Al-Mukhtar Journal of Basic Sciences 22 (3): 233-241, 2024
Doi: https://doi.org/10.54172/sja2f058

Research Article **Open Access**

Estimation of Natural Radioactivity and Radiation Hazards Indices of Some Organic Fertilizers Used in Al-Gable Al-Akhdar, Libya

Asma M. A. Othman [1*] and Rasha Y. M. Elfallah [2]

[2] Department of Physics, Faculty of Science, Darna University, Libya.

*Corresponding author: asma.alabrdi@omu.edu.ly Department of Physics, Faculty of Science, Omar Al-Mukhtar University, Libya.

Received:
19 October 2024

Accepted:
27 December 2024

Publish online:
31 December 2024

Abstract

In the present work, an assessment of the following levels of natural radioactivity in 5 samples of organicafertilizers collected from the market in Al Bayda City, Libya. Sodium iodide (NaI) gamma spectroscopy was used. The activityaconcentrations ofaradionuclides in the ^{238}U and ^{232}Th natural decayachain as well as ^{40}K wereadetermined. The average activity concentrations in ^{226}Ra, ^{238}U, ^{232}Th and 40K in the samples studied were found to be (± 62.74, ± 64.42, ±63.63 and ±70.88 Bq Kg^{-1} (for samples. The results of this study have been compared with the worldarecommended values of (1550, 1500, (7-50) and (100-700)) Bqkg^{-1}, respectively as specified by the [UNSCEAR, 2016]. The results showed that all samples had lower levels of radioactivity than the recommended limits for ^{226}Ra, ^{238}U, ^{40}K for organic fertilizers and the activity concentrations were below the thorium (7-50 Bq kg-1) except fo1,fo4 and fo5 were higher than the recommended limits. , The a radium equivalent, absorbed dose rate in air, annual effective dose equivalent for indoor and outdoor exposure, excess lifetime cancerarisk, internal and external hazard indicators were calculated. The results ofamost samples were within theaglobal averagearecommended by [UNSCEAR,2016]. So, it is safe to consume andadoes not pose a threat to the general public.

Keywords: Organic Fertilizers; Sodium Iodide; The Activity Concentration; Exposure; Cancer Risk.

INTRODUCTION

Each year, the absorbed doses of radiation that humans receive varyadepending on a number of variables, aincluding climate, geologicaallocation, and the use ofaradioactive material andanuclear energy by humans, Energyamanifested as particles orawaves is called radiation. Radiation can be categorized as either ionizing or non-ionizing. Ionizing radiation, such asabeta, neutrons, and gamma radiation, has sufficientaenergy to cause electronsain their orbits to be released, forming positive ions in the atoms. Non-ionizing radiation, which includes radio waves, infrared light, and visible light, isaless energetic than ionizingaradiation and cannot produce ions. Natural radioactivity permeates the terrestrial environmentaand can be found in a variety ofageological formations, including soils, phosphate rocks, air, plants, andaanimals, Around the world, the use ofafertilizers in agriculture hasabecome crucial. In addition to improving soil qualities and nutrient deficiencies, fertilizers are crucial for raising cropayields. Different fertilizers have different effects on a plant's physiology and metabolism, affecting how different elements and radionuclides are absorbed. aFertilizer application has the potential to raise radionuclide content inasoil, resulting in increasedaradionuclide uptake.(Hallenburg, 2020).More than 30 million tons ofaphosphate fertilizers areaannually consumed worldwide, which increases cropaproduction and landareclamation. However, a possibleanegative effect of fertilizers is theacontamination ofacultivated lands by asome naturallyaoccurring radioactiveamaterials the natural radionuclide of fertilizersaconsists mainly ofauranium and thorium series radioisotopes and natural ^{40}K.(KeleÅŸ & Atik, 2018).

MATERIALS AND METHODS

To assess the levels of natural radioactivity in some fertilizers, 5 samples of organic fertilizers were collectedafrom Al-Bayda city market (Libya) Theacollected samples, are locally sourced Table (1) shows the details of the collected samples. They were cleaned, ground as shown in Fig. (1), and dried inathe electric oven in the laboratory for one hour per sample to get rid of moisture in samples asashown in Fig. (2), and weighed then stored in polymer containers of 250 Cm^3 volume oraat least 30 days; toaallow radioactive equilibrium to be reached. This step isanecessary to ensure that radon gas is confinedawithin theavolume and that theadaughters will also remain inathe sample. The measurement time foraboth activity and radiologicalahazards measurement was 3600 seconds. The radionuclides activity concentrations were measured using NaI (TI) detector-based gamma spectrometric system where the digiBASE system that combines a miniaturized preamplifier and detector with a powerful digital multichannel analyzer and special features for fine time-resolution measurements. The digiBASE incorporated into the NaI (TI) detector provides a gain stabilizer to significantly reduce the sensitivity of the detector to changes in ambient temperature and magnetic fields. Three gamma-ray lines of interest were (1460, 1764 and 2615) keV (Baqir, Y.et al., 2020)

