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Original article

Using Gamma Ray Radiation to Estimate the Types and Contents of Radioactive Nuclides in Some Ported Sugar Samples, Libya

Hamad Hasan[1]*, Raja Amhmmid[2], Hamdi Khatab[2], Jamila Ali[3], Amani Al Kaseh[1]

[1]*Chemistry Department, Faculty of Science, Omar Al–Mukhtar University, Libya*
[2]*Chemistry Department, Faculty of Education (Al-marj), Benghazi University, Libya*
[3]*Physic Department, Faculty of Science, Omar Al–Mukhtar University, Libya*
Corresponding author. *hamad.dr@omu.edu.ly*

Abstract
The radioactive nuclides were measured in Sugar samples collected from some Libyan markets by using gamma ray (NaI) detector, the results recorded that all the samples containing different contents and types of radioactive nuclides, their contents were ranged between: The activity concentrations in the sugar samples were fluctuated in the ranges of (17.65 - 48.02), (27.63 - 56.13), (20.92 - 62.34) and (20.45 - 102.93 Bq. Kg^{-1}) for ^{226}Ra, ^{238} U, ^{322}Th and ^{40}K, respectively. For most samples, the activity concentrations of ^{226}Ra for samples under investigation are higher than those of the world's population, with an average of (32, 35, and 30 for Ra, U, and Th, respectively) Bq. Kg^{-1}, respectively. For ^{238}U, the activity concentrations of all samples are higher than the permissible level for all samples under investigation (33 and 20) Bq. Kg^{-1} and 1 Bq.L^{-1}.
Keyword. Radioactive Elements, Sugar Ported, Libya**.**

Introduction

Sugar is defined as a white sweet carbohydrate, while pure and mainly obtained from sugar cane. Commercially, the word “sugar” refers to a saccharide [1]. However, there is a great variety of sugars that are derived from many kinds of vegetables and are produced from different methods. Sugar cane has been produced in large quantities in tropical regions for many centuries and still dominates the world supply of this product. On the other hand, beet sugar is a recent crop that came to be consumed in the 19th century in temperate regions [2]. Sugar comes from cane and is obtained through stalk milling and grinding. The extracted juice is treated in order to remove impurities, and after that, it is concentrated by boiling to form a thick syrup. The crystallized sugar is separated from the syrup by rotation in a centrifuge, and the obtained product is called raw sugar. After the refining process of such raw product, it is obtained the white crystal sugar which is known in commerce [3]. Sugar is classified as a safe category of food. However, it can be considered a product that had several procedures which involved chemical products, contact with equipment and stocking, bagging, packing, and distribution, which can contain several contaminants, compromising the food safety of the product. From the point of view of health, one of the aspects that hasn’t been studied so deeply is the presence of contaminants, which, due to the prolonged consumption of sugar, can compromise the individual’s health, acting also as a source of exposure to other elements at several levels in the environment [3]. Most of the vegetable species that grow on the soil, mainly the polluted ones, absorb metals [4]. The accumulation of traces of metals, metalloids, and other inorganic elements in agricultural soils has a big interest due to food safety and big risks to human health as well as to other soil ecosystems [5]. The presence of inorganic elements in sugars can occur in function of natural factors related to the vegetable planting as for example, the geographic location of the planting, the kind of soil, the content of the drainage of the waters, and the type of planting cultivated surrounding areas [6]. However, the anthropogenic activities as soil intervention for the development of agricultural activities, mineral exploration, solid waste, and industrial processes, have a significant contribution to the contamination of the natural ecosystems. Radionuclides are found throughout nature and it exist in the soil and vegetables. These radionuclides have half-lives that are approximately Earth's age or older (i.e., about 4 to 5 billion years) [7]. Natural radioactive decay series such as ^{238}U and ^{232}Th, as well as singly occurring radionuclides such as ^{40}K, exist in the earth and atmosphere in varied levels. The radioactivity present in the air or in the agricultural land and in the soil may transfer to the crops grown on it. It happens, however, that an amount of some radioactive elements finds their way into human bodies [8]. Generally, the plants (vegetables) may cause accumulation of radionuclides in their organs, which may additionally rely on the chemical and physical properties of the soil. So, there may be a multiplied risk to the human population via the food chain. The main sources of components from the environment to plants are: air, water, and also the soil [9]. There are two ways for transferring the radionuclides present in the environment into plants by indirect and direct methods. The first method (indirect) happens by uptake from the soil through roots. When plants are grown in contaminated soil, the radioactivity is transferred from the soil to the roots and then to shoots plant. In the end, the radioactivity is shifted to the human diet. These radionuclides will get transferred into plants together with the nutrients throughout mineral uptake and accumulation in various components and even reach edible portions [10]. The second method (direct) happens by absorption through the aerial elements of the plants. Presence of emission (alpha, beta, and gamma) in plant organs.

