Medicon Agriculture & Environmental Sciences
Volume 6 Issue 6 June 2024
Article Type: Research Article
ISSN: 2972-2691

Assessment of Natural Background Radiations from Shisha Smokes

Girum Kassa Alemu and Belay Sitotaw Goshu*

Department of Physics, Dire Dawa University, Dire Dawa, Ethiopia

***Corresponding Author:** Belay Sitotaw Goshu, Department of Physics, Dire Dawa University, Dire Dawa, Ethiopia.

Received: May 18, 2024; **Published:** June 06, 2024

Abstract

This study aims to assess the natural background radiation from shisha and evaluate the hazard level. The main part of this study was to estimate the annual effective dosage from inhalation, which will help to clarify the health hazards related to breathing in the radioactive materials included in shishas. The activity concentration of naturally occurring radionuclides was measured in six shisha samples using gamma spectroscopy using a high-purity germanium (HPGe) detector. The specific activity of ^{238}U, ^{232}Th, and ^{40}K in shisha samples ranged from 1.29 ± 0.63 to 9.45 ± 4.5 Bq kg^{-1} with an average of 6.76± 2.83, 2.436.76 ±2.83 to 12.46 + 13.5 Bq kg^{-1} with an average of 7.96 ± 14.6 to 364.9 ± 0.0 Bq kg^{-1}, respectively. The radium equivalent activity for all samples ranged from 6.65 to 53.91 with an average of 33.92 ± 15, respectively below the world-recommended limit. The absorbed dose rate (*DR*) for all samples ranged from 3.09 to 26.47 nGyh^{-1} with an average of 16.48 ±7.53 nGyh^{-1} compared with the world average of 60 nGyh^{-1}. The value of the external hazard index, or yearly effective dosage equivalent, is less than the globally recognized limit, which is a unit. The AEDE was indoor and outdoor varied from 0.015 to 0.145 mSvy^{--1} with an average of 0.090 mSvy^{--1} and ranged from 0.04 to 0.036 with an average of 0.023 mSvy^{-1}, respectively. The value of *ELCR* ranged from 0.066 to 0.568(10^{-3}) with an average of 0.313(10^{-3}). According to these findings, the activities of radium equivalent in all the shisha samples are lesser than the limit (370 Bq kg^{-1}) recommended by the United Nations Scientific Committee on the Effect of Atomic Radiation (UNSCEAR) report, and the annual effective dose was within the safe limit of 1 mSvy^{-1}.

Keywords: Ionizing radiation; specific activity; External index; Internal index; shisha; Dose rate

Introduction

There are naturally occurring radioactive sources all over the planet, but they can expose people to ionizing radiation harmful to their health Ononugbo et al. (2015); Ramachandran, (2011). About 82% of the excess radiation doses that individuals are exposed to come from natural sources. Primordial radionuclides are the source of gamma radiation released by these background radiation sources (BRs). Soil nuclei percentage, altitude, and regional geographic characteristics are the main drivers of BR variations Shahbazi-Ghahbazi, (2003). BR is a measuring element in health physics, according to Shahbazi-Ghahbazi (2013) and Saghatchi et al. (2008). The number of hours spent outside is increased by the resident's exposure dosage rate for indoor and outdoor locations Ramachandran, (2011).

Shisha contains trace amounts of radiation-active isotopes from the uranium and thorium series. The Smokers lungs accumulate radioactive isotopes due to prolonged exposure to sensitive tissues. Radiation exposure is, therefore, localized. When combined with other non-radioactive carcinogens, it has a significant potential for cancer Abd-El-Aziz, et al. (2005).

Radiation-active isotopes from the uranium and thorium series are present in shisha in trace concentrations. Shisha smoke contains these radioactive carcinogens. Radioactive isotopes are long-term exposure to sensitive tissues and accumulate in smokers' lungs. It leads to localized radiation exposure. Both by themselves and in conjunction with other non-radioactive carcinogens, the exposures have the potential to cause cancer Abd-El-Aziz, et al. (2005).

Among other health issues, ionizing radiation causes oral necrosis, anemia, acute leucopenia, and chronic lung diseases. Leukemia and cancers of the lungs, pancreas, liver, bones, and kidneys can result from thorium exposure Shousha and Ahmed, (2016). Youth are currently consuming shisha tobacco close to universities and school zones, which is concerning for the long-term development of law-abiding individuals in the nation Gats Sisay, et al, (2022). These days, it presents a difficulty for the local officials. Therefore, measuring gamma dose rates and continuously monitoring natural radioactivity concentrations are crucial in evaluating related radiological dangers.

According to several studies, smoking-related inhalation of naturally occurring radionuclides is one of the vital causes of lung cancer Akinyose, et al. (2018). Smoking tobacco exposes smokers to trace levels of radiotoxic substances such as ^{210}Pb, ^{210}Po, and ^{238}U.

It has been determined that smoking is a bulky, serious health problem in many nations and that it contributes to the high rates of death and morbidity among smokers and passive smokers. The specific pollutants, particularly cadmium, are found in substantially higher concentrations of fats, blood, and livers of tobacco users than in non-smokers El_Agha, et al. (2002); Husain, et al. (2016).

According to studies, secondhand smoke from other people causes lung cancer in 3000 adult non-smokers every year Jha, (2020). Moreover, the report shows that smokers share some issues with cigarette smokers. Users of ICRP were also seen to have respiratory infections, asthma, dyspnea, hypertension, increased blood sugar, and abnormal sleep patterns ICRP, (2012). Shisha smoking is not safer than cigarette smoking, according to the data.

Ethiopian cities across all regional states have seen a sharp rise in the smoking of shisha or cigarettes. According to the results of this poll conducted in 2021, by Selamawit, et al. (2022), 3.7% of adults currently smoke shisha products. 2.9% smoked cigarettes, and 0.7% smoked cigars, shisha-filled pipes, or any other recorded tobacco product. The new research reveals that boys between the ages of 20 and 24 who are employed, have media exposure, live in large central and metropolitan areas, and are related to Tilhaun et al. (2023).

