditation, among others [3]. Incense is made from natural sources such as tree resins, barks, roots, flowers, aromatic herbs and woody plants. Incense smoke consists of varieties of components that include tiny particles that are generated from burning of the incense [4]. The global burning/consumption of incense were estimated to exceed 200 million tons per year, while the Asia continent has the largest market[4]. With significant inhalation of incense smoke, radionuclides may accumulate in different organ of their affinity and may result in major radiation hazard. Examples of such radioactive gas include Radon-222, which is a colorless, odorless radioactive gas that is produced by the decay of uranium-238 which is often associated with respiratory diseases and Thorium [2].

Findings from a study have linked burning and inhaling of incense smoke to variety of poor health conditions such as respiratory problems, cardiovascular diseases as well as carcinoma [4]. Radionuclides deposited in te respiratory tract are insoluble (not readily translocated to other tissues or excreted) or relatively soluble (more readily translocated to other tissues or excreted). Biological effect resulting from the inhalation of radionuclides depends on the concentration, distribution and deposit of these radionuclides in the body [5]. This may lead to life - span shortening which may be accompanied by certain pathological changes, hematologic effects, Non neoplastic lesions, neoplastic lesion/pulmonary neoplastic and extra-pulmonary lesions [6]. Empirically, studies have linked incense use with upper respiratory tract carcinoma and asthmatic attack[7].

Smokes fumes produced from burning of any raw material may potentially contain some amount of radio-toxic elements such as Lead-210, Polonium-210 and Uranium-238 which when inhaled, can settle in the lungs tissue[5]. Most of the researches were centered on cigarette and tobacco snuffs. However, there is paucity of data on radioactivity from incense. TareqAlrefae[8], studied 27 samples of incense brands (natural and synthetic) collected from the Kweaiti local market and compared the results with Cigarettes and Moassel. Results revealed that the activity concentration of Naturally Occurring Radioactive Materials (NORM) of Radon-226 in processed incense was 25.5Bq/kg which is about nine times higher than the activity concentration in cigarette and Moassel (3 Bq/kg). On the other hand, Potassium-40 was in the same range as the cigarette (600-900 Bq/kg).

In south-east Nigeria, incense is used extensively during religious worships/ festival for rituals, in the churches for consecration and sanctification or purification, shrines and most homes for incantation and meditation, but there is no empirical study on its radionuclide presence and activity concentration. Consequently, there was need to assess the presence of NORM and activity concentration from incense products.

MATERIALS AND METHODS

1 Study Design

A prospective cross sectional survey design was adopted. This was designed for the researcher to assess the presence or absence of radioactivity at one instance without the need for follow-up.

2 Location of Study

Incense Samples were collected from all major incense shops within Onitsha main market. This was because most incense users within the region sorts their product from major incense dealer in Onitsha main market.

3 Sample Size

Spiritual purpose incense

A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15

Domestic purpose incense

B1, B2, B3

B4,

A total of 19 incense samples were included in this study and the incenses were selected purposively as only samples of incense commonly sold and consumed in, Anambra State were included in this study.

5 Ethical Considerations

Ethical approval was obtained from the Research Ethics Committee of the Faculty of Health Sciences and Technology, Nnamdi Azikiwe University, Nnewi Campus and Ministry of Health, Anambra state (protocol number : FHST/REC/024/10).

6 Sample preparations for Nal (TI) Gamma spectrometer

6.1 Incense samples collection

Nineteen samples of incense were collected from major incense stores in Onitsha main market, Anambra state, Nigeria. This is because they are the most commonly used products in the area of study according to the dealers. Samples were sent to Centre for Energy Research and Training, Zaria, for analysis and data generation using NaI (TI) Gamma spectrometry.

6.2 Incense sample preparation

Each of the samples collected was evaporated to dryness with the use of pulverize. Packaging of the samples into radon-impermeable cylindrical plastic containers which was selected based on the space allocation of the detector vessel which measures 7.6cm by 7.6cm in dimension (geometry) was also carried out. To prevent radon-222 escaping, the packaging in each case was triple sealed. The sealing process included smearing of the inner rim of each container lid with vaseline jelly, filling the lid assembly gap with candle wax to block the gaps between lid and container, and tight-sealing lid-container with masking adhesive tape. Radon and its short-lived progenies were allowed to reach secular radioactive equilibrium by storing the samples for 30 days prior to gamma spectroscopy measurements.

