Determination of the Natural Radioactivity in Soil Of Al-Amirya Region

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ABSTRACT

For studying and analyzing the radiation background for Al-Amirya city in Baghdad, Iraq, using nuclear and spectroscopic method, 10 samples of surface soil were collected. The natural specific radioactivity of radioactive (226Ra, 226Th, 40K) in soil were determined using Sodium Iodide detector. The detector was surrounded from all directions by thick lead layer of 10 cm and container made of three plates of aluminum, copper and iron to prevent the effect of background degradation. The relationship between Radium (Ra) equivalent, external Hazard (Hex), internal Hazard (Hin) and gamma level index (lyr) as a function of absorbed dose was studied it was found to be linear The study identified that many nuclides as an equivalent activity for 226Ra, 228 Ac. The results for 226Ra, 40K and 228 Ac were 0.069, 6.864 and 4.0499 Bq/kg respectively for soil.The results showed that the specific activity of radioactive nuclides in most samples is normal and within the allowed limits. The results were in a good agreement with international specifications. Our results indicate that the natural radioactive (Background) in Al- Amirya region for soil is normal.

Keywords: Natural , Radioactivity, Soil, Al-Amirya Region

1-1 Introduction

Due to several legislative, environmental, economic and social constraints, the identification of most sustainable disposal route for solid waste management remains an important issue in almost all industrialized countries.

Areas near landfills have a greater possibility of groundwater contamination because of the potential pollution source of leachate originating from the nearby site. Such contamination of groundwater resource poses a substantial risk to local resource user and to the natural environment. The impact of solid waste leachate on soil has given rise to some of studies in recent years.

Many approaches have been used to assess the contamination of soil and groundwater. It can be assessed either by the experimental determination of the impurities or their estimation through mathematical modeling , Most solid waste disposal sites in around Al-Amirya region are illegal open dumps at numerous locations scattered inside and around the city with no infrastructure for environmental protection. It is usual to find uncovered solid waste. The rainwater runs off over the uncovered top of the waste dump. This water may contaminate the soil. Some of the major problems that result from current solid wastes management are.

1. The unpleasant smells
2. The spread of insects that gather on these solid wastes
3. The emitted smoke from the burning of such wastes
4. The contamination of surface water and groundwater due to the decomposition of the solid wastes.
5. Landscape damaging

The fertility of natural soil ecosystems therefore depends significantly on the rate of turnover of the soil organic matter, mediated by the soil microbial biomass. Agents that may suppress or poison soil organisms, or change the quality or quantity of organic matter (either flesh inputs or the soil organic matter itself), can damage the functioning of the soil-plant ecosystems, either in the shortterm or over much longer periods (Brookes and Verstraete 1989). In agricultural ecosystems soil fertility can be increased by applications of inorganic or organic fertilizer. The fertility of natural ecosystems, however, depends almost entirely on natural microbial processes, including N2 fixation, the mineralization of organic forms of N, C, P, and S, and organic matter transformations, all mediated by the soil microbial biomass. Any decline in natural fertility resulting from pollutants entering soils will therefore have proportionately greater effects.

1-2 Source of Environmental Radiation

The environmental radiation sources are two types' natural source and man-made radioactive radionuclides. In natural causes exposures occurring due to radionuclides are discovered in the earth structure. The other radionuclides are produced in the atmosphere by space radiation. Man-made radionuclides have gone into the environment due to human activities like for example medical purposes that use radionuclides to diagnosis and therapy the body. Other man made causes are power plant reactors that use radioactive uranium and thorium as fuel. We are ceaselessly exposed to radiation by sources external and internal our bodies. The terrestrial radiation and space radiation are external sources.

Internal radiation are radionuclides that enter human bodies with the food, drinking water and air by ingest and exhale.

1-2-1 Terrestrial Radiation Source

Radiation that has the origin from Earth is named terrestrial radiation. Primordial radionuclides (radionuclides that were present when the Earth created about (4.5×10^9 years ago) are detected in the earth. These radionuclides are mixed in stones, rocks even water. These radionuclides are released into water and air from soil and rocks. Also uranium mining and fuel cycle that causes are redistributed terrestrial radionuclides. The important primordial radionuclides include the series ^{238}U, ^{232}Th and their decay products, as well as ^{40}K and ^{87}Rb. previously, one of the human activities that contributed to terrestrial radiation was the nuclear weapons production.

The Chernobyl Accident in 1986, which was an explosion at power reactor, is also another source to increasing background radiation in the world. However, almost all radionuclides that were produced in this mentioned were decayed except ^{137}Cs and "^{90}Sr radionuclides.