Table: (1). Description of the fertilizer samples

Samples No	Description
Fo1	Derna sheep
Fo2	AL-Bayda sheep
Fo3	AL-Bayda cows
Fo4	Derna cows
Fo5	AL hisha horses

Figure: (1). Grind some samples

Figure: (2). The electric oven device

TheoreticalaCalculations

1. Calculation the Activity Concentrations

The activity of an radioactive source is defined as the rate atawhich the isotope decays. Radioactivity may be thought of as the volumeaof radiation produced in a given amount of time. The radioactivityaconcentration of the different identified radionuclides was determined by gamma-ray spectrometry with the measured for eachapeak, and the associated activity (A) was computed by using theaformula (Al-Mousawi et al., 2020).

$$A = \frac{\text{Net area (cps)}}{I_\gamma \times \xi \, .M} \qquad (1)$$

Where **A** is the Activity concentration of the gamma spectral line in Bq/Kg, **Net area (cps)** is the net detected counts per second corresponding to the energy, **ξ** is the Counting system efficiency of the energy, **M** is the Mass of sample in Kg and **Iγ** is the Intensity of the gamma spectral.

2. Radium Equivalent Activity (Bq/kg).

The concentration and distributionaof ^{226}Ra, ^{232}Th and ^{40}K in the studied a samples are not uniform. Uniformity with respect to of exposure to radiation has been defined in terms of radium equivalent Ra_{eq} in (Bq kg-1) is the most extensively used radiation danger index, to represent the activityalevels of ^{226}Ra, ^{232}Th and ^{40}K by a singleaquantity, which takes into account thearadiation hazards associated withaeach component. The radium equivalent for theasamples was calculated fromathe following relation:(Geremew, 2023; Mwalongo et al., 2023).

$$Ra_{eq} = A_{Ra} + 1.34\,A_{Th} + 0.77\,A_K \qquad (2)$$

Where A_{Ra}, A_{Th} and A_K are the activity concentrations (Bq/Kg) for ^{226}R, ^{232}Th and ^{40}K respectively. The maximum value of (Ra_{eq}) must be less than 370 Bq.kg$^{-1.}$

3. Gamma Absorbed Dose Rate (Dr).

The absorbed dose rates DR (nGy h^{-1}) due to terrestrial gamma rays at 1m above ground level can be calculated by using activity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K were calculated by using the equation(AL-abrdi, 2023).

$$D_r = 0.427A_U + 0.662A_{Th} + 0.043A_K \quad (3)$$

Where A_u, A_{Th} and A_K are the activity concentrations (Bq/Kg) for ^{238}U,^{232}Th and ^{40}K respectively. (Najam et al., 2022), 0.427,0.662 and 0.043 nGy.h^{-1}/BqKg^{-1} are the conversion factors of ^{238}U,^{232}Th and ^{40}K respectively

4. Internal HazardaIndex (H_{in}).

The widely used hazard indices that reflect both internal and external exposure are called internal hazard and external hazard respectively. The internalaexposure to ^{222}Rn and its daughter products are controlled by an internal hazard index, H_{in} which is defined as (UNSCEAR, 2000).

$$H_{in} = \frac{A_{Ra}}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad (4)$$

5. External HazardaIndex (H_{ex}).

The external hazard index resulting from samples gamma-ray emissions and radiological danger was computed using the relation

$$H_{ex} = \frac{A_{Ra}}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \leq 1 \quad (5)$$

Where A_{Ra}, A_{Th} and A_K are the activity concentrations (Bq/Kg) for ^{226}R,^{232}Th and ^{40}K respectively (Isinkaye & Emelue, 2015).

6. Excess Lifetime Cancer Risk (ELCR).

People who are exposed to radiation for an extended period of time are thought to be at risk of developing cancer. The ELCR is the increased of acquiring cancer as a result of exposure to a radiation during a person's lifetime. It is determined using the following equation

$$ELCR = E_{out} \times DL \times RF \quad (6)$$

Where E_{out} means the annual effective dose equivalent (outdoor), DL denotes life expectancy (70 years), and RF denotes thearisk factor (Sv^{-1}), which is Sievert'safatal cancer risk (Yalcin et al., 2020).