Material and Methods

Study Area

The shisha samples were collected in Dire Dawa's City, Ashwa's largest open market located in the eastern part of Ethiopia, 515 kilometers east of the country's capital, Addis Ababa, and at a latitude of 9.59 N and longitude of 41.87 E. Its daily average temperature varies from 14 to 33.5 degrees Celsius.

Sample Collection and Preparation

The following five shisha samples were collected and labeled: Fluff Pack (S1), Normal Pack (S3), Semi-Dense Pack (S4), Dense Pack (S5), and Cement Pack (S6). The varieties of shishas and their sample codes are displayed in Table 1.

Every sample was placed in an oven at a temperature of 110°C. After that, the components were mixed, crushed, and put through a 200-mesh sieve, the ideal mesh size known for its concentration of heavy minerals. The materials were measured and then carefully transferred into 500 mL sealed polyethylene Marline beakers weighing 0.16 kg. We did not open these sealed beakers for a minimum of twenty-eight days. This deliberate waiting period was put in place to aid in the secular radioactive equilibrium of radon and its transient progeny. This equilibrium needed to be established to perform gamma-spectrometry analyses in the future.

Sample code	***Mass [kg]***
S1	0.015
S2	0.012
S3	0.015
S4	0.018
S5	0.020
S6	0.022

Table 1: The sample code and the mass of each shisha.

This study aims to evaluate the radioactivity of the different included radionuclides. We prioritize the following points to accomplish this goal:

- Determine which radionuclides are in the samples.
- Evaluate the ^{238}U, ^{232}Th, and ^{40}K specific activity concentrations.
- Estimate the Radium equivalent activity (R_{aeq}), absorbed dose rate (*DR*), annual effective dose equivalent (*AEDE*), the external and internal hazard index (*Hex* & *Hin*), and the excess lifetime cancer.

Experimental Procedures

Calibration of HPGe gamma Spectrometer

To achieve this result using a gamma-ray spectrometry instrument, such as isotope identification and qualitative and quantitative analysis. The system is calibrated for both energy and efficiency. Calibration usually entails determining fixed channels and evaluating the system's efficiency using materials with known qualities and established reference sources.

One of the basic requirements for nuclear spectroscopy measurement is to identify the photon peaks in a spectrum produced by the detection system. Energy calibration is carried out by using a certified mixed radionuclide point source. Determining the exact link between the energy channel and the gamma emissions was the aim of energy (or efficiency) calibration. Accurate nuclide identification depends on the instrument's energy calibration. The calibration was carried out using reference radionuclides of known activity with well-defined energies within the pertinent energy range of 59.4 KeV to 1836 KeV.

Methods

For radioactivity measurements, a lead-shielded gamma spectrometry (HPGe) detector was used as the detector. Its energy resolution is 1.90 keV (FWHM) at 1333 keV and 1.05 keV (FWHM) at 122 keV. Its peak-to-Compton ratio is 70:1. It has a 70% relative value. The obtained spectra were examined using the Genie2000 software. Each sealed sample was placed on the shielded HPGe detector and counted for 28,800 seconds to get a good count peak. The geometry of the sample containers is consistent with that of the used IAEA reference sample. The dimensions of the empty container size and shape were counted for 201,600 seconds to calculate the background distribution spectrum.

Activity Determination

The specific activity of ^{238}U was determined by summing the values of six γ-ray lines that were extracted from the photo peaks of $_{214}Bi$ (609.3 KeV, 1120.29 KeV, and 1764.8 KeV), ^{214}Pb (295.1 KeV and 351.9 KeV), and ^{226}Ra (186.2 KeV). After calculating the mean value of four γ-ray lines (338.5, 911.1, and 968.97 KeV) acquired from the ^{226}Ac, the ^{232}Th specific activity was determined. They measured the ^{40}K specific activity using 1461.8 KeV γ-ray energies. The radionuclides' daughter peaks with the most conspicuous photo peaks were subtracted from the background spectrum to get the net count rates beneath them. The radionuclide activity was computed using the background region of significant gamma-ray energy.

Eq. 1 is used to calculate the specific activity (C) in units of Bq kg^{-1} for each isotope in the materials under study Abas, et al. (2022); Goshu, et al. (2023); Hamza, et al. (2019); Salih, (2021).

$$A = \frac{\frac{N_S}{t_S} - \frac{N_b}{t_S}}{\varepsilon(E_i) I_\gamma M_S} \qquad (1)$$

where N_s and N_b are the net counts of radionuclides in the sample and background, respectively, I_γ is the gamma emission probability (gamma yield), $\varepsilon(Ei)$ is the detector's peak efficiency at energy E_i, t_s, and t_b are the sample and background measuring times and M_s is the sample mass in kilograms.

Radium Equivalent Activity (R_{aeq})

The radiological effects or activity concentration of materials containing the elements $^{238}U(^{226}Ra)$, ^{232}Th, and ^{40}K are compared by a single amount that accounts for the radiation dangers associated with them using a standard index called the radium equivalent specific activity (R_{aeq}). The specific activity (C) for each isotope is determined using Eq. 1 and expressed in units of Bq kg^{-1} Abas, et al. (2022); Goshu, et al. (2023); Hamza, et al. (2019); Salih, (2021).

$$R_{aeq} = A_U + 1.43A_{Th} + 0.077A_K \qquad (2)$$

where A_U, A_{Th}, and A_K are the specific activities of ^{226}Ra, ^{232}Th, and ^{40}K, respectively. Radium equivalent activity (R_{aeq}) of more than 370 Bq.kg^{-1} is prohibited to prevent radiation risks Abas, et al. (2021); Beretka and Mathew, (1985); Goshu, et al. (2023); Hamza, et al. (2019).