1-2-2 Cosmic Radiation

The space radiation and particles come into the Earth's atmosphere from space. Their source are the Earth's radiation belts and the sun or as far away as beyond the boundaries of the solar system. There are two types of radiation: I) galactic cosmic rays (GCR), II) radiation emanating from the Sun. The particle and radiation energy ranges vary spaciously. The biological effect is a combination of the primary particles and the secondary particles. Radiation with beyond solar system sources can transport through Earth's atmosphere, because they have high range energy. These radiations can generate additional fall radiation. They are creating either radionuclide in the atmosphere or secondary fall particles. Almost secondary particles can reach the atmosphere and Earth's surface at high altitudes where the Earth's atmosphere is delicate. The radionuclides are produced by cosmic radiation, named cosmogenic radionuclides. The important radionuclides are '^{3}H, '^{7}Be, '^{14}C and ^{22}Na.

1-2-3 Radiation of Radionuclides in the Body

In our daily life, the terrestrial and cosmogenic radionuclides are entered the human body through such as food, water and air. In this time the short-lived radionuclides are significant since the short-lived radionuclides decay away quickly in body and the long-lived radionuclides are placed in body. These radionuclides are decayed more slowly and collected in specific body tissues for example radon in lung. The terrestrial source radionuclides are the most important radionuclides that enter the human bodies. The radon gases are important ones (and their decay chain radionuclides) that we continuously inhale. Other radionuclides in the body, is as well as "^{40}K. Surface drinking water have very low levels of terrestrial radionuclides however, the ^{226}Ra, ^{228}Ra, and ^{238}U are mixed in ground water. These radionuclides may be higher in some areas of the world than in others places.

1-3 Man-made sources

Man-made sources of radiation account for approximately 14 per cent of our annual radiation dose and are dominated by the use of radiation in medicine.

1-3-1 Medical uses of radiation

Many procedures carried out routinely in medical diagnosis involve exposure to radiation. Some well-known procedures that involve the use of radiation are: dental and chest X-rays, mammography to check for breast cancer, angiocardiograms to determine heart function, CT scans and nuclear medicine using radioactive pharmaceuticals to determine the functioning of body organs.

Some people receive no dose from medical procedures while others receive much higher doses. All medical exposures to radiation must be clinically justified and should only be carried out if recommended by a GP or medical consultant. Exposure to radiation as part of a routine medical check-up is rarely if ever justified.

1-3-2 Radiation in the workplace

Artificial radiation has a number of beneficial uses in medicine, industry and education/research. People working with radioactive materials may receive aradiation dose, but this is normally low. More details are given on the separate fact sheet Uses of Radiation in Medicine, Industry, Education and Research.

1-3-3 Radioactivity in the environment

Radioactivity is also present in our environment due to nuclear weapons testing, accidents at nuclear facilities and the authorised discharge of radioactive wastes from nuclear and other facilities. As with natural radionuclides, this artificial radioactivity is found in the ground, as well as in air, food and water.

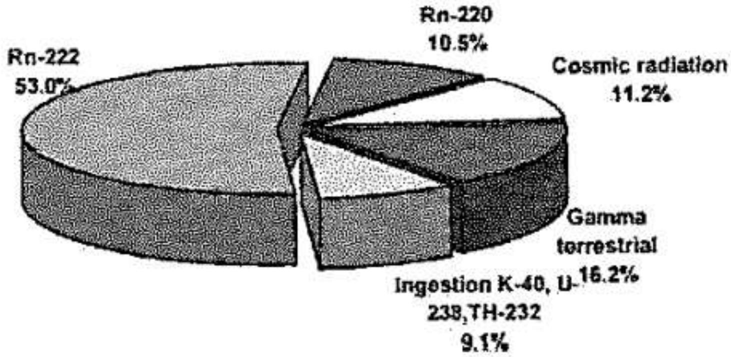

Fig.(1-1). Contribution of the natural radiation sources to the annual collective effective dose

1-4 Radiation Effects

1-4-1 Effects of Low Doses

Most of the radiation doses that are received by members of the public and by radiation workers-both routinely and in accidents-are what are commonly referred to as "low doses." There is no precise definition of "low" but it would include doses below, for example, 10 mSv per year. The average radiation doses received by people in the U.S. are in the "low dose" region. It is obviously important to determine the effects of low radiation doses or, more precisely, the effects of small additions to the unavoidable natural background dose .

However, despite much study, these effects are not known, being too small to see unambiguously. The most prominent assumption, accepted. by most official bodies, is the so-called linearity hypothesis, according to which the cancer risk is directly proportional to the magnitude of the dose, down to zero dose. In applying this assumption a consensus estimate is that the risk to a "typical" individual of an eventual fatal cancer is 0.00005 per mSv (or 0.05 per Sv). Thus, if 100,000 people each receive an added dose of 1 mSv, then 5 additional cancer deaths are to be expected. At the same time, while adopting the linearity hypothesis as a prudent working assumption, many of the leading studies have also indicated the possibility that small increases in radiation dose do not create any additional cancer risk. This reflects the considerable disagreement that exists within the scientific community as to the validity of the linearity hypothesis .

