مجلة كلية التربية الاساسية
كلية التربية الاساسية – الجامعة المستنصرية
Journal of the College of Basic Education Vol.30 (NO. 126) 2024, pp. 146-161

Evaluation of Radioactivity Concentration and Hazard Indices in ash Some Hospitals Incinerators in Baghdad / Al Resafa

Nabaa Qassim kadhem[1], Itab F. Hussein[1][0000-0002-1091-6982] and Basim A. Hussain[2]
[1]Department of Physics, College of Science, Mustansiriyah University, Baghdad, Iraq
[2]Scientific research commission Research and Technology center of Environment,water and Renewable Energy,. Iraq
nabaa.qassim@uomustansiriyah.edu.iq

Abstract
Due to their harmful effects on human health and their tendency to cause cancer, radionuclide concentrations and risk indicators have been measured in hospital incinerator ash. This was done by collecting samples ash of Hospitals Incinerators, examining them, and identifying the risks that emerged from the examination. Three samples Only taken for the study from certain hospitals affiliated with the Baghdad Al-Rusafa Health Department. High purity germanium gamma spectrometer (HPGe) were used to analyze the samples. The concentrations of potassium isotopes (K-40) range from (147.1±16.5 to 214.4±21.1 Bq/kg), While the range of concentrations for Ra-226 isotopes is (7.52±1 to 19±1.8 Bq/kg), and lead (Pb-212) isotope concentrations ranged from (10.1±1.1 to 11.1±1.5 Bq/kg). In addition, the isotope concentration of actinium (Ac-228) is 8.05±1. Radium equivalent (Ra_{eq}), risk index (H), annual effective dose equivalent $(AEDE)$, radioactivity level index $(I\gamma)$, absorbed dose rate D, and lifetime cancer risk $(ELCR)$ were calculated. The results showed that no radiation risk Only indicated by any of the risk indicators. This indicates that the ash from the hospital incinerator does not pose any radioactive danger.

Keywords: Hospitals Incinerators, High Purity Germanium, Absorbed dose, Radium equivalent, Risk index, equivalent of an annual effective dose,Radioactivity (space) level index, Lifetime cancer risk.

1.Introduction
The decay (or disintegration) of matter into an isotope nucleus with the production of nuclear particles like alpha or beta is known as radioactivity. It is possible for isotopes and electromagnetic radiation (gamma rays) to be released, which leads to radioisotope disintegration or breakdown[1]. One of the most important global environmental challenges that has drawn the attention of governments around the world is radioactive pollution[2].

Serious tendencies can be see in the enormous diversity and some industrial complexes' expansion, which frequently accompanied by extreme contamination that degrades the ocean. Furthermore, the more applications of radiation sources and isotopes in human life the higher the risk of radioactive contamination[3],[4],[5]. Ionizing radiation from radioactive elements in the environment is a global health risk that affects everyone. The most significant components of the environment include air, water, soil, and other factors that have an impact on human development[6]. In addition to radionuclides migrating to neighboring locations, rocks and soil are the primary sources of radiation exposure for locals[7]. Due to many human exposure routes, dumpsite soil increases radioactive risk, increases pollution, and poses a serious hazard to public health[8]. Because improper waste disposal and treatment might pose health and environmental problems, there is increased focus on the issue of population exposure to radiation and radioactive transport modes[9]. By using high-purity germanium gamma spectroscopy (HPGe), this study aims to assess the radiological dangers in the ash of hospital incinerators as well as the concentration of radioactivity and risk indicators in the ash.

Study Area

Three hospitals were included in the study region, as shown in Figure 1: Imam Ali Hospital (Al-Jawadar), Sheikh Zayed, and Dhari Al-Fayyad Hospital, all located inside the Baghdad Governorate. Which, as Table 1 illustrates, is situated between latitudes and longitudes.

Table 1. Coordinates of the study area

Sequence	Location	Latitude Coordinate	Longitude Coordinate
1	Imam Ali Al-Jawader Hospital	33.39503	44.46340
2	Sheikh Zayed Hospital	33.31652	44.42842
3	Dhari Al-Fayad Hospital	33.51476	44.39269

مجلة كلية التربية الاساسية
كلية التربية الاساسية – الجامعة المستنصرية
Journal of the College of Basic Education Vol.30 (NO. 126) 2024, pp. 146-161