6.3 Evaluation of Radioactivity of Samples

The analysis was carried out using a 76x76mm Nal (TI) detector crystal optically coupled to a photomultiplier tube (PMT). The assembly has a preamplifier incorporated into it and a 1kilovolt external source. The detector was enclosed in a 6cm lead shield with cadmium and copper sheets. This arrangement was aimed at minimizing the effects of background and scattered radiation. The data acquisition software was Maestro by Camberra Nuclear Products. The samples were measured for a period of 29000 seconds, for each sample. The peak area of each energy in the spectrum was used to compute the activity concentrations in each sample by the use following equation:

$$\mathbf{C(Bq\ kg^{-1}) = \mathit{C}_n / C_f}$$

Where,

C= Activity concentration of the radionuclides in the sample given in Bq/kg

C_n = Count Rate (counts per second)

Count per second (cps) = Net count /Live time

C_f = Calibration factor of the detecting system.

6.4 Calibration and efficiency determinations

Calibration of the system for energy and efficiency was carried out with two calibration point sources, Cs-137 and Co- 60. These were achieved with the amplifier gain that gives 72% energy resolution for the 661.16KeV of Cs-137 and counted for 30minutes.

6. 5 Standards

The standards that were used to check for the calibration are the IAEA gamma Spectrometric reference materials RGK-1 for K-40, RGU-1 for Ra-226 (Bi-214 peak) and RGTH-1 for Th-232 (Ti-208)

6.6 Background

The background count rate was carried out for 29000 seconds

Table 1 Table of spectral energy windows that will be used during the analysis

Isotope	Gamma Energy (Kev)	Energy window
Ra-226	1764.0	1620-1820
Th-232	2614.5	2480-2820
K-40	1460.0	1380-1550

Table 2 Table of energy calibration for quantitative spectral analysis

Isotope	Calibration factors		Conversion factors	Detection limits	
	10^3 (Cps/ppm)	10^{-4} (Cps/ppm)		Ppm	Bq/kg
^{40}K	0.026	6.431	0.032	454.54	14.54
^{226}Ra	10.500	8.632	12.200	.32	3.84
^{232}Th	3.612	8.768	4.120	2.27	9.08

Centre for Energy Research and Training, Zaria, 2025.

6. 7 Data Analysis

Data were saved on a computer Microsoft excel spread sheet and categorized into name of samples. It was independently crosschecked by an independent Statistician. Statistical package for social sciences version 21.0 (IBM Corporation Armonk, NY, 2013) was used for the analysis. Descriptive statistics involving the mean, standard deviation and bar charts was used to analyze the samples in line with the objectives of the study. Parametric test was used for normality of data distribution at 95% confidence level. Table of samples analyzed were arranged in a tabular form with the radionuclides present and activity concentration. Bar chats were used to demonstrate the activity concentration of the current study and compared with the UNSCEAR standards for each natural radionuclides.

RESULTS

Table 1 showed that the activity concentration of potassium (K-40) was highest in Shalimar magnet (0.054108 ± 0.003304 CPC or 84.1493 ± 5.138414 Bq/Kg) and lowest in Wind air freshener (0.01596 ± 0.002394 CPC or 24.82115 ± 3.723484 Bq/Kg) with the rest of the incense samples in-between. The K-40 radionuclide activities in all the incense samples had concentrations less than the UNSCEAR-2000 limit standard of 400Bq/Kg and hence are safe.

Table 2 showed that the activity concentration of radium (Ra-226) was highest in original back to sender incense (0.02282 ± 0.002474 CPS or 26.44264 ± 2.866744 Bq/Kg) and lowest in baygon mosquito coil (0.008901 ± 0.000939 CPS or 10.31402 ±1.088065 Bq/Kg) with the rest of the incense samples in-between as seen in table 4.2. The Ra-266 radionuclide activities in all the incense samples had concentrations less than the UNSCEAR-2000 limit standard of 40Bq/Kg and hence are safe.

Result from table 3 showed that the activity concentration of thorium (Th-232) was highest in A4 (0.042899 ± 0.0034307 CPS or 48.91562 ± 3.911859 Bq/Kg) and lowest in A14 (0.018412 ± 0.001219 CPS or 20.9943 ± 1.389966 Bq/Kg) with the rest of the incense samples in-between as seen in table 3.

The Th-232 concentration in A4 (48.91562 ± 3.911859 Bq/Kg) and A2 (46.75815 ± 2.534778 Bq/Kg) are the only ones that surpass the UNSCEAR-2000 limit standard of 40Bq/Kg for Th-232 and hence are unsafe. The other incenses have concentrations less than the UNSCEAR-2000 limit standard and hence are safe.