1-4-2 Effects of Large Doses

Radiation doses above 3 Gy (300 rad) can be fatal and doses above 6 Gy (600 rad) are almost certain to be fatal, with death occurring within several months (in shorter times at higher doses). [Note: Very high doses are commonly expressed in grays, because the standard quality factor is not appropriate. For gamma rays and electrons, 1 Gy corresponds to 1 Sv.] Above 1 Gy, radiation causes a complex of symptoms, including nausea and blood changes, known as radiation sickness. For doses below 1 Sv (100 rem), there is little likelihood of radiation sickness, and the main danger is an increased cancer risk. The most important data base and analyses are from the RERF studies of the Hiroshima and Nagasaki survivors [12]. In these studies, the exposure and medical histories are analyzed for an exposed group (50,113 people) and an unexposed, or minimally exposed, group (36,459 people). Through 1990, there have been 4,741 cancer fatalities in the exposed group, of which 454 are attributed to radiation exposure. There is a statistically significant excess for both solid cancer tumors and leukemia for doses above 0.2 Sv (20 rem). These data, in a succession of updated versions, have provided much of the information used in comprehensive studies of radiation effects.

1-5 NATIONAL AND INTERNATIONAL REGULATIONS

Many national and international institutions have published rules - mandatory or not that carry the intent of managing the question of radioactivity in drinking water. A short review of the most significant Ones are hereby presented.

1-5-1 World Health Organization (WHO)

WHO guidelines for drinking water suggest performing an indirect evaluation of individual dose criterion (IDC) of 0.1 mSv/y by measuring gross alpha and beta radioactivity and checking compliance of radionuclide activity concentration to derived guidance levels .

Once an IDC of 0.1 mSv from 1 year's consumption of drinking water has been adopted, the recommended assessment methodology for controlling radionuclide health risks from drinking water involves three steps:

−Initial screening is undertaken for both gross alpha activity and gross beta activity. If the measured activity concentrations are below the screening levels of 0.5 Bq/l for gross alpha activity and 1 Bq/l for gross beta activity, no further action is required;

−If either of the screening levels is exceeded, the concentrations of individual radionuclides should be determined and compared with the guidance levels.

−The outcome of this further evaluation may indicate that no action is required or that further evaluation is necessary before a decision can be made on the need for measures to reduce the dose.

A specific guidance level is indicated for uranium. In fact, "The provisional guidance value for total content of uranium in drinking water
is 30 µg/l based on its chemical toxicity, which is predominant compared with its radiological toxicity" .

1-6 literature review

S. Chibowski and A. Gładysz (1998) this study investigates gamma emitter radioactivity in a system consisting of soil and plants. Some selected samples of tissues of animals fed with the plants from these sites were also measured. In soil and plant samples artificial (^{137}Cs, ^{134}Cs) and natural (thorium and uranium series) isotopes were detected. Despite the relatively high content of the natural isotopes in plants and their seeds, their accumulation in animal tissues was not detected. The 40K isotope was transferred in the chain soil-plant-animal in the highest degree. From the group of the natural isotopes, only ^{212}Pb was detected in examined animal tissue samples. Other natural isotopes were below detection level. In the samples heavy metal content was also examined. In any sample no clement concentration was noticed above trade acceptable limit.

Quan-Ying Cai etal.(2007) in this paper the published scientific data on the soil contamination by semivolatile organic chemicals (SVOCs) in China are summarized. Data has been found for more than 150 organic compounds which were grouped into six classes, namely, polychlorinated dibenzop-dioxins and dibenzofurans (PCDD/Fs), polychlorinated biphenyls (PCBs), organochlorine pesticides (OCPs), polycyclic aromatic hydrocarbons (PAHs), polybrominated diphenyl ethers (PBDES) and phthalic acid esters (PAEs). An overview of data collected from the literature is presented in this paper. The Chinese regulation and/or other maximum acceptable values for SVOCs were used for the characterization of soils.

Cristina Nuccetelli etal.(2012) study the Radioactivity in drinking water because Drinking waters usually contain several natural radionuclides: tritium, radon, radium, uranium isotopes, etc. Their concentrations vary widely since they depend on the nature of the aquifer, namely, the prevailing lithology and whether there is air in it or not. Aims. In this work a broad overview of the radioactivity in drinking water is presented: national and international regulations, for limiting the presence of radioactivity in waters intended for human consumption; results of extensive campaigns for monitoring radioactivity in drinking waters, including mineral bottled waters, carried out throughout the world in recent years; a draft of guidelines for the planning of campaigns to measure radioactivity in drinking water proposed by the Environmental Protection Agency (ARPA) of Lombardia.

Raad Obid Hussein Houmady (2013) Activities associated with mining of uranium have generated significant quantities of waste materials containing uranium and other toxic metals. A qualitative and quantitative study was performed to assess the situation of nuclear pollution resulting from waste of drilling and exploration left on the surface layer of soil surrounding the abandoned uranium mine hole located in the southern of Najaf province in Iraq state.