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Naturally, the radioactive contamination of the soil affects the plants, animals, and human beings living in the given area directly, as the radioactive isotopes accumulated in the soil cause direct radiation exposure. Soil and vegetables are recognized as one of the major pathways for the transfer of radionuclides to human beings. The environmental studies took place in Libya during the last twenty years, where different pollutants were estimated in different samples (water soils, marine sediments, and vegetables). Different studies were conducted on the petroleum pollutants in some Libyan samples [11-17].'The contents of heavy metals were estimated in different samples [18-59], also many studies of the treatment of pollutants were carried out [60-65]. In Libya, the detection of radioactive nuclides in different samples, vegetables, soil, fish, and waters were studied [66-68]. The aim of this is to evaluate and estimate the types and concentrations of radioactive elements in Sugar samples collected from Markets in El Baida city, Libya.

Methods

Sampling and Preparation of Samples

Sugar Samples

The sugar samples were collected from local markets in Al-Baida city during winter (2025). Ten samples of sugar from different companies' product types (Table1), selected in this study. Approximately 2 kg of each sugar sample was taken, samples were protected in plastic bags and transported to the laboratory. (Physics Department, Faculty of Science, Omar Al Mukhtar University, Libya).

Table 1. The studied Sugar samples

S. no.	Sugar
1	AL Massa
2	Al Wasar
3	Al Wadi
4	Al Baraka
5	Frunclawi
6	Basma
7	Indian
8	ALJawhra
9	Farah
10	Naeem

Analysis of Radioactive Elements

The natural radioactive nuclei were determined by the Sodium Iodide (NaI) detector method.

Preparation of Samples of NaI Detector

Before measuring samples by sodium Iodide, soil and vegetable samples were dried at a temperature of 95C^{o} for 3 and 4 hours until the moisture was completely removed. The samples were then smashed into fine particles and thoroughly mixed, and passed through a fine mesh sieve (~200 mesh) to obtain composite representative samples. After that weighted the samples are placed in polyethylene bottles of 250 cm^3 volume [69]. The bottles were kept airtight for a month before being put into a NaI spectrometer, in order to secure the secular equilibrium between long-lived radioisotopes ^{238}U, ^{232}Th, and their corresponding daughters. This step is very necessary to ensure the radon gas is confined within the volume and the daughter still also remains in the sample. These samples were placed directly over the detector. The counting time for each sample was 70000 sec. The measured activity concentrations were presented as Bq.Kg^{-1}.Also, some radioactivity indices were calculated according to the following methods:

Radium Equivalent Dose (Ra_{eq})

The radium equivalent **(Bq.kg^{-1})** is estimated by the weighted sum of activities for radionuclides of ^{226}Ra,^{232}Th, and ^{40}K in the sample, and it is given by the relation:

$$\mathbf{Ra_{eq} = A_{Ra} + 1.43\ A_{Th} + 0.077\ A_K}$$

Where: A_{Ra}, $A_{Th,}$ and A_K are the activity concentration (Bq.kg^{-1}) for^{238}U,^{232}Th, and ^{40}K, respectively [70].

External Hazard Index (H_{ex})

The external hazard index (H_{ex}) due to the emitted gamma rays of the samples to estimate the biological hazard was calculated by the relation:

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

Where: A_{Ra}, $A_{Th,}$ and A_K are the activity concentrations for ^{226}Ra,^{232}Th, and ^{40}K in Bq.kg^{-1} [71].

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Internal Hazard Index (H_{in})

Internal exposure arises from the inhalation of radon (^{222}Rn) gas and its progeny products or ingestion of other radionuclides. Since radon is carcinogenic, it is present in all building materials. Hence, for the measurement of radon exposure, the internal hazard index is given as follows in previous studies[78].

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

Radiation Level Index (I γ)

The radiation level index I γ is used to assess the hazard level of radionuclides ^{238}U,^{232}Th, and ^{40}K. The radiation level index is calculated by using the relation :

$$I_\gamma = \frac{A_{Ra}}{150} + \frac{A_{Th}}{100} + \frac{A_K}{1500}$$

Where: A_{Ra}, A_{Th}, and A_K are the activity concentrations for ^{226}Ra,^{232}Th, and ^{40}K in $Bq.kg^{-1}$ [72].

Alpha index (Iα)

The external irradiation, especially radon and its short-lived products, is also hazardous to respiratory organs; they emit radioactive alpha particles and attach to aerosols, dust, and other particles in the air. As we inhale, radon progeny are deposited on the cells lining the airways, where the alpha particles can damage DNA and potentially cause lung cancer. The excess alpha radiation due to radon inhalation is estimated from the alpha index (Iα), which is defined as follows[22].

$$I_\alpha = \frac{A_{Ra}}{200}$$

The recommended upper limit concentration of ^{226}Ra is 200 $Bq.kg^{-1}$, which gives Iα = 1.

Computer Programs

The Excel and origin computer software programs were used in this study.

Description of the method of analysis.