Results as seen in table 4 showed that the radioactivity concentration of potassium (84.1493 ± 5.138414) seems to be generally higher than thorium (48.91562 ± 3.911859) which in turn is higher than that of radium (26.44264 ± 2.866744) across the various samples of incenses. This table gives a clearer description of radionuclide activities in each sample of incenses. Figure 1 showing the K-40 concentration in incense alongside UNSCEAR K-40 standard limit. The K-40 concentration of all the incenses is below the UNSCEAR-2000 standard limit.

Figure 1 showing the Ra-226 concentration in incense alongside UNSCEAR K-40 standard limit

The Ra-226 concentration of all the incenses is below the UNSCEAR-2000 standard limit.

Figure 1 showing the Th-232 concentration in incense alongside UNSCEAR K-40 standard limit

The Th-232 concentration of all the incenses are below the UNSCEAR-2000 standard limit except for A3 and A2 which surpasses the standard limit and is unsafe.

Table 5 showing the average CPS activity concentration of PotassiumK-40), Radium (Ra-226) and Thorium (Th-232) in incenses generally

The average concentration of potassium-40 in incenses generally is seen as the highest (0.33±0.13 CPS) among the radionuclide elements while radium-226(0.013±0.00 CPS) has the least concentration.

Table 6 (Bq/Kg) average activity concentration of PotassiumK-40), Radium (Ra-226) and Thorium (Th-232) in incenses generally.

Result showed that potassium-40 has the highest average radioactive concentration in incenses (51.70±20.02Bq/Kg) followed by thorium-232 (25.33 ± 17.02Bq/Kg) while raduim-226 has the least average radioactive concentration (14.82±3.90Bq/Kg).

Table 7 Showing association between the average means of K-40, Ra-226 and Th-232 in incenses. Result shows there is a statistically significant difference in the mean radioactive activities (Bq/Kg) in incenses between the groups of radioactive elements (K-40, Ra-226 and Th-232) as determined by one-Way ANOVA ($F(2, 15) = 40.705$, $p < 0.001$).

DISCUSSION

Findings in this study confirmed the presence of natural radionuclides such as Potassium-40 (K-40), Radium-226 (Ra-226) and Thorium-232 (Th-232) in all incense samples assessed. K-40 consistently exhibited the highest activity concentration, while Ra-226 was the lowest. This aligns with the report by UNSCEAR [9], which stated that plant-derived materials often accumulate primordial radionuclides from soil during growth through the conducting system (Xylem, phloem and parenchyma) in the plant.

Rocks, soils, ground water and minerals contain NORMs and the fallout radionuclides such as 40K, 238U, 232Th, 137Cs and 90Sr. Naturally occurring radioactive materials contribute significantly to the natural radioactivity present on the Earth [10]. Similar findings were reported by Tchokossa *et al.* [11] in Nigeria, where K-40 was predominant in food, crops, and by Jibiri and Agomuo [12], who observed higher levels of K-40 compared to Ra-226 and Th-232 in soil samples. These studies corroborate the present results, suggesting that incense, being largely plant-based, naturally incorporates radionuclides from its raw materials.

Furthermore, this study showed variation in radionuclide activity concentrations across incense samples. A4 and A2 had the highest levels of K-40 and Th-232 respectively, while B1 and B4 had the lowest. Notably, Th-232 in A4 and A2 exceeded the UNSCEAR limit of 40 Bq/kg, rendering them unsafe for inhalation. This variability observed across the different brands may be linked to the geographic origin of raw materials or differences in production. This trend was in line with study by Ademola *et al[13]* that reported significant variation in radionuclide content across different brands of tobacco product; and by Tufail *et al.* [14], who found brand-to-brand differences in radionuclide concentrations in imported consumer products. This implies that radionuclide levels in incense are not uniform and need to be monitored brand by brand by regulatory agencies.

Radiological hazard assessment indicated that, although most incense samples posed minimal health risks, A4 and A2 presented relatively higher risks due to elevated Th-232. These findings were consistent with findings by Jibiri *et al.[15]*, who reported low effective dose values in Nigerian foodstuffs, and by Al-Saleh and Al-Harshan [16], who found hazard indices from common consumer products to be below permissible limits. However, the potential stochastic radiological effects in few brands where in line with reports by Farai and Vincent[17], that showed that long-term exposure to elevated radionuclide levels, even when marginally above permissible limits, may increase cancer risks in the population.