To measure the specific activity, twenty five surface soil samples were collected, prepared and analyzed by using gamma- ray spectrometer based on high counting efficiency NaI(TI) scintillation detector. The results showed that the specific activities in Bq/kg are 37.31 to 1112.47 with mean of 268.16, 0.28 to 18.57 with mean of 6.68 and 132.25 to 678.33 with mean of277.49

for ^{238}U, ^{232}Th and 40K respectively. Based on these values, radium equivalent activity in Bq/kg and absorbed dose rate one meter above the ground surface nGy/h were calculated and found to be vary 52.72 to 1189.84 and from 25.02 to 553.01. The indoor and outdoor annual effective dose rate in mSv/y ranged from 0.12 to 2.71 and from 0.03 to 0.67 respectively. To evaluate the dangerous of the study area, the external (Hex) and internal (Hin) hazard indexes are calculated and found to be ranged 0.14 to 3.21 and from 0.24 to 6.22. For the purpose of assessing the seriousness of the study area, results were compared with the world wide average. This comparison indicated that the study area is not safe from the radiological protection point view.

Suad Mahdi Glewa and Mustafa Al-Alwani (2013) [19] evaluate the effect of solid waste Leachate of unlined dumping site on soil at study area which located at the north of Hilla city. To assess soil contamination 6 bore holes were bring randomly at the site Three samples were collected at 50, 100, 150 cm for each bore hole. For leachate the samples were taken randomly from three different locations and were mixed prior to its analysis. Concentration of various physico-chemical parameters including heavy metals (Cd, Cr, Cu, Fe,) were determined in soil and leachate samples. The presence of CI,NO3, Cd, Cr, Cu, Fe, in soil, likely indicate that soil is being significantly affected by leachate percolation. Further they proved to be as tracers for groundwater contamination.

Kokrajhar etal. (2014) It has been realized that the environmental changes have exceeded the critical limits and the ecosystem is highly unbalanced. Further, the quantum of Solid waste substance such as newspapers, bottles, plastic bags, polythene, packing material and garbage have also increased drastically leading to pollution of different kinds, the worst affected being the soil. As such, there is an urgent need to control solid waste generated pollution, in which environmental education can play a vital role.

Adil Mahdi Saleh Al-Kinani (2015) Study and analyze the radiation background for Al-Sadar city in Baghdad, Iraq, using nuclear and spectroscopic method, 30 samples of air which was designed in this study, 30 samples of surface soil and 30 samples of drinking water were collected. Indoor radon concentration in all air samples were determined using CR-39, that exposed the samples for one month using closed containers with a hole at the top of the container covered with a light sponge to prevent the entry of dust and allow for the gaseous exchange. The average radon specific activity was 50.56Bq/m3.This result was in normal activity in air. The results showed that the specific activity of radioactive nuclides in most samples is normal and within the allowed limits. The results were in a good agreement with international specifications.

1-7 Aim of the work

Measured concentrations of ^{226}Ra ^{228} Ac and ^{40}K in Soil of Amirya region, Baghdad in Iraq.

2- Compared the obtained results with the permissible limit of EPA to gain a clear picture on these concentrations.

1-8 Results, Discussion and Conclusions

Naturally occurring radionuclides are present as many natural sources. Human activities that exploit these resources may lead to enhanced concentrations of radionuclides and potential radiation exposure such as phosphate ore mining, and phosphate fertilizers manufacture and its agricultural applications in soil. Although direct transfer from soil and rock is the largest aggregate exposure pathway, radon can transfer from water into buildings and constitutes an important secondary source of radon exposure in groundwater-dependent populations. Although both inhalation and ingestion of radon -rich water may represent some exposure to the lungs and stomach, respectively, inhalation is believed to be a larger health risk. This chapter represents the concentration of radionuclide, the hazard indices and excess lifetime cancer risk in soil in 10 different samples (soli) were taken from houses in Al-Amirya region.

1-9 Radionuclides Concentration in Soil

The natural radionuclides concentrations were measured in this study for 10 soil samples taken from houses in Al-Amirya city using HPGe detector, Table 4-5 presents the three natural radionuclide isotopes (^{40}K, ^{226}Ra and ^{228} Ac) which are found in soil samples. Note detect (ND)- 0.69Bqkg-1 and 0-8.736 and 3.95-7.355 Bqkg for ^{226}Ra, ^{228} Ac and ^{40}K respectively. The specific activity average values of ^{226}Ra, ^{232}Th and ^{40}K are 0.069 Bqkg 'Bqkg 4.05 and 6.128 Bqkg respectively as shown in

Table 1-9 Concentration of three natural radionuclide isotopes (226Ra, 228Ac and 40K) in soil samples

Sample No.	K-40 (Bqkg^{-1}")	Ac-228 (Bqkg^{-1})	Ra-226(Bqkg^{-1})
1	6.62663	8.73624	0
2	3.95189	1.4573	0.690314
3	6.46731	3.09833	0
4	6.61969	2.18482	0
5	6.59199	0	0
6	5.06064	5.6832	0
7	7.35586	3.95659	0
8	5.27177	5.16724	0
9	7.10199	2.68303	0
10	6.23814	7.53817	0

1-10 Calculation of Radium Equivalent Activity, Absorbed Dose Rate, Annual Effective Dose Equivalent, the External Hazard Indices, the Internal Indices and ELCR in Soil Samples.