RESULTS AND DISCUSSION

The values of activityaconcentrations for organic fertilizer samples thearecorded values of radionuclides wereavaried from (44.92 to 81.24), (43.51 to 81.79), (45.79 to 82.23) and (48.62 to 85.72) Bq kg^{-1} for ^{238}U,^{226}Ra, ^{232}Th and ^{40}Krespectively,withaaverage (64.42, 62.74, 63.63 and 70.88) Bq kg^{-1} respectively Table (2), Theaoutcomes of radioactive activity concentrations for organic fertilizerasamples, including ^{238}U,^{226}Ra, ^{232}Th, and ^{40}K The samplesaanalyzed in this investigation had activity concentrations less the allowablealevel for uranium (1500 Bq kg^{-1}) (UNSCEAR, 2017), the activity concentrations are below thearadium (1550 Bq kg^{-1}), the activity concentrations are below the thorium (7-50 Bq kg^{-1}) except forasamples (fo1,fo4 and fo5) were higher than the recommendedalimits. The activity concentration is below theapotassium suggested ranges (100–700). Figure (3) show the activity concentrations of radium, uranium, thorium, and potassium in organic fertilizers.

Table (2): The average activity concentrations (Bq kg-^{1}) of the radioactive elements (^{238}U,^{226}Ra, ^{232}Th and ^{40}K) of the investigated samples**.**

Samples	^{238}U	Error	^{226}Ra	Error	^{232}Th	Error	^{40}K	Error
F o1	70.98	± 2.19	65.27	± 3.90	64.65	± 2.84	76.77	± 7.55
Fo2	44.92*	± 1.32	43.51*	± 4.50	45.79*	± 3.61	48.62*	± 9.12
Fo3	47.18	± 1.19	47.86	± 4.13	45.85	± 3.00	60.13	± 8.30
Fo4	78.79	± 1.49	75.27	± 3.87	82.23**	± 2.99	85.72**	± 8.85
F05	81.24**	± 1.63	81.79**	± 4.76	79.65	± 2.76	83.17	± 9.40
Average	64.42	± 1.56	62.74	± 4.23	63.63	± 3.04	70.88	± 8.64
P.L	1500		1550		7-50		100-700	

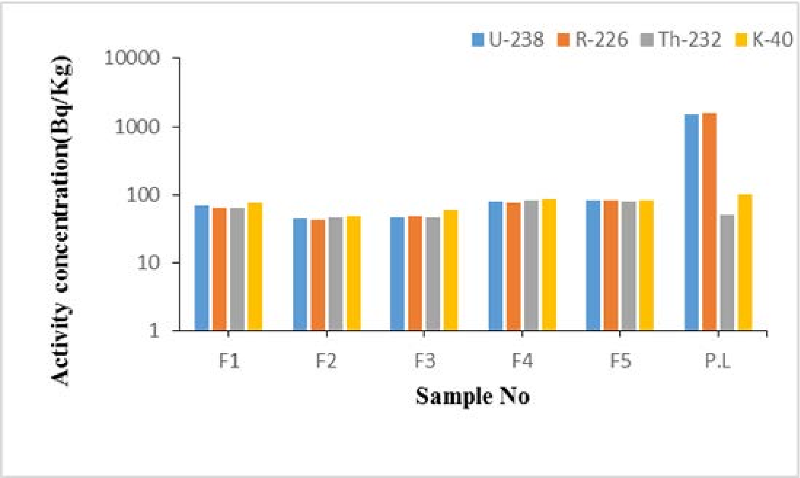

Figure: (3). The activity concentration of organic fertilizers**.**

The Radium equivalent activity (Ra_{eq}) isaa single quantity that compares the activity concentrations of ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K in fertilizer samples to obtain a total activityaconcentration. The results of theacalculated (Ra_{eq}) values for organicafertilizer samples the results range from (112.74 to 202.11 Bq kg^{-1}),awith anaaverage value of 159.20 Bq/kg asashown in Fig. (4). In Table (3), the (Ra_{eq}) values for all fertilizer samples in the present study are lower than the world recommended value 370 Bq kg^{-1} . The estimated absorbed dose rate values for the investigated organic fertilizer samples range from (49.80 to 80.03 nGy h^{-1}), but theaaverage value of the absorbed dose rate for the organic fertilizer samples was 64.98 nGy h^{-1}, Fig. (5) Shows these results the studied organic fertilizer samples, they were within the recommended limits(UNSCEAR, 2017).