The significant differences observed among the radionuclides (ANOVA, $p < 0.001$) supports earlier observations by Tchokossa *et al.[11]* that radionuclide distribution is uneven, with K-40 usually dominant but Th-232 occasionally exceeding safety limits.

CONCLUSION

This study established that incense samples commonly used in South-East Nigeria contain natural radionuclides (K-40, Ra-226, and Th-232), with K-40 showing the highest activity concentrations. Although most radionuclide activity concentrations and hazard indices were within international safety limits, Th-232 levels in A4 and A2 exceeded UNSCEAR's recommended limits, presenting potential radiological health risks.

Conflict of interest: None declared among the authors

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Table 1 Activity concentration (CPS and Bq/Kg) of Potassium (K-40) in different Incense samples

Incense Samples	K-40 ± Error (CPS)	K-40 ± Error (Bq/Kg)	Inference
Original back to sender	0.051637 ± 0.001771	80.30638 ± 2.754277	Safe
Excess grace incense stick	0.052778 ± 0.001925	82.08087 ± 2.993779	Safe
Global demon destroyer	0.049897 ± 0.002542	77.60031 ± 3.953344	Safe
Shalimar magnet	0.054108 ± 0.003304	84.1493 ± 5.138414	Safe
Freedom excess money magnet	0.035521 ± 0.002005	55.24261 ±3.118196	Safe

Original stop evil	0.034364 ± 0.002123	53.44323 ± 3.301711	Safe
Freedom total bondage breaker	0.045732 ± 0.00231	71.12286 ± 3.592535	Safe
Global do as I say	0.024306 ± 0.001757	37.80093 ± 2.732504	Safe
Freedom crowd puller	0.041322 ± 0.002241	64.26439 ± 3.485226	Safe
Frankincense and myrrh	0.033885 ± 0.00163	52.69829 ± 2.534992	Safe
999 lord Krishna puja	0.027253 ± 0.002411	42.38414 ±3.749611	Safe
444 lord brahan puja	0.017257 ± 0.002392	26.83826 ± 3.720062	Safe
Sandesh amber cone	0.023542 ± 0.002169	36.61275 ± 3.373561	Safe
Raw/Natural frankincense	0.033396 ± 0.001493	51.93779 ± 2.321982	Safe
Gravel incense	0.031271 ± 0.002531	48.63297 ± 3.936236	Safe
Wind air freshener	0.01596 ± 0.002394	24.82115 ± 3.723484	Safe
Super killer mosquito	0.017705 ± 0.001601	27.53437 ± 2.490047	Safe
Sunshine air freshener	0.01935 ± 0.00171	30.09331 ± 2.659409	Safe
Baygon mosquito coil	0.02234 ± 0.001869	34.74339 ± 2.906687	Safe

Table 2. Activity concentration (CPS and Bq/Kg) of Radium (Ra226) in different Incense samples

Incense samples	**Ra-226 ± Error (CPS)**	**Ra-226 ± Error (Bq/Kg)**	**Inference**
Original back to sender	0.02282 ± 0.002474	26.44264 ± 2.866744	Safe
Excess grace incense stick	0.009417 ± 0.001381	10.91194 ± 1.60232	Safe
Global demon destroyer	0.009856 ± 0.001691	11.42063 ± 1.95944	Safe
Shalimar magnet	0.014177 ± 0.001656	16.42758 ± 1.918888	Safe
Freedom excess money magnet	0.008992 ± 0.0009232	10.41947 ± 1.069757	Safe
Original stop evil	0.01249 ± 0.001527	14.47277 ± 1.769409	Safe
Freedom total bondage breaker	0.014587 ± 0.001609	16.90267 ±1.864426	Safe
Global do as I say	0.01132 ± 0.001465	13.11703 ± 1.697567	Safe
Freedom crowd puller	0.014583 ± 0.0014861	16.89803 ± 1.722016	Safe
Frankincense and myrrh	0.013507 ± 0.001291	15.65133 ± 1.495944	Safe
999 lord Krishna puja	0.008921 ± 0.001351	10.33731 ± 1.565469	Safe
444 lord brahan puja	0.013016 ± 0.00168	15.08227 ± 1.946698	Safe

Sandesh amber cone	0.016454 ± 0.002215	19.06605 ± 2.566628	Safe
Raw/Natural frankincense	0.01188 ± 0.001319	13.76593 ± 1.528389	Safe
Gravel incense	0.013121 ± 0.001237	15.20394 ± 1.433372	Safe
Wind air freshener	0.014695 ± 0.000986	17.02781 ± 1.142526	Safe
Super killer mosquito	0.009972 ± 0.001084	11.55504 ± 1.256083	Safe
Sunshine air freshener	0.014214 ± 0.00136	16.47045 ± 1.575898	Safe
Baygon mosquito coil	0.008901 ± 0.000939	10.31402 ±1.088065	Safe