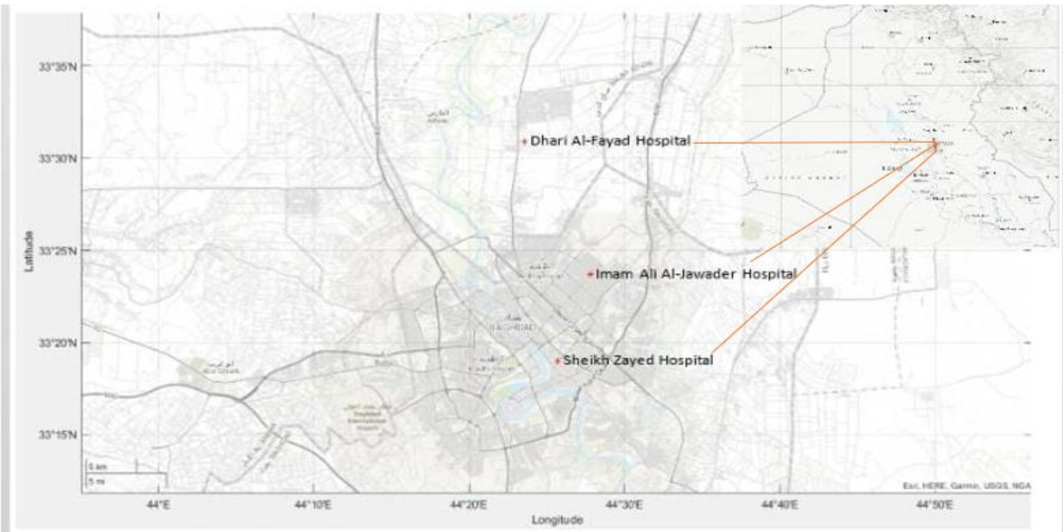


Figure 1. Hospital locations in the study area

2. Resources And Techniques

The investigation completed on three locations within the Baghdad Al-Rusafa Health Department in the capital city of Baghdad. Imam Ali (Al-Jawadar) (ash_2), Sheikh Zayed (ash_1), and Dhari Al-Fayyad (ash_3). Hospital ash samples are collected after burning, crushing, and drying the waste, which represents toxic waste (needles, needles, spent medication containers, in addition to laboratory waste), as shown in Figure 2. The samples are then passed through a silicone sieve to remove any annoying contaminants. When the diameter of the samples reaches $20\mu m$, the sample is weighed using a sensitive balance, and the sample weight was (313g). It is prepared for analysis. High-purity materials spectrometer gamma germanium (HPGe) analyzer, also called low-quantity, low-dose, model 2018, made in the United States of America by Canberra Corporation, is used to measure quantities of radioactive isotopes. The detector allows handling of small quantities. The device is calibrated using a standard source with a duration of 30 minutes. The measurement process begins with models with a duration of 60 minutes with the same geometric shape containing the standard radioactive source. The equation for energy calibration for this figure (3)

$$E = 2.44 \times 10^{-1} + 8.25 \times 10^{-1} \times C \qquad (1)$$

Where E:- is the peak energy in units (K eV)

C:- is the channel number corresponding to the peak power

The detection efficiency (ε) of the detector show in figure (4) at the energy peak for a specific isotope can be calculated from the following equation

$$(\varepsilon) = 2.621 + 9.38 * (1 - exp^{\left(-\frac{E-1.151}{1.179}\right)})^{0.369} * exp^{\left(-\frac{(E-1.15)}{1.119}\right)} \qquad (2)$$

It has a wide range of energies starting from (59.54kev to 1332.5kev) (Co-60). The findings indicated that (K-40), (Pb-212), (Ra-226), and (Ac-228) were present. The isotope Ra-226 is an extension of the uranium series U-228. While the isotopes Pb-212 and Ac-228 are extensions of the thorium series Th-232. After measuring the concentrations of radioactive isotopes, the device works to draw a relationship between energy and efficiency.