Sodium iodide scintillation NaI (Tl) detectors are used to measure the samples. The detector was inserted in the cylindrical lead shield to reduce the background and noise radiation from many natural, radionuclides such as (^{40}K), decay series, and cosmic rays. The based system of gamma ray spectroscopy consists of a NaI(Tl) detector, high voltage power supply, Multi-Channel Analyzer (MCA box), and Sensor Cassy. The gamma ray spectra data were analyzed by using Cassy Lab software on a PC. The block diagram of the equipment's setup of the sodium iodide detector is shown in) Figure 1).

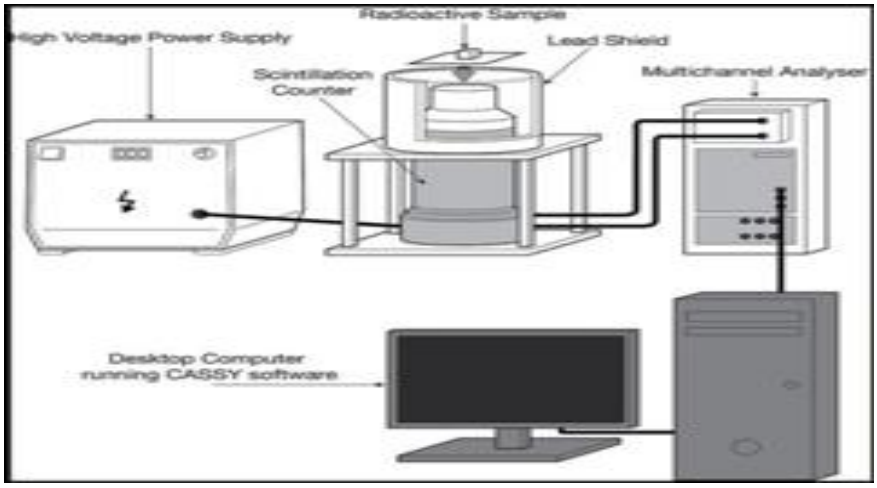

Figure 1. Description of the block diagram of system.

Results

For the analysis of samples in the sugar samples, the background measurement is very important. The background radiation spectrum of the ionized water is obtained for two days (14,0000 sec) and the other samples for one day (70000 sec). Different sources contribute to background radiation around the detection environment. This includes ambient air for the detector, shielding, and electronic components of the detector itself. [23]. For all samples, the activity concentration of ^{226}Ra was determined from the photo peak at 186.2 keV. The activity concentration of ^{238}U series determined ^{214} Pb photo peak (295.2 and 351.9) keV and ^{214}Bi (609.3, 768.4, 1120.3, 1238.1, 1377.7, and 1764.5) keV. similarly, for the ^{232}Th series, the activity concentration was determined from ^{228}Ac (92, 209.5, 338.5, 911.1, and 968.9) keV and ^{208} Tl 583 keV ^{212}Bi 727.2 keV. ^{40}K was determined from photo peak 1460 keV [73].

The activity concentrations in the sugar samples were fluctuated in the ranges of (17.65 - 48.02),(27.63 - 56.13), (20.92 - 62.34), and (20.45 - 102.93 $Bq.Kg^{-1}$) for ^{226}Ra, ^{238}U, ^{322}Th, and ^{40}K, respectively.For most

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samples, the activity concentrations of ^{226}Ra for samples under investigation are higher than those of the world's population, with an average of (32, 35, and 30 for Ra, U, and Th, respectively) $Bq.Kg^{-1}$ (UNSCEAR, 2008), respectively. For ^{238}U the activity concentrations of all samples are higher than the permissible level for all samples under investigation (33 and 20) $Bq.Kg^{-1}$ and 1 $Bq.L^{-1}$ [74].

Table 2. The activity concentrations ($Bq.Kg^{-1}$) of the radionuclides ^{226}Ra,^{238}U, ^{23} Th, and ^{40} K of the investigated samples.

Sample name	Sample code	^{226}Ra	U^{238}	^{232}Th	^{40}K
AL Massa	Su1	24.71	39.24	42.10	37.06
Al Wasar	Su2	30.36	42.56	33.30	31.57
Al Wadi	Su3	26.13	27.63	30.91	54.90
Al Baraka	Su4	17.65	24.15	25.17	96.07
Frunclawi	Su5	36.01	47.31	54.58	45.29
Basma	Su6	26.13	41.34	40.69	20.45
Indian	Su7	40.25	48.00	60.42	27.45
ALJawhra	Su8	30.01	47.49	55.28	57.64
Farah	Su9	48.02	56.13	62.34	102.93
Naeem	Su10	41.66	47.57	20.92	34.31
P.L (UNSCEAR, 2000)		32	35	30	400

UNSCEAR, 2000. United Nations. Scientific Committee on the Effects of Atomic Radiation. Sources and Effects of Ionizing Radiation: Sources (Vol. 1). United Nations Publications, New York.

Table 3. Absorbed dose rate, indoor and outdoor annual effective dose, excise life cancer risk, and annual gondola effective dose of the tea sample.