Absorbed Dose Rate

Radiation deposited or absorbed per mass measures how much ionizing energy radiation deposits in a material. It is expressed in joules per kilogram and can be shown as rad or gray (Gy), the corresponding SI unit. The following expression can be used to find the absorbed dose rate of natural radionuclides because they have a constant dosage rate of absorbed gamma radiation close to the ground Ashebir et al. (2022).

$$D_R = 0.462A_U + 0.604A_{Th} + 0.0417A_K \qquad (3)$$

where D_R is absorbed dose rate in nGyh^{-1}.

Smoke from shisha kabobs often includes 75% radioisotopes Baiwa and Kokif, (2022); UNSCEAR, (2000). This smoke becomes partially absorbed and lodges in the lung tissues. The annual effective dose equivalent (*AEDE*) and estimated values of dose rate equivalent for each individual were calculated using the occupancy factors of 0.8 (19/24) for indoor environments and 0.2 (5/24) for outdoor environments, respectively, and the dose rate conversion factor of 0.7 Sv Gy^{-1}. The conversion factors from an absorbed dose as measured in the air to an effective (0.7 Sv·Gy^{-1}) and an outdoor occupancy factor of 0.2 is employed to estimate the yearly effective $AEDE_{in}$. Thus, the effective dose rate is given by: Abas, et al. (2022); Ashebir, et al. (2022); Ayalew, et al. (2019); Goshu, et al. (2023).

$$AEDE_{in}\ (\text{mSvy}^{-1}) = D_R\ (\text{nGy.h}^{-1}) \times 8760\text{y}^{-1} \times 0.8 \times 0.7\text{Sv.Gy}^{-1} \times 10^{-6} \qquad (4)$$

The annual indoor effective dose ($AEDE_{out}$), which may be computed using Eq. 5 UNSCEAR (2000), is the dosage a person receives indoors. The time spent within a structure, conversion dose factors, and the amount of gamma radiation found in the building affect the annual indoor effective dose.

$$AEDE_{out}\ (\text{mSvy}^{-1}) = D_R\ (\text{nGy.h}^{-1}) \times 8760\ \text{hy}^{-1} \times 0.2 \times 0.7\text{Sv.Gy}^{-1} \times 10^{-6} \qquad (5)$$

where $mSv{\cdot}y^{-1}$ (millisieverts per year) is the unit for the annual effective dose rate ($AEDE_{in}$) $nGy{\cdot}h^{-1}$ (nano Gray per hour) is the unit of the absorbed dose rates (D_R) $hy{\cdot}r^{-1}$ (an hour per year) given 24 hours (a day) × 365 days (in a year).

^{232}Th, ^{226}Ra, and ^{40}K are the principal naturally occurring radioactive elements that expose humans to external radiation. The U and Th series radionuclide production results in significant human exposure. Eq. (3), as stated in Abas, et al. (2021); Goshu, et al. (2023); Segour and Seghour, (2009); Fatima, et al. (2021), is used to derive the external hazard index (Hex):

$$H_{\mathrm{ex}} = \frac{C_{\mathrm{U}}}{370} + \frac{C_{\mathrm{Th}}}{259} + \frac{C_{\mathrm{K}}}{4810} \leq 1 \qquad (6)$$

The internal hazard index (Hin) can be determined by Eq. (4), mentioned in Abas, et al. (2021); Ashebir, et al. (2022); Goshu et al. (2023); Segour and Seghour, (2009).

$$H_{\mathrm{in}} = \frac{C_{\mathrm{U}}}{185} + \frac{C_{\mathrm{Th}}}{259} + \frac{C_{\mathrm{K}}}{4810} \leq 1 \qquad (7)$$

The value of this index must be less than unity to make negligible the radiation hazard. Both indices are pure numbers and do not have dimensions Abas, et al. (2021); Ashebir, et al. (2022); Goshu et al. (2023); Segour and Seghour, (2009), Tadelech and Tilahun, (2020); Fatima, et al. (2021); Goshu, (2024).

The likelihood of acquiring cancer throughout a lifetime at a specific exposure level is known as excess lifetime risk (*ELCR*). An increased *ELCR* value suggests a higher probability of cancer induction in the exposed person. It is possible to compute it with the following formula: Goshu, et al. (2023); Taskin, et al. (2009).

$$ELCR_{in} = AEDE_{in} \times DL \times RF \qquad (8)$$

$$ELCR_{out} = AEDE_{out} \times DL \times RF \qquad (9)$$

where *DL* is the duration of life (estimated to be 70 years), and *RF* is a risk factor in Sv^{-1}. The International Commission on Radiological Protection (ICRP) uses RF as 0.05 for the general public's ICRP for stochastic effects ICRP. (2012); Taskin, et al. (2009).

The gamma radiation hazard index (I_γ) is another radiation index and is defined by the following formula:

$$I_\gamma = 0.0067C_U + 0.01C_{Th} + 0.00067C_K \leq 1 \qquad (10)$$

Results and Discussion

Results

The examination of background radiation from smoking shisha produced several intriguing findings. Various configurations displayed varying levels of background radiation. A comparison between background radiation and the prevalence of shisha was carried out to look for any possible correlations. The radioactive background radiation was measured using the samples collected from the Ashwa open market in Dire Dawa City, Ethiopia. This work determined the specific activity of ^{238}U, ^{232}Th, ^{40}K, radium equivalent, radiation hazard indices, public health dangers, and the annual effective dosage that establishes the cancer risk level.

Table 2 shows the radium equivalent activity of all shisha samples, with 370 Bq kg^{-1} being the suggested global average value. Since the activity index's value is below the advised global limit, it serves as a helpful guideline for managing radiation safety requirements for the general people living in the area under inquiry.