The radium equivalent activity was calculated using Eq.2-5, were ranged from 0.507558 Bqkg in sample 3 to 13.00307 Bqkg 'in sample 1, as shown in Fig.1-10 ,Table 4-2 shows all radium equivalent activity are below the permissible values 370 Bqkg'[8]. Absorbed dose rate is calculated by using Eq. 2-6 and its ranged from 0.272895 nGyh^{-1} in sample 5 to 5.717 nGyh" in sample 1. Fig.3-2 shows the absorbed dose rate in air as a function of soil samples. Also, the present values of outdoor and indoor annual effective dose equivalent were calculated using Eqs.2-10 a and b, were ranged from 0.000335 and 0.001339 mSv in sample 5 to 0.007011 and 0.028045 mSv in sample 1 as shown in Figs.10- 3 and 3-10 for outdoor and indoor annual effective dose equivalent respectively. All values of indoor and outdoor annual effective dose equivalent lower than the world average values (0.07mSv/y for outdoor and 0.45mSv/y for indoor) , Furthermore, the external hazard indices were calculated using Eq. 2-8 a, were ranged from 0.00137 in sample 5 to 0.035108 in sample 1 and internal hazard indices were calculated using Eq.2-8 b, were ranged from 0.00137 in sample 5 to 0.035108 in sample 1 as shown in Figs.10-5 and 10-6 for external and internal hazard indices respectively. All external and internal indices values are less than the world permissible value of unity. Gamma Level index (yr) calculated using Eq. 10-9, was ranged from 0.004394 in sample 5 to 0.09178 in sample 1,Fig.3-10 shows the Gamma Level index (lyr) as a function of soil samples number, these value are listed in table 10-2. This indicates that the values will not lead to respiratory diseases such as asthma and cancer and external diseases such as skin cancer and cataracts.

Table 1-10: Racq, Absorbed dose rate, the annual effective dose, the hazard indices and gamma level index in soil sample contained natural radionuclids.

Sample No.	Ra eq ($Bqkg^{-1}$)	Absorbed dose rate ($nGyh^{-1}$")	Theannual effective dose(mSv/y) (Outdoor)(Indoor)		(Hex)	(Hin)	Gamma Level Index (Tyr)
1	13.00307	5.71702	0.007011	0.028045	0.035108	0.035108	0.09178
2	3.078549	1.389741	0.001704	0.006618	0.008314	0.01018	0.02181
3	4.9285995	2.198006	0.002696	0.010783	0.013307	0.013307	0.035295
4	3.634009	1.635198	0.002005	0.008022	0.009812	0.009812	0.026261
5	0.507558	0.272895	0.000335	0.001339	0.00137	0.00137	0.004394
6	8.51645	3.75044	0.004599	0.018397	0.022995	0.022995	0.060206
7	6.224325	2.769488	0.003397	0.013588	0.016806	0.016806	0.04447
8	7.795079	3.437442	0.004216	0.016863	0.021047	0.021047	0.055187
9	4.383586	1.96555	0.002411	0.009642	0.011836	0.011836	0.031565
10	11.25992	4.954539	0.006076	0.024305	0.030402	0.030402	0.07954

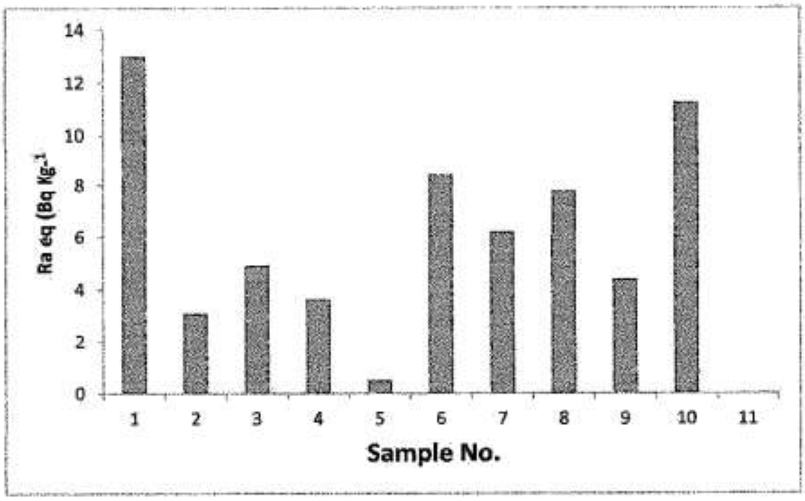

Fig. 1-10: The Radium equivalent as a function of soil samples number.