Sample name	Sample code	D_R ($nGy.h^{-1}$)	E_{in} $mSvy^{-1}$)(	E_{out} $mSvy^{-1}$)(	ELCR× 10^{-3}
AL Massa	**Su1**	38.40	0.19	0.05	0.15
Al Wasar	**Su2**	35.47	0.17	0.04	0.14
Al Wadi	**Su3**	33.04	0.16	0.04	0.13
Al Baraka	**Su4**	27.39	0.13	0.03	0.11
Frunclawi	**Su5**	51.51	0.25	0.06	0.21
Basma	**Su6**	37.51	0.18	0.05	0.15
Indian	**Su7**	56.24	0.28	0.07	0.23
ALJawhra	**Su8**	52.45	0.21	0.06	0.21
Farah	**Su9**	64.16	0.31	0.08	0.26
Naeem	**Su10**	33.32	0.26	0.04	0.13
P.L (UNSCEAR, 2010)		84	1	0.07	0.29

UNSCEAR, United Nations Scientific Committee on the Effects of Atomic Radiation. (2010). "Sources and Effects of Ionizing Radiation", UNSCEAR 2008 Report Vol. 1 to the General Assembly, with scientific annexes, United Nations Sales Publication, United Nations, New York.

The activity concentration A was determined for all radionuclides in the samples by using the relation of ^{238}U and ^{232}Th were measured for each peak, and the associated activity (A) was computed using the formula:

$$A = \frac{CPS}{I_\gamma \times \varepsilon \times M} \quad (1)$$

Where:
CPS: The net counts per second corresponding to the energy.
I_γ : is the gamma ray emission probability to the peak energy.
ε : is the absolute efficiency at photo peak energy.
M: is the mass of the measured sample in(kg).

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t : is the time of the sample spectrum collection in seconds.
The absorbed dose rates D (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 in marble, ceramic and cement samples by using the following relation. building materials, negligible.

$$D_R = 0.462A_{Ra} + 0.604A_{Th} + 0.042A_K \quad (2)$$

Where: A_{Ra}, A_{Th}, and A_K are the activity concentrations of ^{226}Ra, ^{232}Th series, and ^{40}K element, respectively.
The annual effective dose equivalent is calculated by multiplying the outdoor and indoor doses by the factors 0.2 and 0.8, respectively, to convert from the air-absorbed dose to the effective dose (0.7Sv.y^{-1}), where the outdoor and indoor doses are multiplied by the factors 0.2 and 0.8, respectively. So, the annual effective dose equivalent can be obtained from the two following formulas:

$$E_{out}(mSv.y^{-1}) = D_R(nGy.h^{-1}) x\ 8760(h.y^{-1})\ x\ 0.2\ x\ 0.7(Sv.Gy^{-1})\ x\ 10^{-6} \quad (3)$$

$$E_{in}(mSv.y^{-1}) = D_R(nGy.h^{-1}) x\ 8760(h.y^{-1})\ x\ 0.8\ x\ 0.7(Sv.Gy^{-1})\ x\ 10^{-6} \quad (4)$$

Where: (D) denotes the Dose rate.
P.L = Permissible level

Discussion

Uranium, thorium, and radium are radioactive elements that originate naturally in the soil and different plants. Uranium is the most abundant in the earth's crust and also tends to spread during the soil because the rocks in the outer crust have suffered from weathering processes (water, air, plants) as a result of these processes and different factors other the soil is formed, the soil pollution depends on relevant information transport and disposal operations away from the site of contamination, Because the accumulation of radioactive material and its movement depends on the interaction of materials and compounds with the hard part of the soil and the type of this reaction reflects the soil's ability to retain radioactive materials and on the other hand the rate of fall rainfall, quantity of irrigation water, type of cultivated plant and soil management processes lead to the movement of radioactive contaminants into groundwater or their transfer to plants or other medium such as water and air, radioactivity includes soil models of radionuclides, which belong to the ^{238}U series and the most important of radioactive element is ^{226}Ra [75].
Radiation pollution in groundwater is due to radium resulting from the melting of underground reservoir rocks, and ^{222}Ra, which is highly soluble in water. There are radionuclides produced by the decomposition of uranium, thorium, granitic and sedimentary rocks, which produce radioactive materials. Sedimentary rocks form the late Cretaceous uranium-rich Cretaceous rock, which is spread over a wide area of North Africa and the Middle East. The high concentrations of uranium, radon, and radium in drinking water cause genetic mutations, deformed births, and serious cancerous diseases. Most of them need hundreds of years to have no negative impact on human life. The topography of the topsoil of the aquifer has a large role in hiding and increasing pollution in groundwater. The soil's own ability to purify polluted water is related to soil quality and its properties that allow or impede the movement of pollutants into groundwater. There are highly purified soils that contribute significantly to water purification from their pollutant before they reach to groundwater[76].
The higher average levels of ^{238}U than average global values in the studied area may be due to the use of phosphate fertilizers required to treat soil and plants, as sugar depletion of natural nutrients is removed through agriculture and erosion. This fertilizer is composed of phosphate rocks that contain a high concentration of uranium. Elevated levels of ^{232}Th indicate the presence of carbonate and monazite rocks, which are known to be rich in these radionuclides. The high levels of ^{40}K are because the samples were collected from agricultural land where there is application of some potassium-rich inorganic fertilizers and other chemicals used to promote crop production. The variations of radioactivity elements in samples depend primarily on the geological structure and geographical conditions, such as the location of the study area, which can significantly contribute to the presence of radioactive elements. Therefore, the high percentages of these nuclei in the soil also affect the concentrations in vegetable samples. The concentrations of radionuclides of ^{226}Ra (ppt) and ^{238}U and ^{232}Th (ppm), and ^{40}K for all samples. The use of some fertilizers and pesticides may be affecting the distribution of radioactivity, where there is a relative increase in their contents in vegetables collected from farms [77-78].