Figure 2. Medical waste ash before and after the grinding process

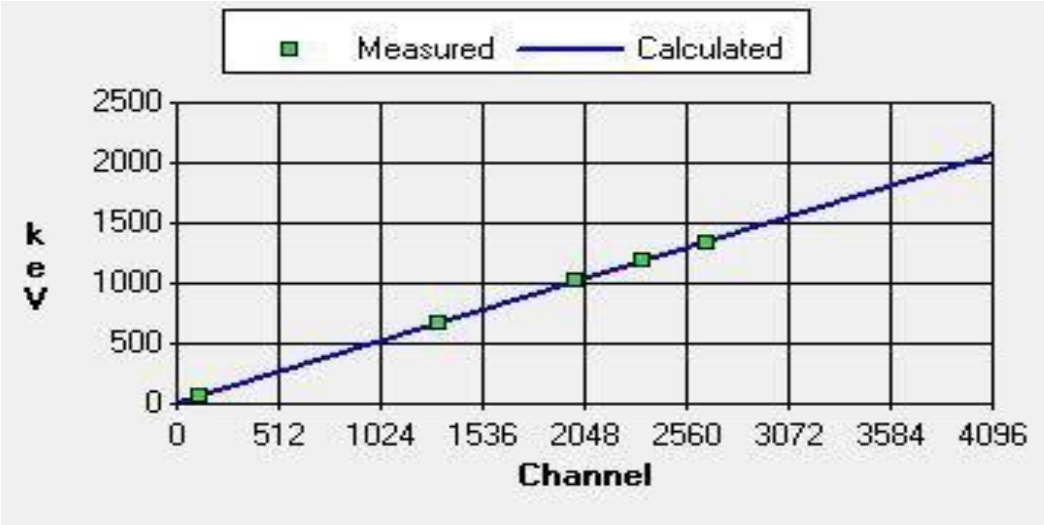


Figure (3). energy calibration of the measuring system

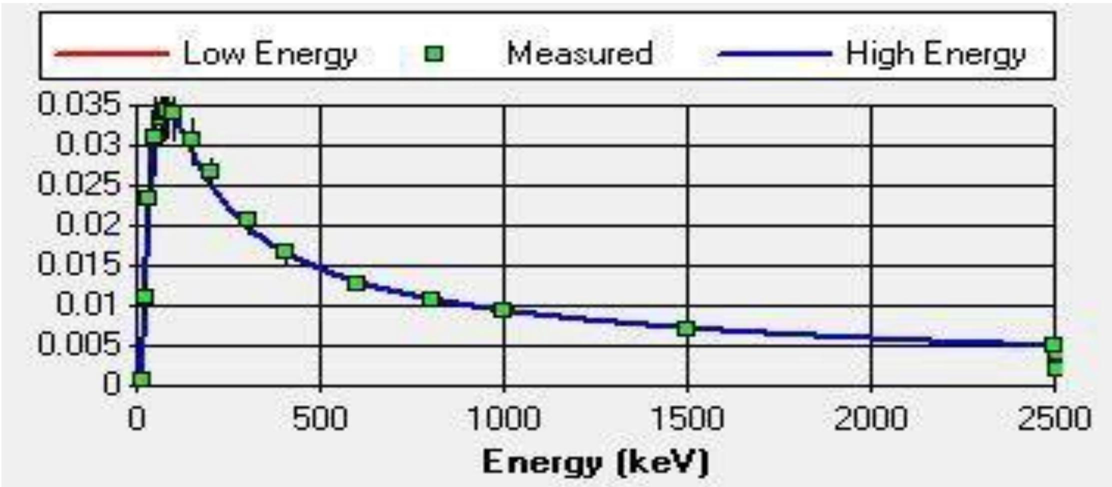


Figure (4). Efficiency calibration of the measuring system

2.1 Absorbed dose rate D (nGy^{-1})

Equations was utilized to determine the rates of absorbed doses both indoors and outdoors, [10, 11].

$$D_{out}\left(\frac{nGy}{h}\right) = (0.462\times A_{Ra}) + (0.621\times A_{Th}) + (0.0417\times A_K). \qquad (3)$$

$$D_{in}\left(\frac{nGy}{h}\right) = (0.92\times A_{Ra}) + (0.081\times A_K) + (1.1\times A_{Th}). \qquad (4)$$

Where: A_{Ra},A_{Th} and A_K The radioactivity concentration in (Bq/kg) of Uranium, potassium and thorium respectively 84 (nGy^{-1}) represents the permissible limit established by the Scientific Panel on the Impact of Radioactive Ions 2000[12].

2.2 Radioactivity equivalent to radium (Bq/kg)

The can be Radium equivalent radioactivity expressed by[13],[14]. 370 Bq/kg represents the permissible limit established represents the permissible limit established by the Scientific Panel on the Impact of Radioactive Ions 2000 [12].

$$Ra_{eq} = (A_{Ra}) + (1.43A_{Th}) + (0.077A_K). \qquad (5)$$

2.3 Index of Hazard (H)

The evaluation of external gamma radiation exposure is done using the outside and inner hazard indices. The outdoor and indoor hazard indices can be calculated using the equations[15],[16]. According to UNSCEAR and ICRP, the limit of these indices should be less than or equal to 1[17, 18].

$$H_{ex} = \left(\frac{A_U}{370\frac{Bq}{kg}} + \frac{A_{Th}}{259\frac{Bq}{kg}} + \frac{A_K}{4810\frac{Bq}{kg}} \right). \qquad (6)$$

$$H_{in} = \left(\frac{A_U}{185\frac{Bq}{kg}} + \frac{A_{Th}}{259\frac{Bq}{kg}} + \frac{A_K}{4810\frac{Bq}{kg}} \right). \qquad (7)$$

2.4 Equivalent annual effective dose (EAED) (μSv/y)

The computation equivalent annual effective dose rate takes into account the outside occupancy factor (0.2) as well as the conversion factor derived from the dose absorbed within the air (0.7Sv/Gy).

The formula below is used to compute the yearly effective dose equivalent rates in (mSv/y) as a result[19]. The limits of these indices should be less than or equal to 290[20].

$$EAED_{out} = D_{out}\left(\frac{nGy}{h}\right) \times 8760\left(\frac{h}{y}\right) \times 0.7\left(\frac{Sv}{Gy}\right) \times 0.20 \times 10^{-3} \qquad (8)$$

$$EAED_{in} = D_{in}\left(\frac{nGy}{h}\right) \times 8760\left(\frac{h}{y}\right) \times 0.7\left(\frac{Sv}{Gy}\right) \times 0.80 \times 10^{-3} \qquad (9)$$

2.5 Index of radioactivity level $I\gamma$

The amount of radiation risk, particularly gamma radiation, connected to naturally occurring radionuclides in a substance estimated using this indicator. It has the following definition[21].

$$I_\gamma\left({}^{Bq}/_{kg}\right) = \left(\left(\frac{A_{Ra}}{150}\right) + \left(\frac{A_{Th}}{100}\right) + \left(\frac{A_K}{1500}\right)\right). \qquad \leq 1 \qquad (10)$$

The activity concentrations of Ra-226, Th-232, and K-40 are denoted by A_{Ra}, A_{Th}, and A_K, respectively, in units of Bq/kg.