Table (3): The value of radium equivalent**.**

Samples code	Ra_{eq} Bq/Kg
Fo1	163.63
Fo2	112.74
Fo3	118.06
Fo4	199.47
Fo5	202.11
Average	159.20
P.L	370

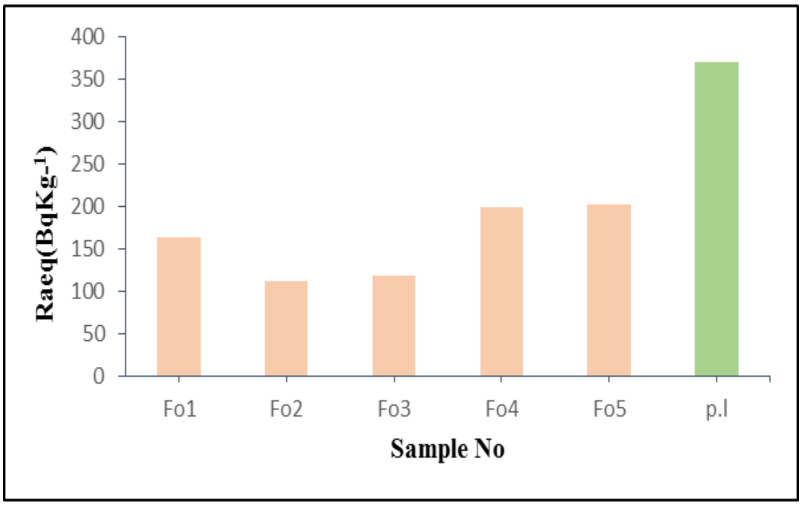

Figure: (4). Radium Equivalent of organic fertilizer samples

Table (4): The value of absorbed dose rate.

Samples code	Dose rate Dr(nGyh-$^{1)}$
Fo1	72.42
Fo2	49.80
Fo3	52.33
Fo4	70.05
Fo5	80.3
Average	64.98
P.L	84

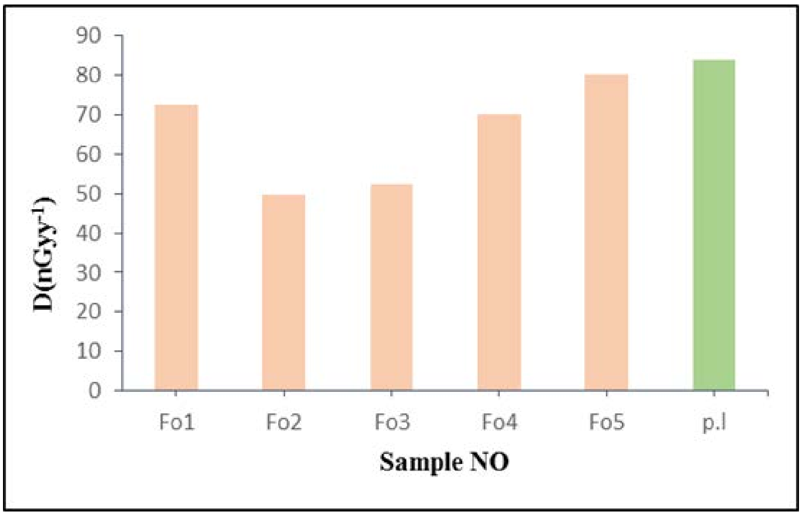

Figure: (5). The absorbed dose rate of organic fertilizer samples

The internal and externalahazard results were obtained and shownain Table (5). The results value of organicafertilizerasamples ranged from (0.42 to 0.78), with an average value 0.60, as shown in Fig. (6). in the results, all internal hazard values for the fertilizer samples under study werealower than the (UNSCEAR, 2017),arecommended values. The external hazard for organic fertilizer samples the resultsaranged from (0.30 to 0.54), with an average of 0.43, as shown in Fig. (7).