Conclusion

This study was carried out to estimate and evaluate the radioactive elements in pocket sugar samples collected from local markets of El-Baida city, Libya. The results of this recorded presence different natural radioactive nuclides as ^{226}Ra, ^{238}U,^{232}Th, and ^{40}K, for all samples. Some of the studied samples contained high levels of safe limits.

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Conflict

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This article was not submitted to be published in any other journals; also, the results recorded in this study were not plagiarized from any other studies.

References

1. Kubota J, Welch RM, Van Campen DR. Partitioning of cadmium, copper, lead, and zinc amongst above-ground parts of seed and grain crops grown in selected locations in the USA. Environ Geochem Health. 1992;14(3):91-100. doi:10.1007/BF02694390.
2. Draycott AP, Christenson DR. Nutrients for Sugar Beet Production: Soil-plant Relationships. Wallingford, United Kingdom: CABI Publishing; 2003.
3. Ioannidou MD, Zachariadis GA, Anthemidis AN, Stratis JA. Direct determination of toxic trace metals in honey and sugars using inductively coupled plasma atomic emission spectrometry. Talanta. 2005;65(1):92-7. doi:10.1016/j.talanta.2004.05.008.
4. Junk WR, Pancoast HM. Handbook of Sugars: For Processors, Chemists and Technologists. 2nd ed. Westport, Ireland: AVI Publishing Company; 1973.
5. Sanna G, Pilo MI, Piu PC, Tapparo A, Seeber R. Determination of heavy metals in honey by anodic stripping voltammetry at microelectrodes. Anal Chim Acta. 2000;415(1-2):165-73.
6. Blaser P, Zimmermann S, Luster J, Shotyk W. Critical examination of trace element enrichments and depletions in soils: As, Cr, Cu, Ni, Pb, and Zn in Swiss forest soils. Sci Total Environ. 2000;249(1-3):257-80. doi:10.1016/s0048-9697(99)00522-7.
7. United States Environmental Protection Agency. Radiation Protection: Uranium. 2015.
8. The Government of the Hong Kong Special Administrative Region. Radiation and Food Safety. 2013.
9. Adeniji AE, Alatise OO, Nwanya AC. Radionuclide concentrations in some fruit juices produced and consumed in Lagos, Nigeria. Am J Environ Prot. 2013;2(2):37-41. doi:10.11648/j.ajep.20130202.11.
10. Hamad IH, Nuesry MS. The poly cyclic hydrocarbons levels in some fishes tissues collected from Derna City (Libya) Coast [abstract]. In: Proceedings of the International Conference on Chemical, Agricultural and Medical Sciences; 2014 Dec 10-11; Antalya, Turkey. p. 52-6.
11. Hamad MAH, Mounera AAE, Baseet ESM, Eman E, Al-Badri M. Identification and detection the aromatic and aliphatic hydrocarbons in Epinephelus Marginatus fish samples collected from Benghazi coast. Int J Adv Multidiscip Res Stud. 2023;3(3):107-13.
12. Mohammed A, Hamad MAH, Mounera AAE, Eman IHE. Extraction and identification of aliphatic hydrocarbons in marine sediment samples at Benghazi city and Dyriana town coasts (Libya). J Res Humanit Soc Sci. 2023;11(10):168-74.
13. Hasan MAH, Muftah HS, Abdelghani KA, Saad SI. Poly aromatic hydrocarbon concentrations in some shell samples at some Tobrouk city coast regions: could the oil industry be significantly affecting the environment. Ukr J Ecol. 2022;12(3):21-8. doi:10.15421/2022_347.
14. Hasan HMI, Mohamad ASA. A study of aliphatic hydrocarbons levels of some waters and sediments at Al-Gabal Al-Akhder coast regions. Int J Chem Sci. 2013;11(2):833-49.
15. Eltawaty SA, Abdalkader GA, Hasan HM, Houssein MA. Antibacterial activity and GC-MS analysis of chloroform extract of bark of the Libyan Salvia fruticosa Mill. Int J Multidiscip Sci Adv Technol. 2021;1(1):715-21.
16. Hamade MH, Abdelraziq SA, Gebreel AA. Extraction and determination the of Beta carotene content in carrots and tomato samples collected from some markets at ElBeida City, Libya. EPH Int J Appl Sci. 2019;1(1):105-10.
17. MdZeyaullah R, Naseem A, Badrul I, Hamad MI, Azza SA, Faheem AB, et al. Catechol biodegradation by Pseudomonas strain: a critical analysis. Int J Chem Sci. 2009;7(3):2211-21.
18. Hamad MH, Noura AAM, Salem AM. Phytochemical screening, total phenolic, anti-oxidant, metal and mineral contents in some parts of plantago Albicans grown in Libya. World J Pharm Res. 2024;13(3):1-17.
19. Anees AS, Hamad MIH, Mojahidul I. Antifungal potential of 1,2-4triazole derivatives and therapeutic efficacy of Tinea corporis in albino rats. Der Pharm Lett. 2011;3(1):228-36.
20. Hamad Hasan, Marwa Mohammed, Amal Haroon. Determining the contents of antioxidants, total phenols, carbohydrate, total protein, and some elements in Eucalyptus gomphocephala and Ricinus communis plant samples. Libyan Med J. 2015;1(1):222-31.
21. El-Mehdawe MF, Eman KS, Hamad MIH. Heavy metals and mineral elements contents of leaves and stems for some herbal plants at AL-Gabal AL-Akhder region. Chem Sci Rev Lett. 2014;3(12):980-6.
22. Hesien RA, Amira AKA, Ahlaam MA, Hamad MAH. Determination the anti–oxidant capacity, total phenols, minerals and evaluation the anti- bacteria activity of leafs and stems of Gaper plant extracts. Sch J Appl Med Sci. 2024;12(4):451-7. doi:10.36347/sjams.2024.v12i04.021.
23. Anas FAE, Hamad MAH, Salim AM, Azza MH. Phytochemical screening, total phenolics, antioxidant activity and minerals composition of Helichrysum stoechas grown in Libya. Afr J Biol Sci. 2024;3(6):2349-?.
24. Naseer RE, Najat MAB, Salma AA, Hamad MAH. Evaluation of metal and mineral contents of leafs, stems and roots of C. Parviflorus Lam and C. Salviifolius L plants growing at Al Ghabal Al-Khder (Libya). Int J Adv Multidiscip Res Stud. 2024;4(5):191-4.
25. Enam FM, Wesam FAM, Hamad MAH. Detection the contents of minerals of (sodium, potassium and calcium) and some metals of (iron, nickel and copper) in some vegetable and soil samples collected from Al-Marj. Int J Adv Multidiscip Res Stud. 2023;5(3):304-9.
26. Abdul Razaq A, Hamad H. Estimate the contents and types of water well salts by the Palmer Roger model affecting the corrosion of Al-Bayda city (Libya) network pipes. AlQalam J Med Appl Sci. 2025;?:744-53.
27. Abdulsayid FA, Hamad MAH, Huda AE. IR spectroscopic investigation, X-ray fluorescence scanning, and flame photometer analysis for sediments and rock samples of Al-Gabal Al-Akhder coast region (Libya). IOSR J Appl Chem. 2021;14(4):20-30.