Table 3 Activity concentration (CPS and Bq/Kg) of Thorium (Th-232) in different incense samples

Incense Samples	**Th-232 ± Error (CPS)**	**Th-232 ± Error (Bq/Kg)**	**Inference**
Original back to sender	0.027743 ± 0.0009463	31.63398 ± 1.079019	Safe
Excess grace incense stick	0.041007 ± 0.002223	46.75815 ± 2.534778	Unsafe
Global demon destroyer	0.031002 ± 0.001875	35.35006 ± 2.13797	Safe
Shalimar magnet	0.042899 ± 0.0034307	48.91562 ± 3.911859	Unsafe
Freedom excess money magnet	0.02463 ± 0.002452	28.08438 ± 2.795895	Safe
Original stop evil	0.03107 ± 0.0020363	35.42759 ± 2.321893	Safe
Freedom total bondage breaker	0.020049 ± 0.001939	22.86089 ± 2.210946	Safe
Global do as I say	0.021321 ± 0.001765	24.31129 ± 2.012543	Safe
Freedom crowd puller	0.023646 ± 0.002339	26.96237 ± 2.667047	Safe
Frankincense and myrrh	0.032523 ± 0.00317	37.08438 ± 3.614595	Safe
999 lord Krishna puja	0.025138 ± 0.001943	28.66363 ± 2.215507	Safe
444 lord brahan puja	0.03252 ± 0.003439	37.08096 ± 3.921323	Safe
Sandesh amber cone	0.03181 ± 0.00246	36.27172 ± 2.805017	Safe
Raw/Natural frankincense	0.018412 ± 0.001219	20.9943 ± 1.389966	Safe
Gravel incense	0.019508 ± 0.001647	22.24401 ± 1.877993	Safe
Wind air freshener	0.023624 ± 0.002349	26.93729 ± 2.678803	Safe
Super killer mosquito	0.021459 ± 0.002014	24.46864 ± 2.296465	Safe
Sunshine air freshener	0.029051 ± 0.002245	33.12543 ± 2.559863	Safe

Baygon mosquito coil	0.02230 ± 0.002047	25.42759 ± 2.334094	Safe

Table 4 Specific activities of radionuclide (Bq/Kg) in incense samples

Incense Samples	K-40 ± Error (Bq/Kg)	Ra-226 ± Error (Bq/Kg)	Th-232 ± Error (Bq/Kg)
Original back to sender	80.30638 ± 2.754277	26.44264 ± 2.866744	31.63398 ± 1.079019
Excess grace incense stick	82.08087 ± 2.993779	10.91194 ± 1.60232	46.75815 ± 2.534778
Global demon destroyer	77.60031 ± 3.953344	11.42063 ± 1.95944	35.35006 ± 2.13797
Shalimar magnet	84.1493 ± 5.138414	16.42758 ± 1.918888	48.91562 ± 3.911859
Freedom excess money magnet	55.24261 ±3.118196	10.41947 ± 1.069757	28.08438 ± 2.795895
Original stop evil	53.44323 ± 3.301711	14.47277 ± 1.769409	35.42759 ± 2.321893
Freedom total bondage breaker	71.12286 ± 3.592535	16.90267 ±1.864426	22.86089 ± 2.210946
Global do as I say	37.80093 ± 2.732504	13.11703 ± 1.697567	24.31129 ± 2.012543
Freedom crowd puller	64.26439 ± 3.485226	16.89803 ± 1.722016	26.96237 ± 2.667047
Frankincense and myrrh	52.69829 ± 2.534992	15.65133 ± 1.495944	37.08438 ± 3.614595
999 lord Krishna puja	42.38414 ±3.749611	10.33731 ± 1.565469	28.66363 ± 2.215507
444 lord brahan puja	26.83826 ± 3.720062	15.08227 ± 1.946698	37.08096 ± 3.921323
Sandesh amber cone	36.61275 ± 3.373561	19.06605 ± 2.566628	36.27172 ± 2.805017
Raw/Natural frankincense	51.93779 ± 2.321982	13.76593 ± 1.528389	20.9943 ± 1.389966
Gravel incense	48.63297 ± 3.936236	15.20394 ± 1.433372	22.24401 ± 1.877993
Wind air freshener	24.82115 ± 3.723484	17.02781 ± 1.142526	26.93729 ± 2.678803
Super killer mosquito	27.53437 ± 2.490047	11.55504 ± 1.256083	24.46864 ± 2.296465
Sunshine air freshener	30.09331 ± 2.659409	16.47045 ± 1.575898	33.12543 ± 2.559863
Baygon mosquito coil	34.74339 ± 2.906687	10.31402 ±1.088065	25.42759 ± 2.334094