2.6 Lifetime cancer risk (LCR)

It is possible to presume that radionuclides increase the lifelong risk of cancer. This equation is[22],[23].

$$LCR_{out} = (EAED_{out} \times DL \ \times RF). \qquad (11)$$

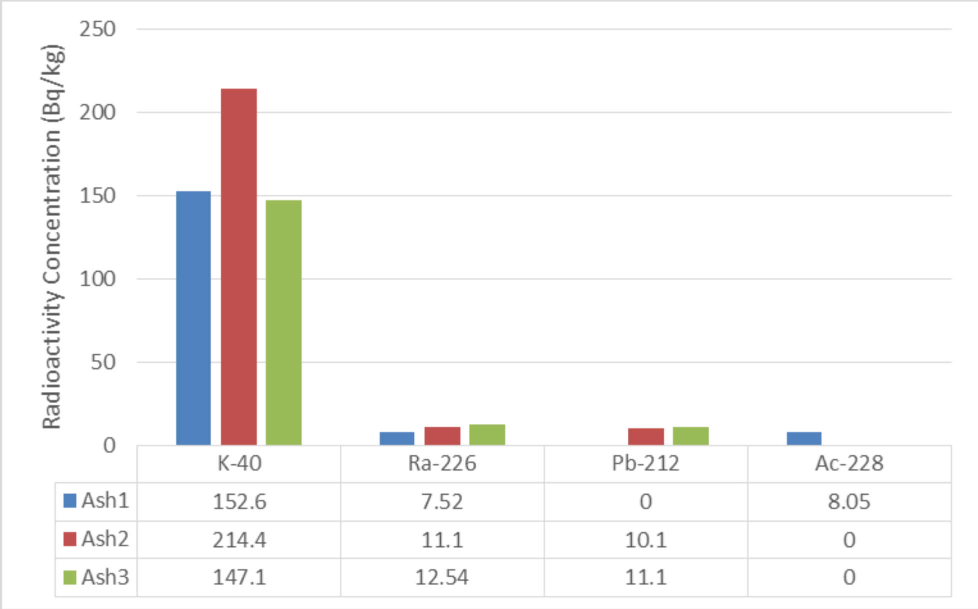
$$LCR_{in} = \ (EAED_{in} \times DL \ \times RF\ ). \qquad (12)$$

Where DL is the life duration (70 years), EAED the annual effective dose equivalent, and RF is the risk factor (0.05 Sv^{-1}). A 0.05/Sv is used by ICRP 60 for stochastic effects. Effects at Random. $LCRut$ for low level radiation should be less or equal than 0.29 and $ELCin$ should be less or equal than 1.16.as reported by UNSCEAR,2000[12].

3. Results and Discussion

The concentrations of radioactivity in incinerator ash waste samples from three hospitals. The activity concentration of ^{238}U ranges from 19 ± 1.8 to 7.52 ± 1 (Bq/kg) and the average value is 11.1 ± 1.5 (Bq/kg). While the ^{40}K concentration ranges from 214.4 ± 21.1 to 147.1 ± 16.5 (Bq/kg). With average value is 152.6 ± 15 (Bq/kg), and the concentration of ^{232}Th ranges from 11.1 ± 1.5 to 8.05 ± 1 (Bq/kg). as depicted in Figure 5. The radioactivity parameters and radionuclide activity levels in waste incinerator ash exhibit variability.

Figure 5. Radioactivity in waste incinerator ash.



3.1 CORRELATION ANALYSIS.

By using SPSS Statics 17.0, a link between one radioactive element and another was established; the outcomes are show in Table (2). Outcomes of each tested radioactive element. Ra-226, K-40, and Pb-212 have been find to be strongly correlated, and a link between Ac-228 and Pb-212 has been find. To varied degrees, K-40 shown a favorable association with other elements. These findings suggest a relationship between the type of medical waste and the concentration of radioactive elements.

Table 2. The relationship between an element and another radioactive element

	K-40	Ra-226	Pb-212	Ac-228
K-40	1			
Ra-226	+0.896	1		
Pb-212	+0.601	+0.878	1	
Ac-228	+0.234	+0.547	+0.861	1

3.2 Risk parameters

مجلة كلية التربية الاساسية
كلية التربية الاساسية – الجامعة المستنصرية
Journal of the College of Basic Education Vol.30 (NO. 126) 2024, pp. 146-161

- **Radium equivalent activity and absorbed dose**

The outcomes of the radium equivalent activity and absorbed dosage computations. the absorbed dose rate and radium equivalent activity were below the permissible range according to UNSCEAR, 2000[12]. Figure 6 displays the values that computed to be both inside and outside of the absorbed dosage rate. The range of values for the external absorbed dosage is 23.990–14.836 (nGy/h). There is an average of 15.174 (nGy/h). The internal dosage rate is 45.956 to 28.134 (nGy/h) in its range and Its average value 29.057 (nGy/h) in sample ash1 of Hospitals Incinerators. Figure 7 displays the computed values for activities corresponding to radium. The results (Bq/kg) varied from 49.951 to 30.781. with average (Bq/kg) value is 30.781