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28. ALambarki M, Hasan HMA. Assessment of the heavy metal contents in air samples collected from the area extended between Albayda and Alquba cities (Libya). AlQalam J Med Appl Sci. 2025;?:695-707.
29. Al-Nayyan N, Mohammed B, Hamad H. Estimate of the concentrations of heavy metals in soil and some plant samples collected from (near and far away) of the main road between Al-Bayda city and Wadi Al-Kouf region. AlQalam J Med Appl Sci. 2025;?(1):816-26.
30. Hasan HMI. Studies on physicochemical parameters and water treatment for some localities along coast of Alexandria [PhD dissertation]. [Alexandria, Egypt]: Alexandria University; 2006.
31. Hamad MAH, Hager AA, Mohammed EY. Chemical studies of water samples collected from area extended between Ras Al–Halal and El Haniea, Libya. Asian J Appl Chem Res. 2022;12(3):33-46.
32. Hamad MH. Studies on physicochemical parameters and water treatment for some localities along coast of Alexandria. J Alex. 2006;?:?.
33. Hamad M, Mohammed AA, Hamad MAH. Adsorption and kinetic study for removal some heavy metals by use in activated carbon of sea grasses. Int J Adv Multidiscip Res Stud. 2024;4(6):677-85.
34. Hamad MAH, Hamad NIH, Mohammed MYA, Hajir OAA, Al-Hen dawi RA. Using bottom marine sediments as environmental indicator state of (Tolmaitha – Toukra) region at eastern north coast of Libya. Sch J Eng Technol. 2024;2(14):118-32.
35. Hamad MIH. The heavy metals distribution at coastal water of Derna city (Libya). Egypt J Aquat Res. 2008;34(4):35-52.
36. Hamad MIH, Mojahid ul Islam. The concentrations of some heavy metals of Al-Gabal Al-Akhdar coast sediment. Arch Appl Sci Res. 2010;2(6):59-67.
37. Hamad MAH, Amira AKA. Estimate the concentrations of some heavy metals in some shoes polish samples. J EPH Int J Appl Sci. 2016;2(2):24-7.
38. Hamad MAH, Hussien SSM, Basit EEM. Accumulation of some heavy metals in green algae as bio indicators of environmental pollution at Al-Haniea region: Libya coastline. Int J Adv Multidiscip Res Stud. 2024;4(5):188-90.
39. Hamad MIH, Ahmed MA. Major cations levels studies in surface coastal waters of Derna city, Libya. Egypt J Aquat Res. 2009;35(1):13-20.
40. Hamad MIH, Yahiya AI, Hassan SS, Salama MM. Biological study of transition metal complexes with adenine ligand. In: Proceedings of the ?; 2019; ?. p. 77.
41. Hamad MIH, Masoud MS. Thermal analysis (TGA), diffraction thermal analysis (DTA), infrared and X-rays analysis for sediment samples of Toubrouk city (Libya) coast. Int J Chem Sci. 2014;12(1):11-22.
42. Hamad R, Ikraiam FA, Hasan H. Estimation of heavy metals in the bones of selected commercial fish from the eastern Libyan coast. J Rad Nucl Appl. 2024;9(1):47-51.
43. Hasan HAH. Estimate lead and cadmium contents of some archeological samples collected from ancient cities location (Cyrene and Abolonia) at Al-Gabal Al-Akhder Region, Libya. Univ J Chem Appl. 2021;12(21):902-7.
44. Hasan HMI. Studies on physicochemical parameters and water treatment for some localities along coast of Alexandria [PhD dissertation]. [Alexandria, Egypt]: Alexandria University; 2006.