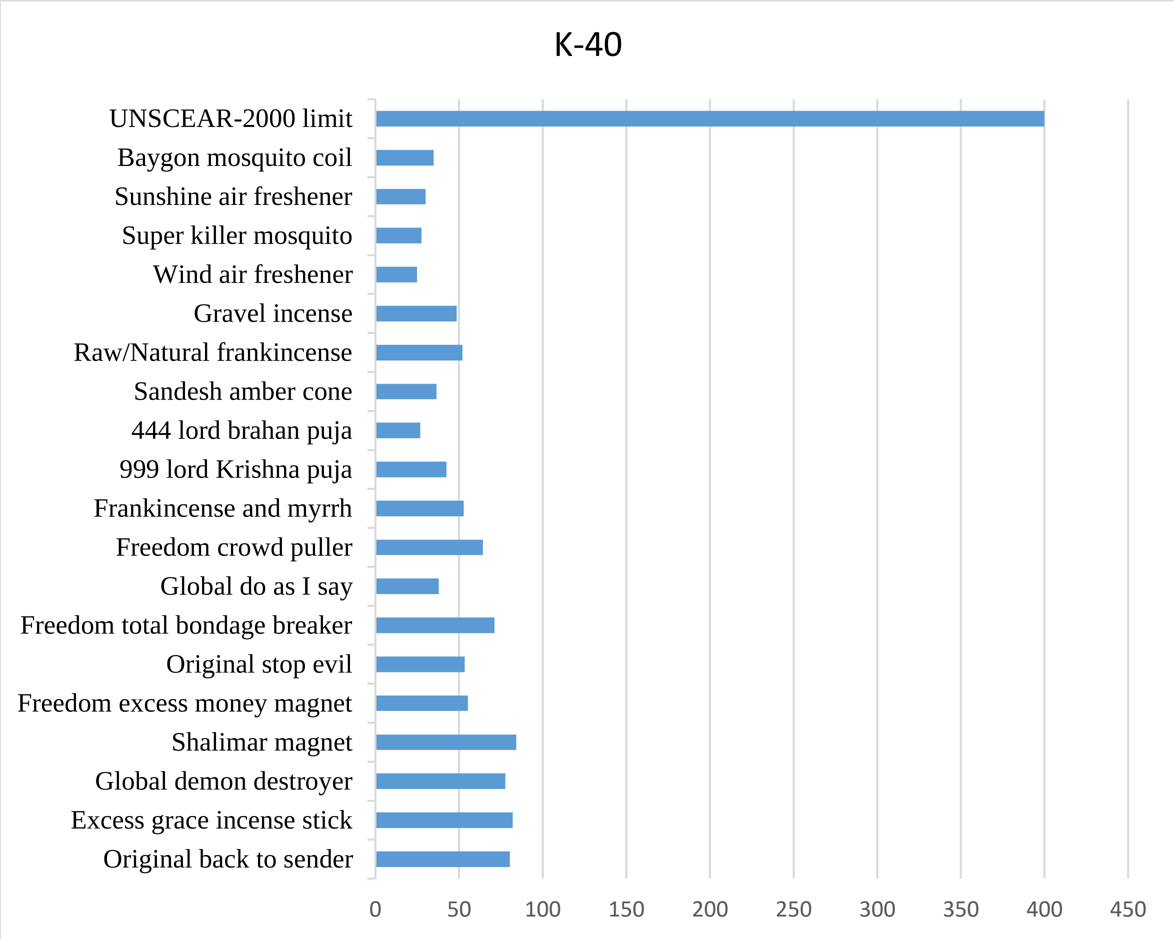

Figure1: The K-40 concentration in incense alongside UNSCEAR K-40 standard limit