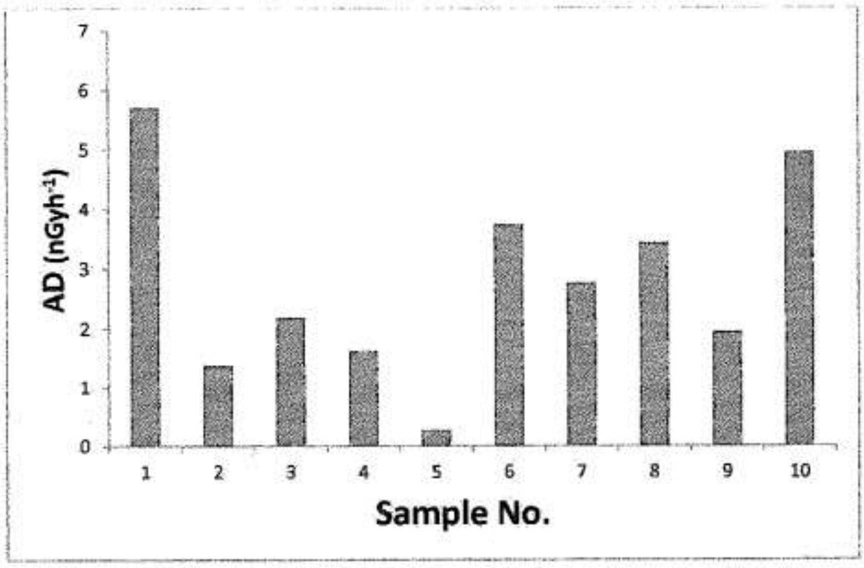

Fig. 2-10: The absorbed dose rate in air as a function of soil samples number.

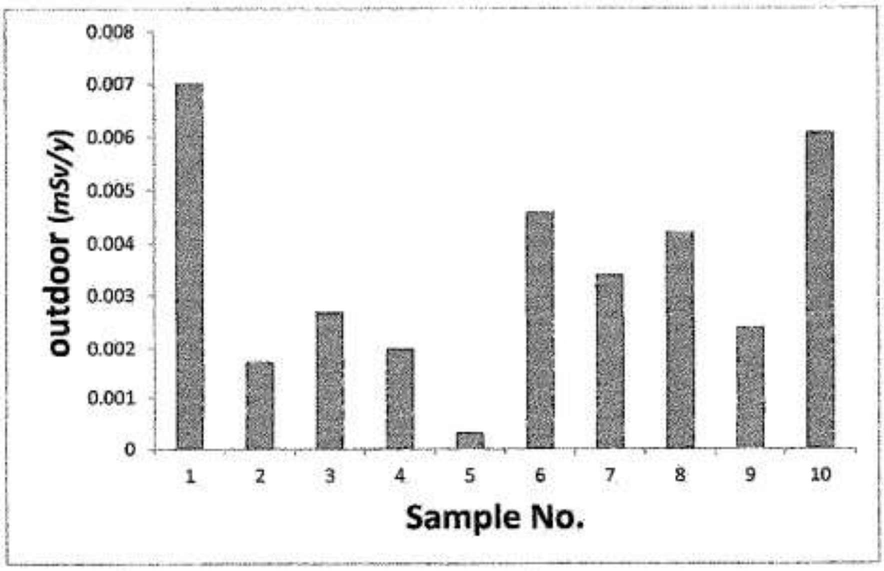

Fig. 3-10: The annual effective dose outdoor as a function of soil samples number.

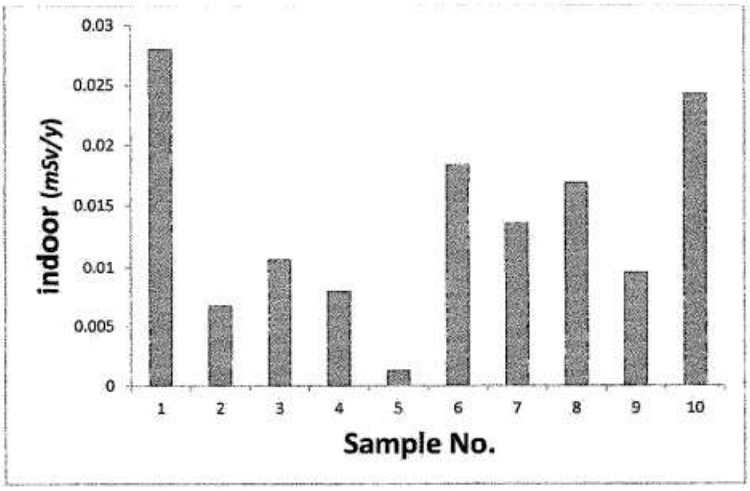

Fig. 4-10: The annual effective dose indoor as a function of soil samples number.