45. Hasan JA, Hasan HMA. Potential human health risks assessment through determination of heavy metals contents in regularly consumed yogurta in Libya. World J Pharm Pharm Sci. 2024;13(12):100-12.
46. Mamdouh SM, Wagdi ME, Ahmed MA, Alaa EA, Hamad IH. Heavy metals accumulation in sediments of Alexandria coastal areas. Bull Fac Sci. 2012;47(1-2):12-28.
47. Mamdouh SM, Wagdi ME, Ahmed MA, Hamad MIH. Chemical studies on Alexandria coast sediment. Egypt Sci Mag. 2005;2(4):93-102.
48. Mamdouh SM, Wagdi ME, Ahmed MA, Alaa EA, Hamad MIH. Distribution of different metals in coastal waters of Alexandria, Egypt. Egypt Sci Mag. 2010;7(1):1-19.
49. Mohamed AE, Afnan SA, Hamad MA, Mohammed AA, Mamdouh SM, Alaa RE, et al. Usage of natural wastes from animal and plant origins as adsorbents for the removal of some toxic industrial dyes and heavy metals in aqueous media. J Water Process Eng. 2023;55:104192. doi:10.1016/j.jwpe.2023.104192.
50. Mohamed HB, Mohammed AZ, Ahmed MD, Hamad MAH, Doaa AE. Soil heavy metal pollution and the associated toxicity risk assessment in Ajdabiya and Zueitina, Libya. Sci J Damietta Fac Sci. 2024;14(1):16-27.
51. Nabil B, Hamad H, Ahmed E. Determination of Cu, Co and Pb in selected frozen fish tissues collected from Benghazi markets in Libya. Chem Methodol. 2018;2:56-63.
52. Wesam FAM, Hamad MAH. Study the accumulation of minerals and heavy metals in Ulva algae, Cladophora, Polysiphonia and Laurencia algae samples at eastern north region of Libya coast. GSC Biol Pharm Sci. 2023;23(03):147-52. doi:10.30574/gscbps.2023.23.3.0389.
53. Alaila AK, El Salhin HE, Ali RF, Hasan HM. Phytochemical screening of some herbal plants (Menthe, Origanum and Salvia) growing at al-gabal al-akhder region- Libya. Int J Pharm Life Sci. 2017;8(4):?.
54. Elsalhin H, Abobaker HA, Hasan H, El–Dayek GA. Antioxidant capacity and total phenolic compounds of some algae species (Anabaena and Spirulina platensis). Sch Acad J Biosci. 2016;4(10):782-6.
55. Ahmed O, Ahmed NH, Hamad MAH, Fatin ME. Chemical and biological study of some transition metal complexes with guanine as ligand. Int J New Chem. 2023;10(3):172-83.
56. Hamad H, Zuhir A, Farag S, Dala A. Efficiency of Cynara cornigera fruits on antibacterial, antifungal and its phytochemical, anti-oxidant screening. Libyan Med J. 2025;?:120-8.
57. Citrine El Maleh, Hamad Hasan, Hajer Afergani. Contents of metal oxides in marine sediment and rock samples from the eastern Libyan coast, utilizing the X-ray method. AlQalam J Med Appl Sci. 2015;?:1316-21.
58. Hasan HMI. Studies on physicochemical parameters and water treatment for some localities along coast of Alexandria [PhD dissertation]. [Alexandria, Egypt]: Alexandria University; 2006. 254 p.
59. Hasan H, Abdelgader I, Emrayed H, Abdel-Gany K. Removal of the medical dye safranin from aqueouse solutions by sa grasses activated carbon: A kinetic study. Alqalam J Med Appl Sci. 2025;?:428-34.
60. Hasan HMA, Alhamdy MA. Adsorpition and kinetic study for removal some heavy metals by usein activated carbon of sea grasses. Int J Adv Multidiscip Res Stud. 2024;4(6):677-85.