Table (5): The value of internal and external hazards

Samples code	Hin	Hex
Fo1	0.62	0.44
Fo2	0.42*	0.30*
Fo3	0.45	0.32
Fo4	0.74	0.54**
Fo5	0.78**	0.55
Average	0.60	0.43
P.L	1	1

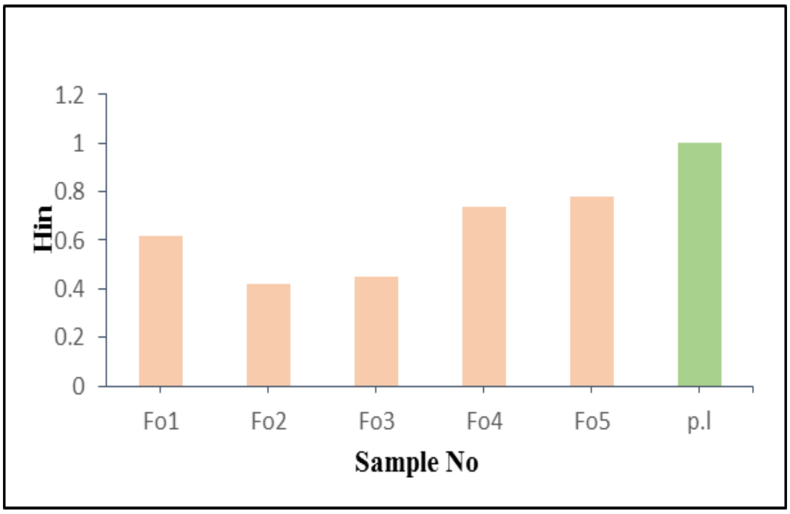

Figure: (6). Internal hazard index of organic fertilizer samples

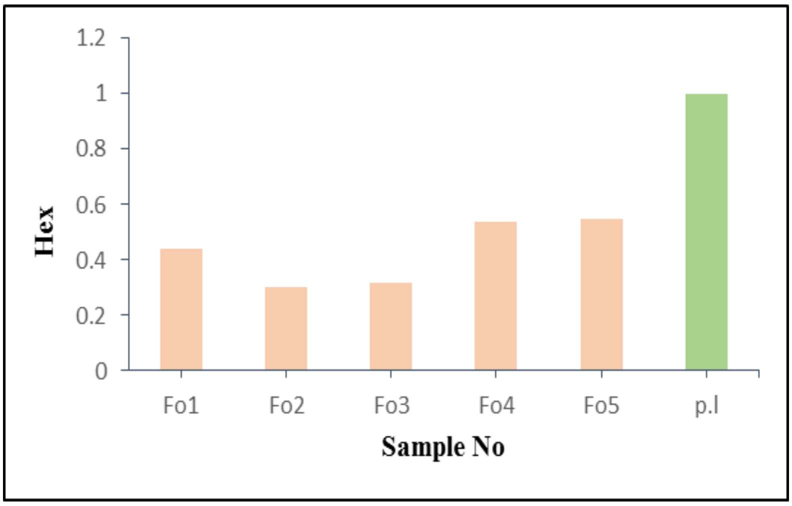

Figure: (7). External hazard index of organic fertilizer samples

Equation (6) has been calculated of ELCR where the equation dependent of life expectancy (70 years) and risk factor (0.05 sv^{-1}). Table (6) shows the excess lifetime cancer risk factor ELCR for allasamples, the recorded values of ELCR arange from (0.19 to 0.22) with an average value 0.22. The results of the ELCR values for all the organic fertilizerasamples studied were withinathe recommended limits of 0.29×10^{-3}(UNSCEAR, 2017), as shown in Fig. (8).

Table (6): The value of Excess Lifetime Cancer Risk (ELCR).

Samples code	Cancer risk factor ELCR×10^{-3}
Fo1	0.29
Fo2	0.20
Fo3	0.21
Fo4	0.19*
Fo5	0.22**
Average	0.22
P.L	0.29

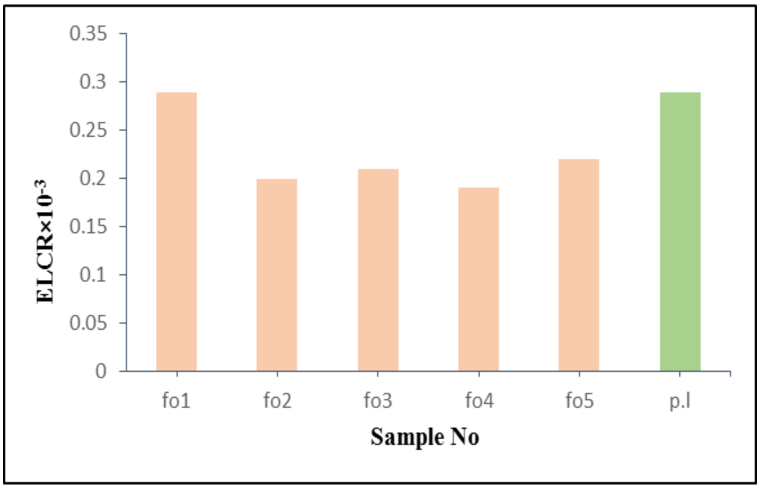

Figure: (8). The cancer risk factor of the organic fertilizer samples.