Sample code	*Specific Activity*			R_{eaq} [Bq kg^{-1}]
	^{238}U [Bq kg^{-1}]	*^{232}Th [Bq kg^{-1}]*	*^{40}K [Bq kg^{-1}]*	
S1	7.67 ± 0.57	7.99 ± 0.63	222.0± 10.5	36.19
S2	1.29 ± 0.13	2.43 ± 0.34	24.5 ±14.6	6.65
S3	8.07 ± 0.65	12.46 ± 5.75	364.9±0.0	53.99
S4	7.25 ± 0.45	7.61 ± 2.23	203..8 ±8.23	33.85
S5	6.82 ± 0.60	8.61±2.23	207.5 ±10.9	35.11
S6	9.45±4.5	17.75±1.25	345.25±2.75	61.42
Maximum	8.07 ± 6.3	17.75 ± 13.5	364.9 ±0.0	61.42
Minimum	1.29 ±0.63	2.43± 0.23	24.5± 14.6	6.65
Average	6.76 ±2.80	9.48± 2.74	227.99± 15.28	37.87
World Average	35	30	400	[35]

Table 2: The specific activity of ^{238}U, ^{232}Th, and ^{40}K, in addition to the radium equivalent, in samples of shisha collected from the Ashwa local market in Dire Dawa, Ethiopia.

Table 2 displays the specific activity concentrations of ^{238}U, ^{232}Th, and ^{40}K measured in shisha samples. The average values range from 1.29 ±0.63 to 8.07 ± 6.3, with an average of 6.76 ±2.80, 2.43± 0.23to 17.75 ± 13.5, with an average of 9.48 ± 2.74, and 24.5 ± 38.2 to 364.9 ± 0.0, with an average of 227.99 ± 15.28 Bq kg^{-1}, respectively. The ^{238}U and ^{232}Th shisha concentrations were below the global limit. The average specific activity for ^{40}K was lower than the global average concentration of 400 Bq kg^{-1} UNSCEAR (2000).

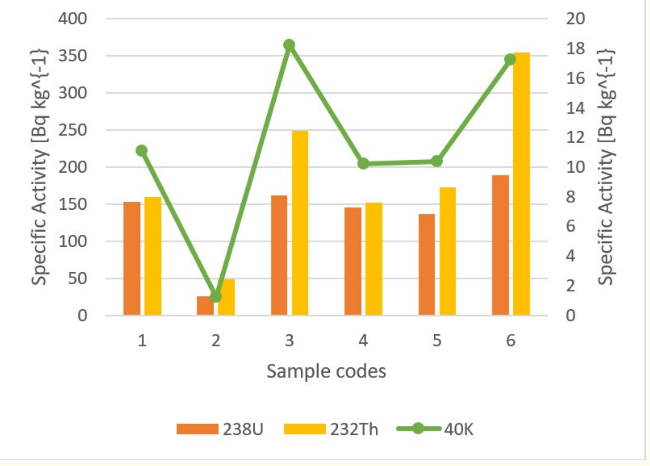

Figure 1: The specific activities of radionuclides elements ^{238}U, ^{232}Th, and ^{40}K from shisha samples.

A bulk variation of ^{238}U, ^{232}Th, and ^{40}K activity concentrations are observed in the samples shown in Figure 1. The red line corresponds to specific activity ^{238}U, the orange line corresponds to ^{232}Th, and the green line corresponds to ^{40}K. It might be due to variations in radionuclide content present in shisha samples due to their planting areas or maybe the production areas. The minimum specific activity was observed in S2.

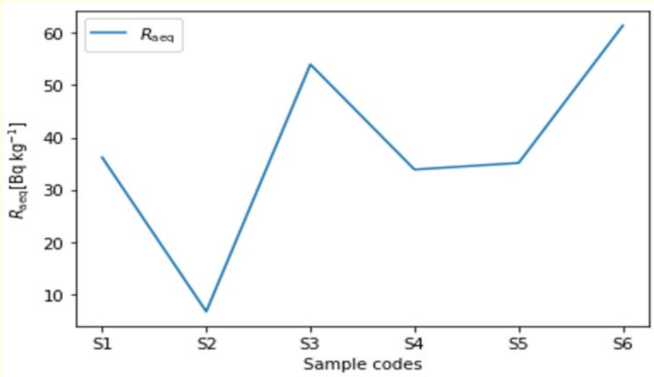

Figure 2: The radium equivalent shisha samples.

The last column of Table 2 and Figure 2 shows the radium equivalent of shisha samples. The results show that the R_{aeq} samples ranged from 6.65 to 53.99 with an average of 33.16 Bq kg^{-1} lower than the recommended limit of 370 Bq kg^{-1}. But the highest R_{aeq} was observed in S3.

Sample code	*D_R [nGyh^{-1}]*	*AEDE (mSv y $^{-1}$)*		*H_{ex}*	*H_{in}*	*I_γ*
		Indoor	*outdoor*			
S1	17.63	0.086	0.022	0.098	0.118	0.280
S2	3.09	0.015	0.004	0.018	0.021	0.049
S3	26.47	0.130	0.032	0.146	0.168	0.423
S4	16.46	0.081	0.020	0.091	0.111	0.261
S5	17.00	0.083	0.021	0.095	0.113	0.271
S6	29.48	0.145	0.036	0.166	0.166	0.472
Max	29.48	0.145	0.036	0.166	0.166	0.472
Min	3.09	0.015	0.004	0.018	0.021	0.049
Average	18.35	0.090	0.024	0.102	0.121	0.293

Table 3: The absorbed dose rate, outdoor and indoor annual effective dose, and external and internal hazard index of shisha samples collected from the Ashwa local market in Dire Dawa City.

The dose rate, the gamma index, the internal and external hazard indices, and the indoor and outdoor yearly effective equivalent dose rates are displayed in Table 3. The outcome reveals that the average dose rate was 18.35 nGyh^{-1}, ranging from 3.09 to 26.47 nGyh^{-1}. The *AEDE* indoor and outdoor environments were between 0.015 and 0.145, corresponding to 0.090 mSvy^{-1}, and between 0.004 and 0.036 mSvy^{-1}, an average of 0.024 mSvy^{-1}. The external and internal hazard indices, which were lower than UNSCEAR (2008) and Toosi et al. (2017), agreed with the international standards.