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61. Almadani EA, Hamad MAH, Kwakab FS. Kinetic study of the adsorotion of the removal of bromo cresol purple from aqueus solutions. Int J Res Granthaalayah. 2019;7(12):?.
62. Alfutisi H, Hasan H. Removing of thymol blue from aqueous solutions by pomegranate peels. EPH Int J Appl Sci. 2019;1(1):111-9.
63. Mamdouh SM, Wagdi ME, Ahmed MA, Alaa EA, Essam AM, Hamad MIH. Rice husk and activated carbon for waste water treatment of El-Mex Bay, Alexandria Coast, Egypt. Arab J Chem. 2016;9:S1590-S1596. doi:10.1016/j.arabjc.2012.04.037.
64. Abdelrazeg A, Khalifa A, Mohammed H, Miftah H, Hamad H. Using melon and watermelon peels for the removal of some heavy metals from aqueous solutions. AlQalam J Med Appl Sci. 2025;?:787-96.
65. Hamad R, Ikraiam F, Hasan H. Determination of specific natural radionuclides in the bones of some local fish commonly consumed from the eastern Libyan coast. J Rad Nucl Appl. 2023;8(3):283-9.
66. Sroor AT, Walley El-Dine N, El-Bahi SM, Hasa HMA, Ali JM. Determination of radionuclides levels and absorbed dose for soil, rock, plant and water in gondola- Libya. ISOR J Appl Phys. 2018;10(4):40-9.
67. Hayder AMS, Hasan HM, Ikraiam F. Determination and comparative analysis of natural radioactivity levels using gamma spectrometry in shore sediment samples from the east coast, libya. In: Sebha University Conference Proceedings; 2024; Sebha, Libya. p. 297-300.
68. Faanu A, Adukpo OK, Tettey-Lawluvi H, Kpeglo DO, Darko EO, Emi-Reynolds G, et al. Natural radioactivity levels in soils, rocks and water at a mining concession of Perseus gold mine and surrounding towns in Central Region of Ghana. Springerplus. 2016;5:98. doi:10.1186/s40064-016-1726-3.
69. Saleh IH. Radioactivity of 238U, 232Th, 40K, and 137Cs and assessment of depleted uranium in soil of the Musandam Peninsula, Sultanate of Oman. Turk J Eng Environ Sci. 2012;36(3):236-48. doi:10.3906/muh-1112-5.
70. Al-Harbi WR, El-Taher A. Elemental analysis and natural radioactivity levels of clay by gamma ray spectrometer and instrumental neutron activation. Sci Technol Nucl Install. 2016;2016:8040728. doi:10.1155/2016/8040728.
71. El-Taher A, Alzahrani JH. Radioactivity measurements and radiation dose assessment in soil of Al-Qassim region, Saudi Arabia. Indian J Pure Appl Phys. 2014;52:147-54.
72. Estoková A, Palaščáková L. Assessment of natural radioactivity levels of cements and cement composites in the Slovak Republic. Int J Environ Res Public Health. 2013;10(12):7165-79. doi:10.3390/ijerph10127165.
73. Gilmore G. Practical Gamma-ray Spectrometry. 2nd ed. Chichester, UK: John Wiley and Sons, Ltd; 2008.
74. Sutherland RA, de Jong E. Statistical analysis of gamma-emitting radionuclide concentrations for three fields in southern Saskatchewan, Canada. Health Phys. 1990;58(4):417-28.
75. United Nations Scientific Committee on the Effects of Atomic Radiation. Sources and Effects of Ionizing Radiation, UNSCEAR 2008 Report: Volume I: Sources. New York, NY: United Nations; 2010.
76. Al-Hawas IA. Irrigation water quality evaluation of Al-Hassa springs and its predictive effects on soil properties. Pak J Biol Sci. 2002;5(6):651-5.
77. Ewieda EA, Hamza MS, Ali AIM, Hamed MA. Distribution of uranium in some water and soil at different locations in the Nile Delta, Egypt. In: Proceedings of the 4th International Conference on Geochemistry; 1999; Alexandria, Egypt. p. 369-81.

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