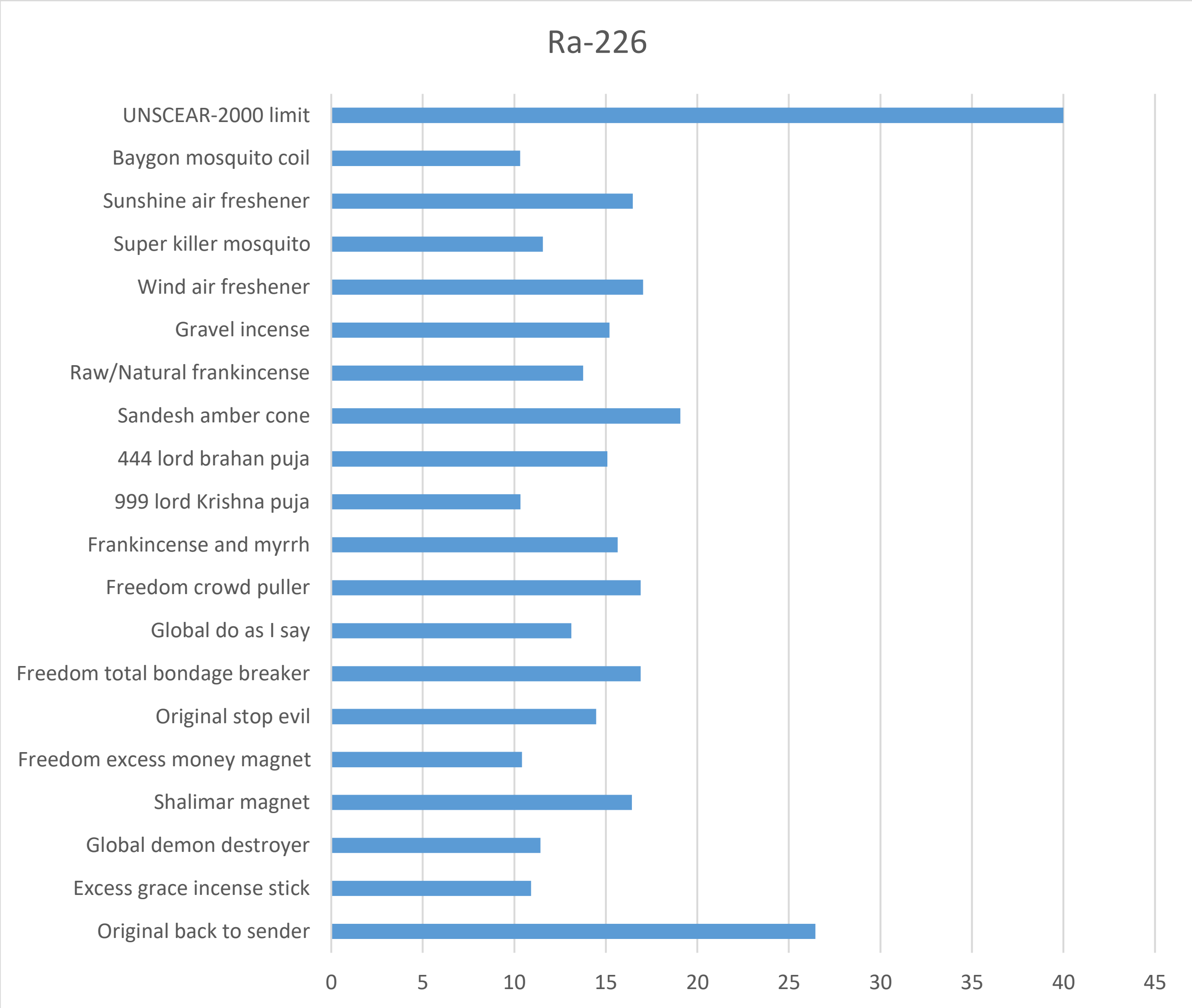

Figure 1: The Ra-226 concentration in incense alongside UNSCEAR K-40 standard limit