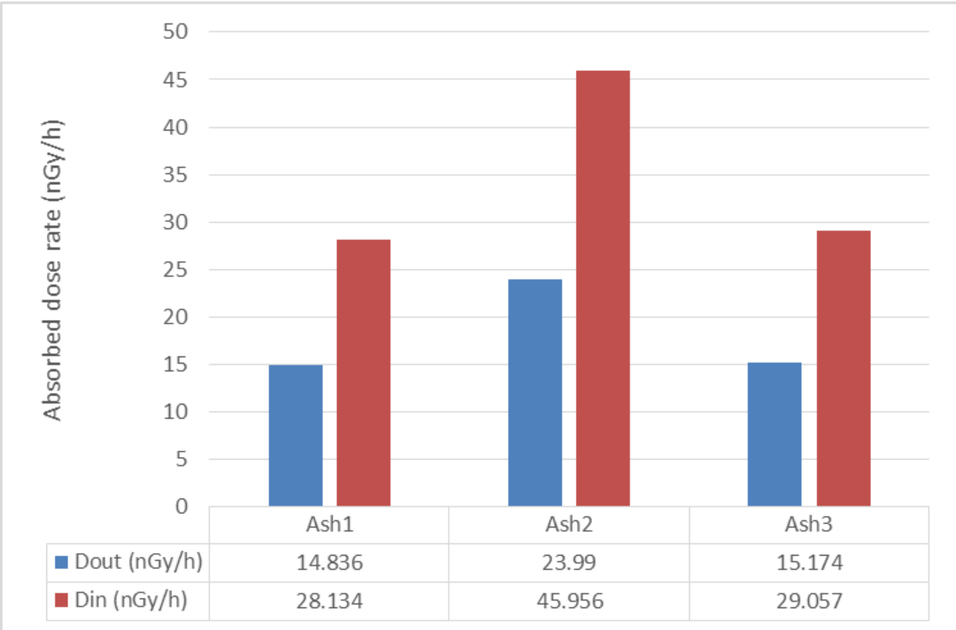


Figure 6. Absorbed dose rate in waste incinerator ash

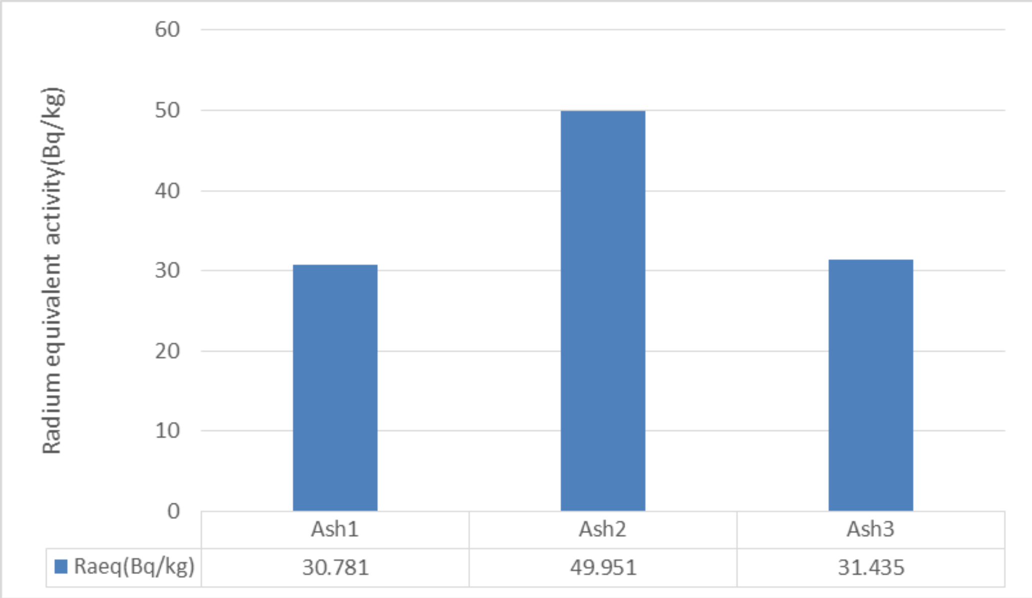


Figure 7. Radium equivalent activity in waste incinerator ash.

- **Index of hazards**

As in Figure 8 the external and internal risk indices. The sample (ash_2) had a maximum internal risk index of 0.134 (Bq/kg) and a minimum value of 0.083 (Bq/kg) (ash_1). The maximum internal value (Bq/kg) for the sample was 0.186 (ash_2). In comparison, the sample with the lowest value (ash_1).