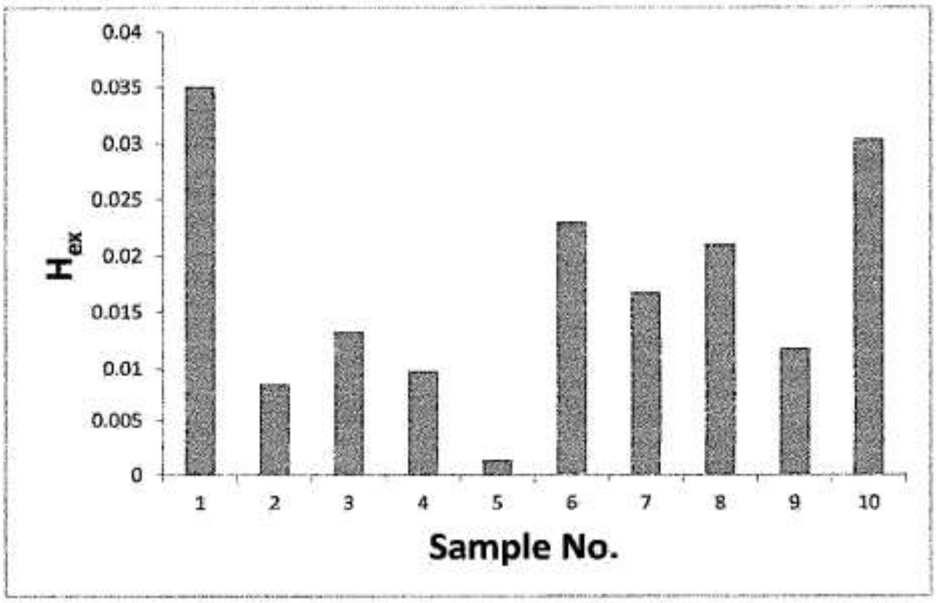

Fig. 5-10: The external hazard index as a function of soil samples number.

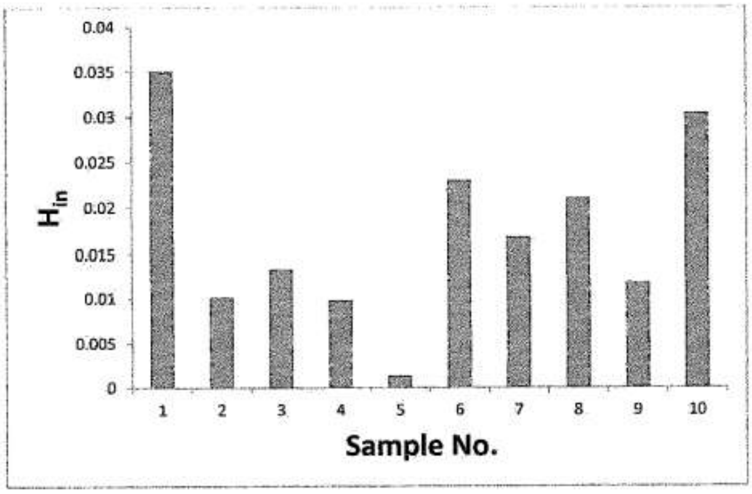

Fig. 6-10: The internal hazard index as a function of soil samples number.

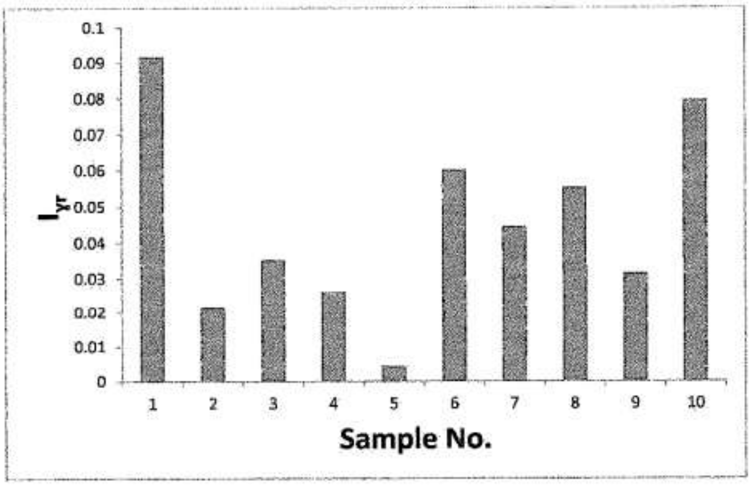

Fig. 7-10: The Gamma Level index (Tyr) as a function of soil samples number

When compared our results with previous studies, the values of concentration of three natural radionuclide isotopes (^{40}K, ^{226}Ra and ^{228} Ac) in soil samples of Al-Amirya region are within the allows range .