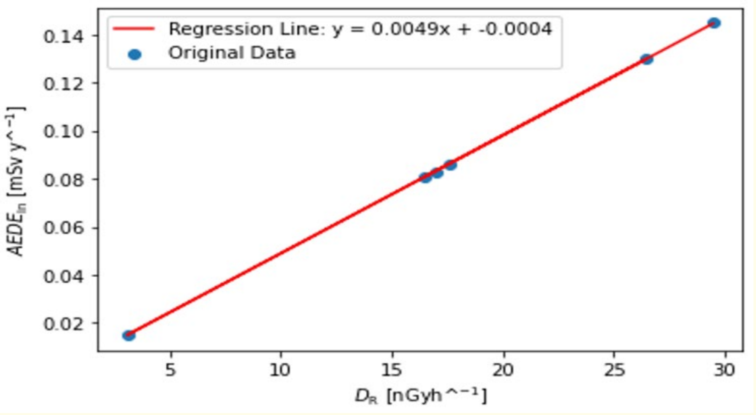

Figure 3: The annual effective dose is equivalent to the natural radioactivity of shisha indoors vs. the absorbed dose rate.

As seen in Figure 3, the findings indicate a positive relationship between the absorbed dose rate in indoor and outdoor environments. The model that emerged between indoor and outdoor environments showed a positive relationship, whereas the regression line equation is $DR_{ind} = 0.0688DR_{outd} + 0.000143$.

Similarly, Figure 4 shows the annual effective dose rate. The result shows the two parameters are related positively, and the regression line is $y\ (AEDE_{out}) = 0.00123x(D_R) - 0.00002$.

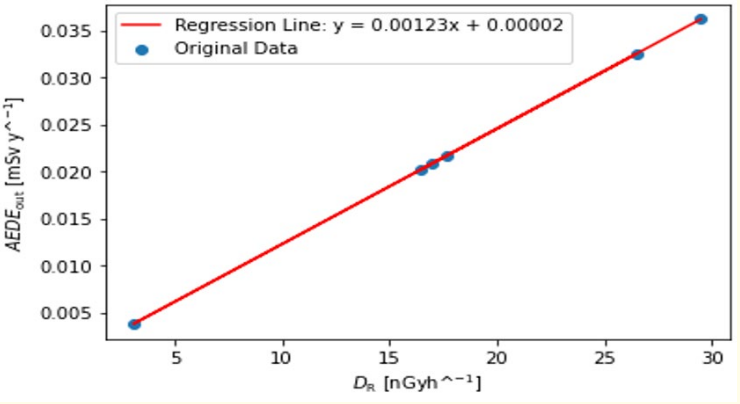

Figure 4: Annual effective dose is equivalent to the natural radioactivity of shisha outdoors vs. the absorbed dose rate.

Similarly, the data reported in column five of Table 3 indicate the gamma index was less than a unit, however in one of the samples, S3, the observed gamma index was comparatively higher than the other ones; its value was less than the international limit.

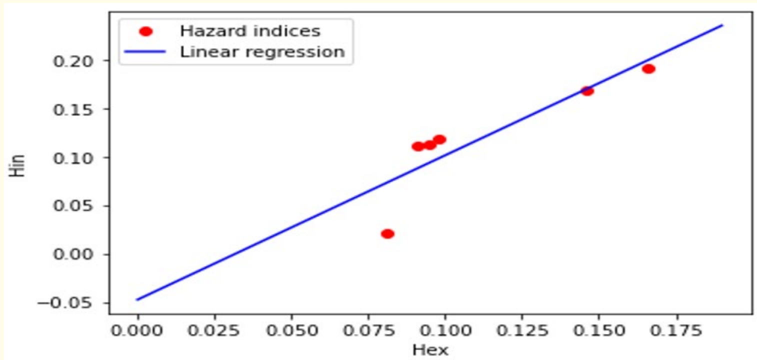

Figure 5: The internal hazard index vs the external.

The correlation between the samples and the internal hazard index (Hin) and external hazard index (Hex) is positive, as seen in Figure 5. It suggests that the two variables have a definite linear relationship and are given by $H_{in} = 1.489H_{ex} - 0.0477$.

Let's compute the yearly effective dosage attributable to inhalation for an individual taken annually based on the mass of shisha shown in Table 1. Each shisha sample in this study was inspected using High Purity Germanium (HPGe). The average daily shisha use in Ethiopia one puff was 16.2 g. The mass of shisha people use per year is 5.90 kg. y^{-1}. Therefore, the annual effective dose of shisha E due to its consumption (μSv y^{-1}) was calculated using Eq. 11

$$E = 0.75 \times C_i \times M \times DCE \quad (11)$$

where E is the annual effective dose for shisha smoke, and C_i is the specific activity. M is the mass of shisha per year, and DCF is the standard dose conversion factor. The most recent dose conversion coefficients for the case of inhalation of shisha for adults are 5.0×10^{-7}, 1.1×10^{-4}, and 2.1×10^{-9} $SvBq^{-1}$ for ^{238}U, ^{232}Th, and ^{40}K, respectively ICRP. (2012); Toosi, et al. (2017) [16].

The average yearly shisha consumption rate is 5.90 kg. y^{-1} Oluide, et al. (2019) The average *ELCR* was higher than the international standards, at 0.394 (10^{-3}), according to Table 4's statistics. The range of the *ELCR* was 0.066 - 0.568 (10^{-3}). Furthermore, inside had a higher annual effective dosage rate than outdoor settings. Besides, the outcome demonstrates that the absorbed dose rate determines the excess lifetime cancer; the higher the dose rate, the higher the *ELCR*, as seen in Figure 6.

Sample Code	*$AEDE_{in}$[$mSvy^{-1}$]*	*$AEDE_{out}$[$mSvy^{-1}$]*	*$ELCR_{Total}$[10^{-3}]*
S1	0.086	0.022	0.378
S2	0.015	0.004	0.066
S3	0.130	0.032	0.568
S4	0.081	0.020	0.353
S5	0.083	0.021	0.365
S6	0.145	0.036	0.633
Max	0.145	0.036	0.633
Min	0.015	0.004	0.066
Average	0.090	0.023	0.394

Table 4: Excess life cancer and annual effective dose rate in and outdoors of shisha samples.