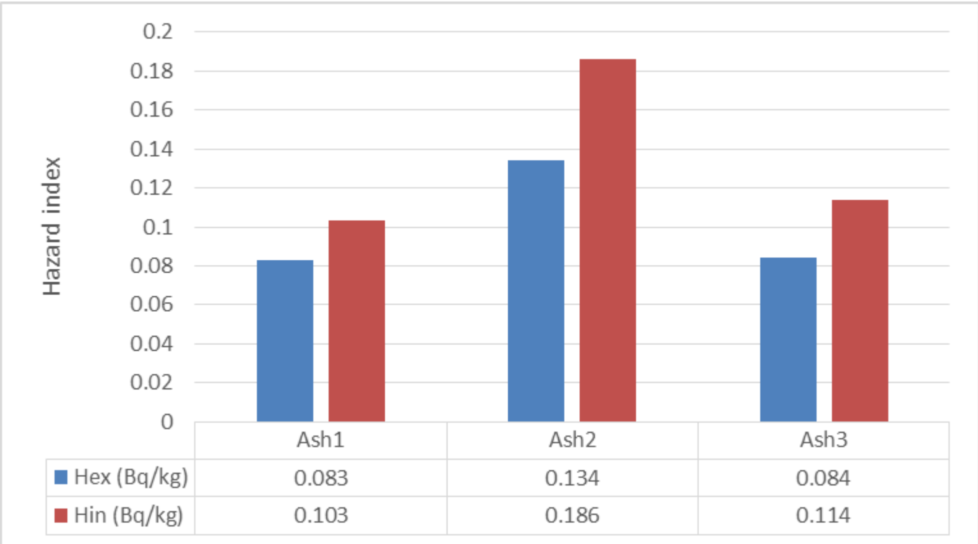
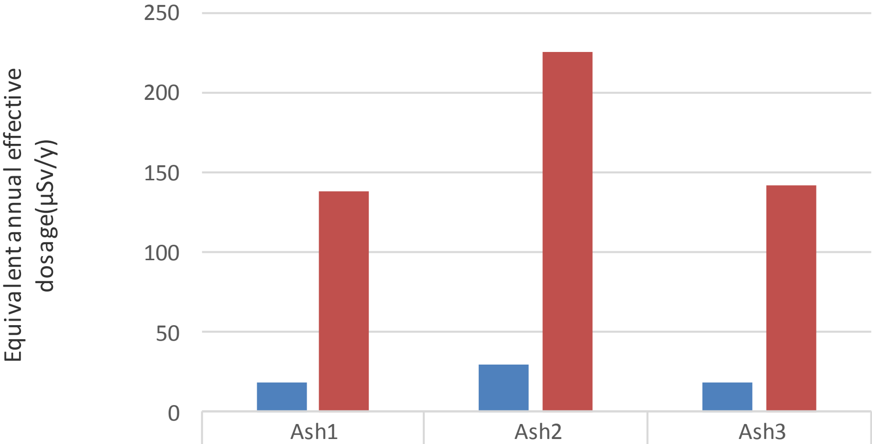


Figure8 . index of hazards in waste incinerator ash.

- **Equivalent annual effective dosage**

According to the results of the annual effective dose of incinerator ash samples shown in Figure7, the highest concentrations in the second sample outside and inside the body were 225.443 and 29.422. The third sample represented the lowest dose outside the body (18.610). The results of the first sample represented the lowest dose in the body (138.014). As shown in Figure 9. All of these results were within the permissible limit set by UNSCEAR,2000[12].



	Ash1	Ash2	Ash3
EAEDout (μSv/y)	18.195	29.422	18.61
EAEDin (μSv/y)	138.014	225.443	142.542

Figure 9. equivalent annual effective dosage in waste incinerator ash.

- **The index of radiation level and lifelong cancer risk**

The indicator of radiation level and lifelong cancer risk in ash of hospitals incinerators samples displayed in Figures 10 and 11. The value of the indicator of radioactivity level was ≥1 below the allowable limit, ranging from 0.370 to 0.23. The findings indicated that the lifetime cancer risk in samples of ash of Hospitals Incinerators is more than the 0.29-1.16 global average that UNSCEAR reported[12]. In Ash_2, the external risk index peaked at 102.977 (Bq/kg). At 498.898 (Bq/kg), Ash_1's internal risk index has the highest value. Alternatively, among incinerator ash samples for hospitals, the lowest value for ash_1 was 65.685 (Bq/kg).

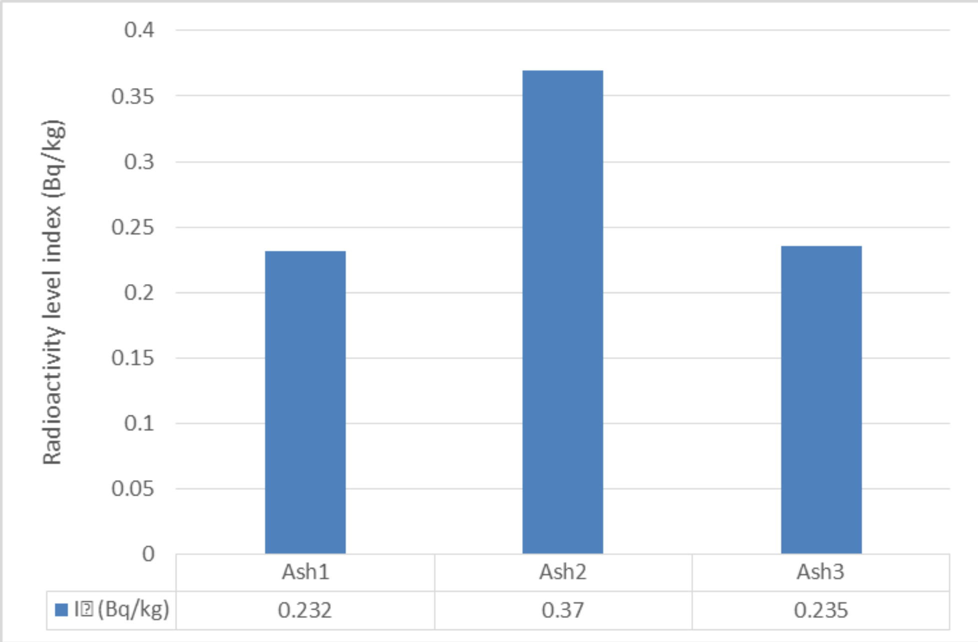


Figure 10. Radioactivity level index in waste incinerator ash.