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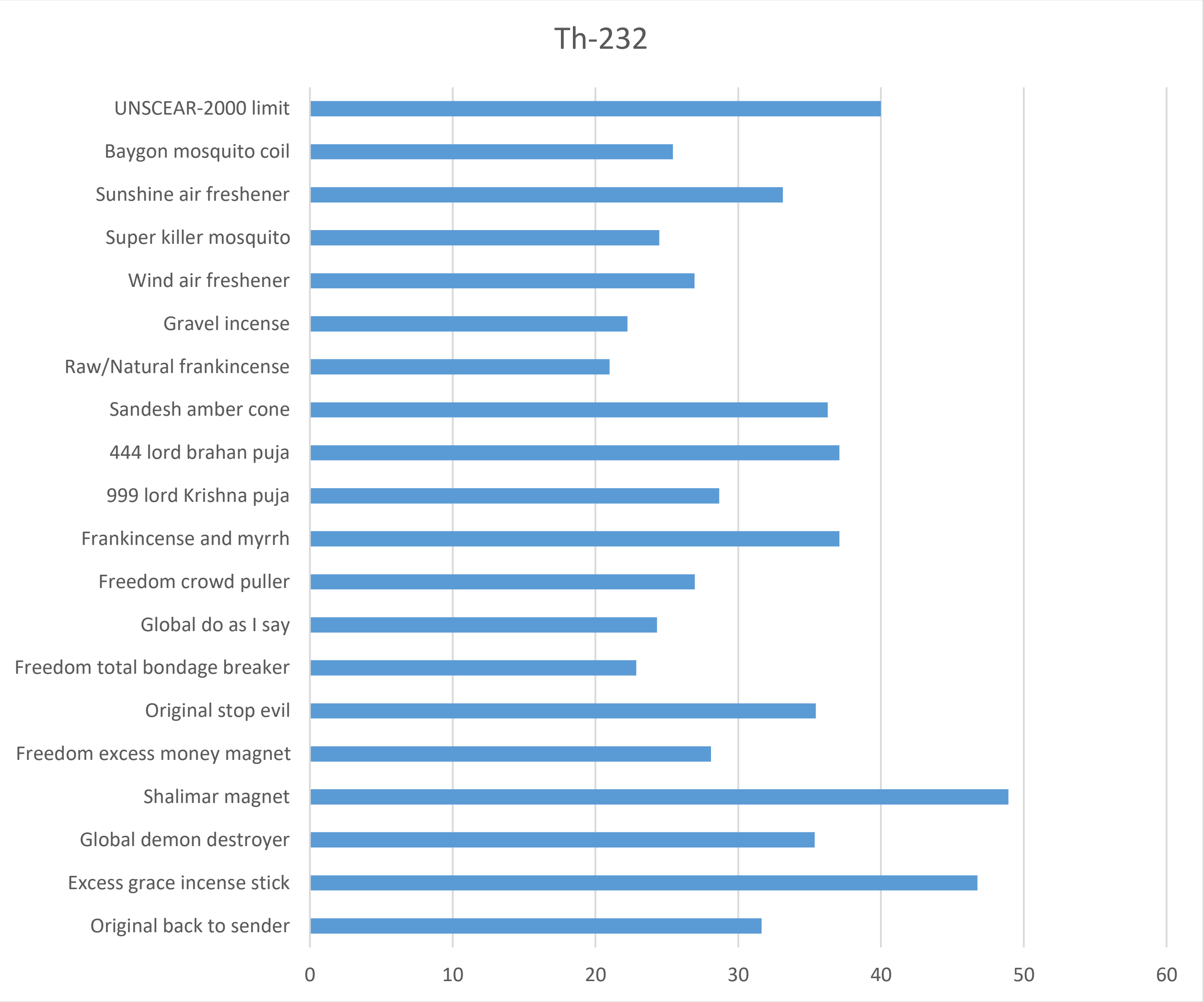

Figure 1: The Th-232 concentration in incense alongside UNSCEAR K-40 standard limit

Table 5 Average activity concentration in CPS of Potassium(K-40), Radium (Ra-226) and Thorium (Th-232) in incenses generally

Radiation activity concentration (CPS)	**Mean ± SD**	Minimum	Maximum	Inference
K-40 (CPS)	0.33±0.13	0.015960	0.054108	Safe
Ra-226 (CPS)	0.01±0.00	0.008901	0.02820	Safe
Th-232 (CPS)	0.27±0.01	0.018412	0.042899	Safe

Table 6 Average activity concentration in Bq/Kg of Potassium(K-40), Radium (Ra-226) and Thorium (Th-232) in incenses generally

Radiation activity concentration (Bq/Kg) in vegetables	**Mean ± SD**	**Minimum**	**Maximum**	**Inference**
K-40 (Bq/Kg)	51.70±20.02	24.82	84.15	Safe
Ra-226 (Bq/Kg)	14.82±3.90	10.31	26.44	Safe
Th-232 (Bq/Kg)	31.19±7.90	20.99	48.91	Unsafe

Table 7 Difference in mean activity concentration of the three radionuclide elements in incenses

		N	**Radioactivity in Incenses**	**F-value**	**p-value**
Radioactive elements	K-40	19	51.70±4.59	40.705	<0.001
	Ra-226	19	14.81±0.90		
	Th-232	19	31.19±2.60		