CONCLUSION

The study on natural radioactivity levels in organicafertilizers in Al-Bayda city, Libya, produced the followingaconclusions:

- Use of simple NaI gammaaspectrometer showed potential in theaassessment of radioactivity concentration.
- In this study, the activityaconcentrations of radionuclide ^{226}Ra, ^{238}U, ^{232}Th, and ^{40}K were determined to be lower than the world-recommendedavalue for all organic fertilizerasamples
- Furthermore, the activity concentrationsawere used to estimateavarious radiological features in the samples.
- The studied organic fertilizer samples hadaradium equivalent activityabelow the world recommended value of 370 Bq kg^{-1}.
- The absorbed dose rate values of theastudied samples for organic fertilizers, it was less than thearecommended limits.
- The obtained values of internal hazardaindex H_{in}, and external hazardaindex H_{ex} for all the studied sample werealower than the recommended value.
- The Excess lifetimeacancer risk (ELCR) values areafound to be much lower than the permissible level (0.29) for organic samples(UNSCEAR, 2017).

ACKNOWLEDGEMENT

We do not have any financial support or relationships that may pose conflict of interest in the cover letter submitted with the manuscript.

Duality of interest: The authors declare that they have no duality of interest associated with this manuscript.

Author contributions: A and B. developed the theoretical formalism, performed the analytic calculations and performed the numerical simulations. Both A and B. authors contributed to the final version of the manuscript. A. supervised the project.

Funding: No specific funding was received for this work.

REFERENCES

AL-abrdi, A. M. (2023). Measurements of natural radioactivity and evaluation of radiation hazard indices in Barley Samples in Libya Markets. *Libyan Journal of Basic Sciences, 20*(2), 51-64.

Al-Mousawi, N., Mouhamad, R., & Alsaadie, N. (2020). Radiation hazards assessment of phosphate fertilizers used in Latifiyah region, Iraq. *DYSONA-Applied Science, 1*(2), 73-80.

Geremew, H. (2023). Activity Concentration of Natural Radionuclides in Agricultural Soil, Fertilizer, their Transfer to Some Commonly Used Cereal Types, and Associated Health Hazards, Holeta, Ethiopia.

Hallenburg, J. K. (2020). *Standard methods of geophysical formation evaluation*. CRC Press.

Isinkaye, M., & Emelue, H. (2015). Natural radioactivity measurements and evaluation of radiological hazards in sediment of Oguta Lake, South East Nigeria. *Journal of Radiation Research and Applied Sciences, 8*(3), 459-469.

KeleÅŸ, E., & Atik, D. (2018). Estimation of radioactivity caused by chemical fertilizers on Trakya sub-region soils and its potential risk on ecosystem. *European Journal of Sustainable Development, 7*(3), 413-413.

Mwalongo, D. A., Haneklaus, N. H., Carvalho, F. P., Lisuma, J. B., Kivevele, T. T., & Mtei, K. M. (2023). Influence of phosphate fertilizers on the radioactivity of agricultural soils and tobacco plants in Kenya, Tanzania, and Uganda. *Environmental Science and Pollution Research, 30*(34), 83004-83023.

Najam, L. A., Mahmmod, R. H., & Albanna, O. M. J. (2022). Evaluation of Natural Radionuclides in Samples of Plant Fertilizers Used in Iraq and Radiation Hazard Indicators. *Iranian Journal of Science and Technology, Transactions A: Science, 46*(3), 979-987.

UNSCEAR, U. N. S. C. o. t. E. o. A. R. (2000). *Sources and Effects of Ionizing Radiation, United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 2000 Report, Volume I: Report to the General Assembly, with Scientific Annexes-Sources*. United Nations.

UNSCEAR, U. N. S. C. o. t. E. o. A. R. (2017). *Sources, effects and risks of ionizing radiation, united nations scientific committee on the effects of atomic radiation (UNSCEAR) 2016 report: report to the general assembly, with scientific annexes*. United Nations.

Yalcin, G. D., Danisik, N., Baygin, R. C., & Acar, A. (2020). Systems biology and experimental model systems of cancer. *Journal of Personalized Medicine, 10*(4), 180.