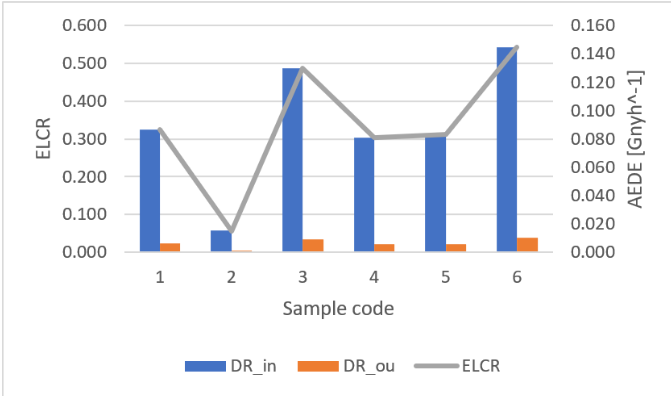

Figure 6: The indoor and outdoor dose rate of shisha vs the excess lifetime cancer risk.

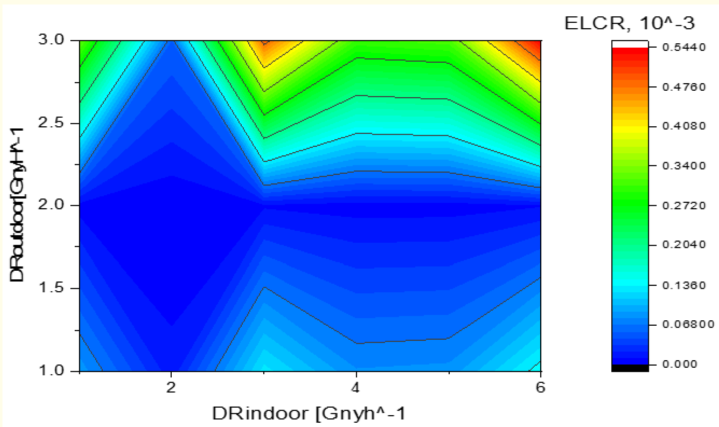

Figure 7: The excess lifetime cancer risk with indoor and outdoor absorbed dose rate.

As can be shown in Figure 7, there was a significant increase in lifetime cancer in samples S3 and S6. This resulted from the characteristics of the radioactive elements present in these specimens. The extra lifetime hazards in S1, S2, S4, and S5 were negligible.

Discussions

Based on data from UNSCEAR (2000), the average concentrations of ^{238}U, ^{232}Th, and ^{40}K in shisha are shown in Table 2 and Figure 1. The specific activity of ^{238}U ranged from 4.01 to 8.07 Bq kg^{-1}, with an average value of 6.75 Bq.kg^{-1} lower than the global limit of 35 Bq kg^{-1} UNSCEAR (2000). The specific activity of ^{232}Th ranged from 2.43 to 17.45 Bq kg^{-1}, with an overall average of 9.48 Bq kg^{-1}; this is again below the international limit UNSCEAR (2000).

These results, which highlight the factors influencing shisha radiation, are consistent with other studies that show the effects of location, production processes, and other variables on radioactivity levels (SKWARZEC et al., 2001; Gats et al., 2016). Its variety highlights the necessity for a comprehensive and diverse approach by weighing how it is to assess and understand the radioactive content in tobacco products.

The radium equivalent activity ranged from 6.65 to 61.42 Bq kg^{-1} with an average of 37.87 Bq.kg^{-1}. Remarkably, each shisha's computed R_{aeq} is far lower than the 370 Bq kg1 internationally acknowledged threshold Tadelech and Tilahun, (2020). Additionally, the results show that the Reaq for shisha is higher than Baiwa, et al. (2022). Additionally, the specific activity for ^{232}Th and ^{40}K was lower than the global limit and Baiwa, et al. (2022) and higher than the previous study and the international limit displayed in Table 4 Baiwa, et al. (2022); UNSCEAR (2000) for ^{238}U.

Parameters	***Shisha***		
	Recommended limit UNSCEAR (2000).	***Baiwa, et al. (2022)***	***This study***
R_{eaq} [Bq.kg^{-1}]	370	34.55	37.87
^{238}U [Bq.kg^{-1}]	35	8.44±1.9435	6.76
^{232}Th [Bq.kg^{-1}]	30	5.45±0.6	9.48
^{40}K [Bq.kg^{-1}]	400	258.12±18.40	227.99
D_R [(nGy h^{-1}]	57	17.37	18.35
ELCR [10^{-3}]	0.2	17.42	0.394

Table 5: Comparison of the previous studies with current studies of radiological hazards from shisha.

According to the study's findings, the examination of absorbed dose rates shows a spectrum spanning from 3.09 to 29.45 $nGyh^{-1}$. The reported values continually fall short of the 60 $nGyh^{-1}$ global threshold for absorbed dose rates mentioned by MISSIMER, et al. (2019); and UNSCEAR (2000) and were higher than the results shown in Table 5 Baiwa, et al. (2022). It adds a vital context to radiological safety by highlighting the general adherence to international standards that minimize potential hazards of radiation exposure related to the samples under examination. We infer from the mean annual effective dosage equivalent of 0.1 $mSvy^{-1}$ that every shisha sample falls below the 0.48 $mSvy^{-1}$ global recommended limit.

Shisha's extra-life cancer was calculated using Eq. 11 and shown in Table 5. According to the results, the *ELCR* ranged from 0.066 to 0.568 (10^{-3}), with an average of 0.313 (10^{-3}). Furthermore, the highest and lowest *ELCR* values were noted in samples S1 and S2, respectively. The lifetime cancer risk average is higher than the 0.25 × 10^{-3} global average UNSCEAR (2000). Additionally, the outcome of this work is better than Baiwa, et al. (2022); Eckerman, et al. (1989); and Boumala, et al. (2019). It suggests that there is an increased risk of cancer exposure when using shisha.