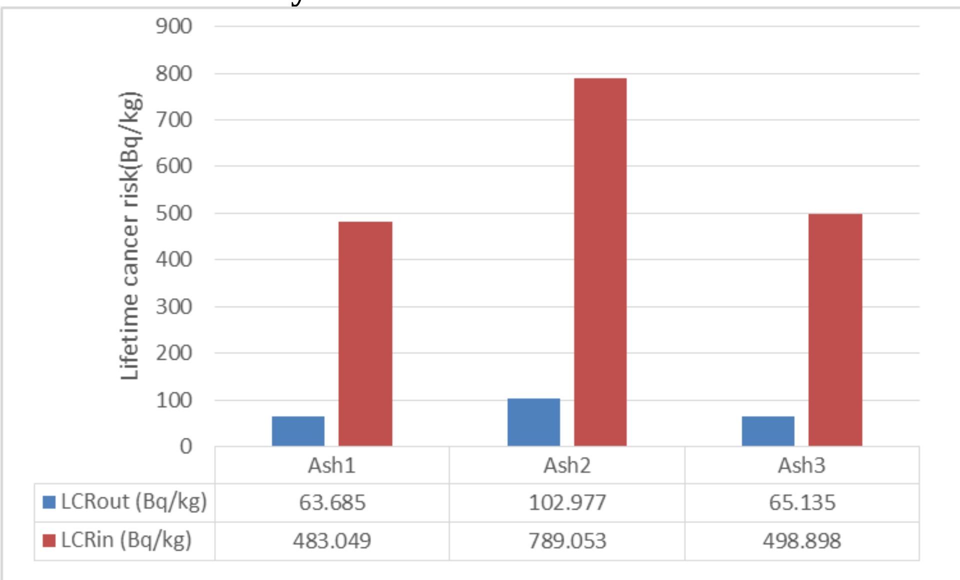


Figure 11. Lifetime cancer risk in waste incinerator ash.

Conclusion

Radioactivity in ash samples from several medical waste sites in Baghdad showed that the average concentrations did not exceeded by the average activity allowable limit concentration and average readings were ^{238}U, ^{232}Th, and 40K for the three samples investigated. Radium equivalent, lifetime cancer risk, annual effective dose, risk index, absorbed dose rate, and radioactivity level index. Every risk indicator's magnitude fell between allowed bounds. UNSCEAR reports that lifetime cancer risk (CLR) levels were, nevertheless, greater than the norm worldwide. The results indicate that while there may not be any health problems for the public, long-term radiation exposure may have health consequences of its own. As a result, care needs to be take when handling ash of Hospitals Incinerators.

Acknowledgments. The authors are grateful for their help from the Mustansiriyah University in Baghdad-Iraq and The Ministry of Health and Hospital Administration for their cooperation in providing ash of Hospitals Incinerators samples.

References

1.Vallabhajosula, S., *Radioactivity*, in *Molecular Imaging and Targeted Therapy: Radiopharmaceuticals and Clinical Applications*. 2023, Springer. p. 49-62.

2.Fathi, R.A., et al., *Environmental pollution by depleted uranium in Iraq with special reference to Mosul and possible effects on cancer and birth defect rates.* 2013. **29**(1): p. 7-25.

3.Ajayi, J., et al., *Levels of radionuclide contents in stream waters of some selected rivers in Ogbomoso Land, South West Nigeria.* 2012. **4**(9): p. 835-837.

4.Becker, K.J.B.S.-A.D.I.S.D.L.I.D.E.M., *How much protection against radon do we need?* 2001. **114**(3): p. 24-29.

5.Durrani, S.A. and R.K. Bull, *Solid state nuclear track detection: principles, methods and applications*. Vol. 111. 2013: Elsevier.

6.Abojassim, A.A., R.J. Dosh, and A.K.J.C.R.I.S.S. Abdulzahar, *Radioactivity in Soil.* 2022: p. 89.

7.Raja, W.N. *Measurement of radon concentrations in water around the northern areas of Baghdad using the CN-85 track detector*. in *AIP Conference Proceedings*. 2019. AIP Publishing.