According to KHATER, et al. (2008); and Skwarzec, et al. (2001), for smokers who inhaled 50% of shisha smoke from one (1) puff of shisha per day, the excess lifetime cancer risk (*ELCR*, × 10^{-3}) varied from 0.10 to 0.36, an average of 0.24. Similarly, in research that was done in Dire Dawa in cigarettes by Girum, et al. (2023), the lifetime cancer risk (*ELCR*, ×10^{-3}) varied from 0.105 to 0.14, with an average of 0.229). The finding shows that the lifetime cancer risk for shisha was higher than both findings.

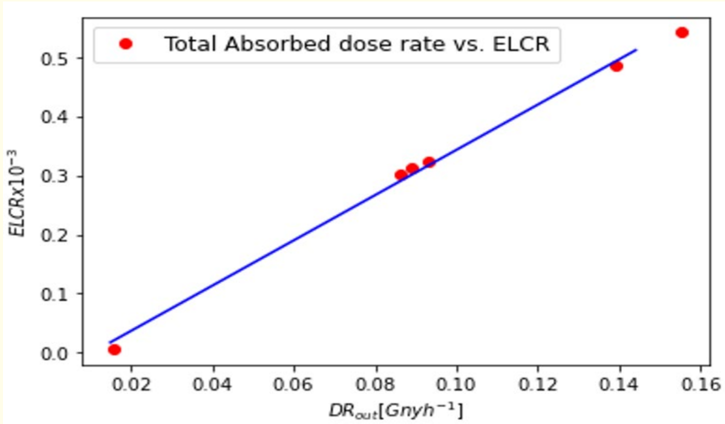

Figure 8: Excess lifetime cancer risk vs. the dose rate for shisha.

Figure 8 shows the increased lifetime cancer risk vs. dosing rate. The findings show that the relation was defined linearly and that the additional risk is directly proportional with $ELCR=3.837DR_{\{total\}}$ - 0.0405, with a r^2 = 0.9999 for six samples of shisha.

For six samples, the result shows a positive association between the absorbed dose rate and the *ELCR*. It implies that the two variables are directly correlated and that the absorbed dose rate increased proportionately in regions with higher excess lifetime cancer.

Conclusions and Recommendations

Conclusions

This study aimed to evaluate the possible effects of background radiation from shisha smoke. Background radiation is the natural radiation from the sun, the earth, and building materials. The shisha was retrieved from the Ashwa local market in Dire Dawa City, Ethiopia. The associated radiation danger features were evaluated using gamma-ray spectroscopy or a high-purity germanium detector (HPGe). The specific activity of ^{238}U, ^{232}Th, and ^{40}K for shisha samples are less than the global limits of 35, 30, and 400 Bq kg^{-1}, in that order. Shisha has detrimental effects on one's health, finances, social standing, and other issues. Even shisha's inherent radioactivity may be a foremost contributing factor to the harmful consequences of shisha usage on health.

Recommendations

The projected increased lifetime cancer risk values are in accord with the recommendations for shisha. According to the report, public awareness of the health hazards that smoking and shisha pose in public places for both smokers and non-smokers. The researchers advised Ethiopia's government to build on the close community relations he established five years ago by raising awareness of the dangers of smoking in public places.

Additionally, this study's data may be valuable for mapping naturally occurring radioactivity and serving as a baseline for further research.

Acknowledgments

We sincerely acknowledge the Ethiopian Radiation and Protection Agency for the opportunity to utilize one of their laboratories, the low background counting laboratory, and the research facilities therein. The authors appreciate the Department of Physics at Dire

Dawa University's technical support to complete this research project on time.

Conflict of interest: The author has no conflicts of interest to disclose.

Data Availability

Upon reasonable request, the corresponding author will provide the data supporting the study's conclusions. request.

References

1. Abas E, B Sitotaw and E Mengistu. "Evaluation of radionuclides specific activity of groundwater resources. A case of Dire Dawa City, Ethiopia". Romanian J. Biophys 31.1 (2021): 1-11.
2. Abd El-Aziz N, Aem Khater and HA AL-Sewaidan. "Natural radioactivity contents in tobacco". International Congress Series 1276 (2005): 407-408.
3. Akinyose FC., et al. "Radiological Impacts of Natural Radioactivity in Locally Produced Tobacco Products in Oyo State, Nigeria". Journal of Physical Chemistry & Biophysics, Momona Ethiopian Journal of Science (MEJS) 10.1 (2018): 59-75.
4. Alemu GK, Taju, E and Mengistu E. "Assessment and Evaluation of Natural Radioactivity in Cigarettes Found in Ethiopia and Their Radiological Effects". Mather Thesis, Dire Dawa University, Ethiopia, Unpublished (2023).
5. Ashebir NC, BS Goshu and E Mengistu. "Assessment of Natural Radioactivity in Soil Samples and Tea Leaves at Gumero Tea Farm, Ethiopia". Romanian j. Biophys 32.2 (2022): 103-119.
6. Ayalew D, B. Sitotaw E. "Mengistu, Assessment of natural radioactivity levels in the soil of Dire Dawa city, Ethiopia". Romanian J. Biophys 29.4 (2019): 113-122.
7. Baiwa AI and Koki FS. "Determination of radionuclides in selected samples of cigarette, shisha, and shisha charcoal mostly used In Kano State, Nigeria". Bayero Journal of Pure and Applied Sciences 13.1 (2022): 347-351.
8. Beretka J and Mathew PJ. "Natural radioactivity of Australian building materials, industrial wastes, and by-products". International Journal of Environmental Science and Technology 48.1 (1985): 87-95.
9. Boumala D., et al. "Annual effective dose and excess lifetime cancer risk assessment from tobacco plants". ScienceDirect 12 (2019): 1-4.
10. Eckerman KF., et al. "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion". Federal Guidance Report No. 11, U.S Environmental Protection Agency (EPA) (1989).
11. El-Agha O and Gökmen İG. "Smoking habits and cadmium intake in Turkey". Biol Trace Elem Res 88 (2002): 31-43.
12. Fatma Ragab and Hanan AS Aly. "Investigation of Radionuclides in Shisha Tobacco and Hazards Impact on the Egyptian Smokers". Journal of Scientific Research in Science 38.1 (2021): 19-35.
13. Mengesha SD., et al. "Tobacco use prevalence and its determinate factor in Ethiopia- finding of 2016 Ethiopian". BMC Public Health 22.1 (2022): 555.
14. Goshu BS. "Modeling Assessment of Indoor Air Quality and Radiation Exposure in Shisha Smoking Rooms: Implications for Public Health". SIASAT Journal of Social, Cultural and Political Studies 9.1 (2024): 56-65.
15. Goshu BS, Abasa E and Woldeamanuel M. "Assessment of The Natural Radioactivity of Bottled Drinking Water Produced in Dire Dawa, Ethiopia". Romanian J. Biophys 33.3 (2023): 89-103.
16. Hamza ZM, SA Kadhim and HH Hussein. "Assessment of the norms for agricultural soils in Ghammas town". Iraq, Plant Archives 19.1 (2019): 1483-1490.
17. Husain H., et al. "Is Smoking Shisha Safer than Cigarettes: Comparison of Health Effects of Shisha and Cigarette Smoking among Young Adults in Kuwait". Medical Principles and Practice 25.2 (2016): 117-122.
18. ICRP. Compendium of dose coefficients based on ICRP publication 60. International Commission on Radiological Protection, ICRP Publication 119, Annex of ICRP 41 (2012).
19. JHA P. "The hazards of smoking and the benefits of cessation: a critical summation of the epidemiological evidence in high-in-

come countries". Elife 9 (2020): e49979.

20. Khater A., et al. "Radiological hazards of Narghile (hookah, shisha, goza) smoking: Activity concentrations and dose assessment". Journal of Environmental Radioactivity 99 (2008): 1808-1814.
21. Missimer TM., et al. "Natural Radiation in the Rocks, Soils, and Groundwater of Southern Florida with a Discussion on Potential Health Impacts". Int J Environ Res Public Health 16.10 (2019): 1793.
22. Oluyide SO., et al. "Natural Radioactivity and Radiological Impact Assessment of Soil, Food, and Water around Iron and Steel Smelting Area in Fashina Village, Ile-Ife, Osun State, Nigeria". Journal of Applied Sciences and Environmental Management 23.1 (2019): 135-143.
23. Ononugbo C, Avwiri G and Tutumeni G. "Estimation of indoor and outdoor effective doses from gamma dose rates of a residential building in Emelogu village in river's state, Nigeria". Inter Res J Pure Applied Physic 3 (2015): 18-2.
24. Ramachandran T. "Background radiation, people and the environment". Int J Radiat Res 9 (2011): 63.
25. Salih NF. "Measurement of the natural radioactivity concentration levels of radionuclides in selected vegetables collected from Kirkuk, Iraq using an HPGe detector". International Journal of Environmental Analytical Chemistry 27 (2021): 1-20.
26. Saghatch F, Salout M and Eslam A. "Assessment of annual effective dose due to natural gamma radiation in Zanjan (Iran)". Radiat Prot Dosimetry 132 (2008): 346-9.
27. Sam AK and N Abbas. "Assessment of radioactivity and associated hazards in local and imported cement types used in Sudan". Radiation Protection Dosimetry 93.1 (2010): 275-277.
28. Selamawit Hirpa., et al. "An Emerging Problem of Shisha Smoking among High School Students in Ethiopia". nt. J. Environ. Res. Public Health 18.13 (2021): 7023.
29. Shahbazi-Gahroue D, Gholam M and Setayandeh S. "A review on natural background radiation". Adv Biomed Res 2 (2013): 65.
30. Shahbazi-Gahroue D. "Natural background radiation dosimetry in the highest altitude region of Iran". J Radiat Res 44 (2003): 285-7.
31. Seghour A and FZ Seghour. "Radium, and ^{40}K in Algerian bottled mineral waters, and consequent doses". Radiation Protection Dosimetry 133.1 (2009): 50-57.
32. Shousha HA and Ahmed F. "Lifetime Cancer Risk of Gamma Radioactivity Results from Smoking". Journal of Cancers Review 3 (2016): 1-9.
33. Skwarzec B., et al. "Inhalation of 210Po and 210Pb from cigarette smoking in Poland". Journal of Environmental Radioactivity 57 (2001): 221-230.
34. Tadelech S and Tilahun T. "Investigations of Natural Radioactivity Levels and Assessment of Radiological Hazard of Tea Samples Collected from Local Market in Ethiopia". Journal of Nuclear and Particle Physics 10.1 (2020): 9-12.
35. Taskin H., et al. "Radionuclide concentrations in soil and lifetime cancer risk due to gamma radioactivity in Kirklareli, Turkey". Journal of Environmental Radioactivity 100 (2009): 49-53.
36. Kassew T., et al. "The prevalence and determinant factors of substance use among the youth in Ethiopia: A multilevel analysis of Ethiopian Demographic and Health Survey". Frontiers Psychiatry 14 (2023): 1096863.
37. Toosi MB., et al. "Assessment of Environmental Gamma Radiation (Outdoor and Indoor Spaces) in the Region of Bandar Abbas Gachine". J Biomed Phys Eng 10.2 (2017): 177-186.
38. UNSCEAR (2000). Sources and Effects of Ionizing Radiation. United Nations Scientific Committee on the Effects of Atomic Radiation Sources to the General Assembly with Annexes, Effects, and Risks of Ionizing Radiation, New York: United Nations Publication.
39. UNSCEAR. Sources and effects of ionizing radiation. United Nations Scientific Committee on the effects of atomic radiation. New York: United Nations Publication; 2008. UNSCEAR. (2008). Sources and Effects of Ionizing Radiation. Annex B.

Volume 6 Issue 6 June 2024
© All rights are reserved by Belay Sitotaw Goshu., et al.