8.Gbadamosi, M., et al., *Pollution sources identification, health, and radiological risk assessment of naturally occurring radioisotopes and heavy*

metals in waste dumpsites in Ijebu-Ode, Ogun State, Southwest Nigeria. 2023. **24**(5-6): p. 238-255.
9.Niyongabo, E., et al., *Generation, management practices and rapid risk assessment of solid medical wastes: a case study in Burundi.* 2019. **21**: p. 950-961.
10. Radiation, U.N.S.C.o.t.E.o.A., *Ionizing radiation: sources and biological effects. 1982 report to the general assembly, with annexes*. 1982.
11. Choo, W.S. and W.K.J.A.i.A.S.R. Yong, *Antioxidant properties of two species of Hylocereus fruits*. 2011. **2**(3): p. 418-425.
12. Rangaswamy, D., et al., *Measurement of natural radioactivity and radiation hazards assessment in rock samples of Ramanagara and Tumkur districts, Karnataka, India.* 2016. **75**: p. 1-11.
13. Srinivasa, E., D. Rangaswamy, and J.J.E.E.S. Sannappa, *Assessment of radiological hazards and effective dose from natural radioactivity in rock samples of Hassan district, Karnataka, India*. 2019. **78**(14): p. 431.
14. Tarik Al-Alawy, I., M.J.E. Dhyeaa Salim, and T. Journal, *Evaluation of natural radioactivity in selected soil samples from the archaeological of Girsu City in Dhi-Qar Governorate, Iraq*. 2014. **32**(13): p. 3120-3129.
15. Mamont-Ciesla, K., et al., *Radioactivity of building materials in Poland*, in *Natural radiation environment*. 1982.
16. Issa, S., et al., *Gamma radioactivity measurements in Nile River sediment samples.* 2013. **37**(1): p. 109-122.
17. Protection, R.J.A.I., *ICRP publication 103*. 2007. **37**(2.4): p. 2.
18. Radiation, U.N.S.C.o.t.E.o.A., *Sources and effects of ionizing radiation, united nations scientific committee on the effects of atomic radiation (UNSCEAR) 2008 report, volume I: Report to the general assembly, with scientific annexes A and B-sources*. 2010: United Nations.
19. Ridha, A.A., A.N. Jameel, and N.F. Kadhim. *Transfer factor of natural radionuclides from soil to silhouette plants using gamma spectroscopy*. in *AIP Conference Proceedings*. 2020. AIP Publishing.
20. El-Taher, A. and J. Al-Zahrani, *Radioactivity measurements and radiation dose assessments in soil of Al-Qassim region, Saudi Arabia.* 2014.
21. Ebongue, A.N. and M.K.J.R. Njock, *Assessment of natural radioactivity levels and the associated radiological hazards in some building materials from Mayo-Kebbi region, Chad.* 2018. **53**(4): p. 265-278.

22. Taskin, H., et al., *Radionuclide concentrations in soil and lifetime cancer risk due to gamma radioactivity in Kirklareli, Turkey.* 2009. **100**(1): p. 49-53.
23. Ramasamy, V., et al., *Evaluation of natural radionuclide content in river sediments and excess lifetime cancer risk due to gamma radioactivity.* 2009. **1**(1): p. 6-10.

مجلة كلية التربية الاساسية
كلية التربية الاساسية – الجامعة المستنصرية
Journal of the College of Basic Education Vol.30 (NO. 126) 2024, pp. 146-161

تقييم تركيز النشاط الإشعاعي ومؤشرات الخطر في رماد محارق بعض مستشفيات بغداد / الرصافة

نبأ قاسم كاظم[1]، عتاب فاضل حسين[1] وباسم عبد الستارحسين[2]
[1]قسم الفيزياء، كلية العلوم، الجامعة المستنصرية، بغداد، العراق
[2] دائرة بحوث البيئة والمياه ، وزارة العلوم والتكنولوجيا. العراق

مستخلص البحث:
نظرا للآثار الضارة التي يسببها الإشعاع على صحة الإنسان وتسببه في الإصابة بالسرطان، تم تقييم تركيز النويدات المشعة ومؤشرات الخطورة في رماد محارق المستشفيات الثلاثة (الأمام علي (الجوادر)،شيخ زايد، ضاري الفياض. تم جمع النماذج من رماد محارق المستشفيات التابعة لدائرة صحة بغداد / الرصافة بعد عملية حرق النفايات. تم أخذ ثلاث نماذج للدراسة والفحص، وتم تحديد المخاطر الناجمة عنها. وباستخدام مطيافية جاما وكاشف الجرمانيوم عالي النقاوة، أظهرت النتائج أن تراكيز البوتاسيوم تراوحت من (147.1±16.5 إلى 214.4±21.1 بيكريل/كغم)، في حين تراوحت تراكيز الراديوم من (7.52±1 إلى 19±1.8 بيكريل/كغم). تراكيز الرصاص من (10.1±1.1إلى 11.1±1.5 بكريل/كغم). بينما تركيز الأكتينيوم هو 8.05±1. تم حساب مكافئ الراديوم، ومؤشر الخطر، ومكافئ الجرعة الفعالة السنوية، ومؤشر مستوى النشاط الإشعاعي، ومعدل الجرعة الممتصة، وخطر الإصابة بالسرطان مدى الحياة. وأظهرت النتائج عدم وجود خطر إشعاعي يشير إليه أي من مؤشرات الخطر. وهذا يدل على أن الرماد المنبعث من محرقة المستشفى لا يشكل أي خطر إشعاعي.