1-11 The absorbed dose rate and other radiation hazard indices in soil samples.

Figures 8-11, 9-11, 10-11 and 11-11 shows some relationships between the absorbed dose rate and other radiation hazard indices. From these figures, one can find fitting equations that are very important and useful because the absorbed dose rate can be measured experimentally by any dosimeter. So, any hazard index can be calculated without measurement of any S.A of terrestrial radionuclides but for all conditions of these measurements. These fitting equations can be listed as in the following.

$$Ra_{eq}(Bqkg^{-1}) = 2.081D(nGyh^{-1}) - 0.037 \quad (3\text{-}1)$$

$$H_{ex} = 0.005D(nGyh^{-1}) - 7 * 10^{-5} \quad (3\text{-}2)$$

$$H_{in} = 0.007D(nGyh^{-1}) + 0.004 \quad (3\text{-}3)$$

$$I_{yr} = 0.015D(nGyh^{-1}) - 0.001 \quad (3\text{-}4)$$

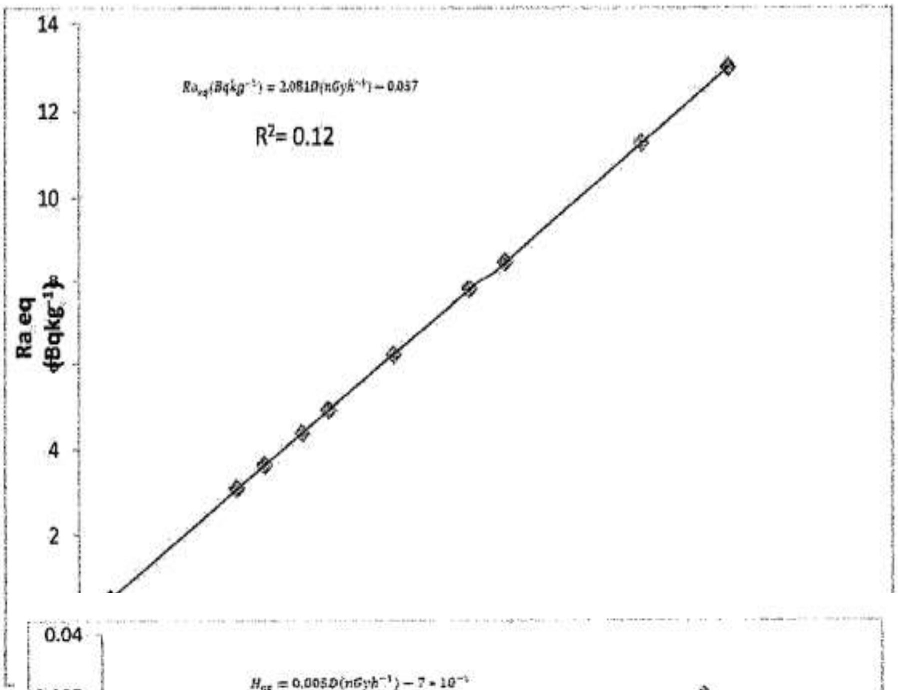

Fig. 11-8: The equivalent Radium Raeq (Bqkg-1) as a function of (D (nGyh-1`')).

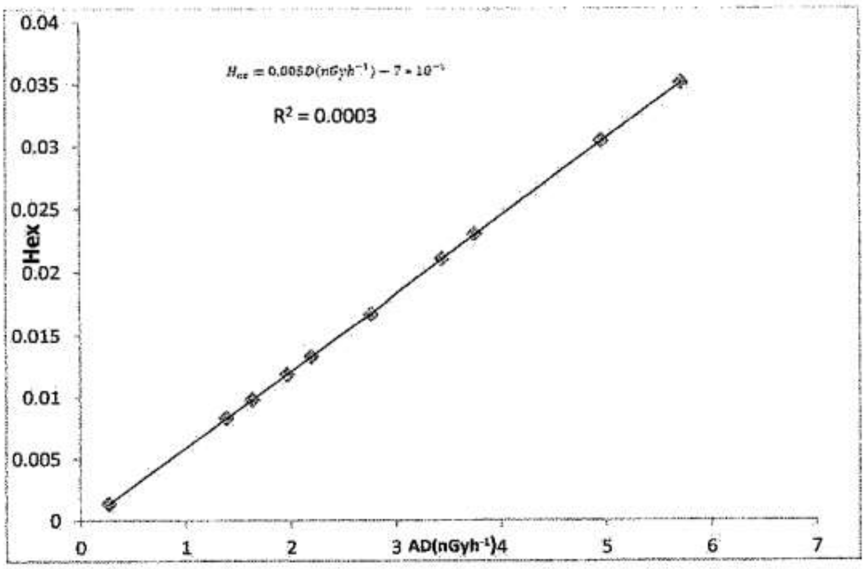

Fig. 11-9: The (Hex) as a function of (D (nGyh-1)).

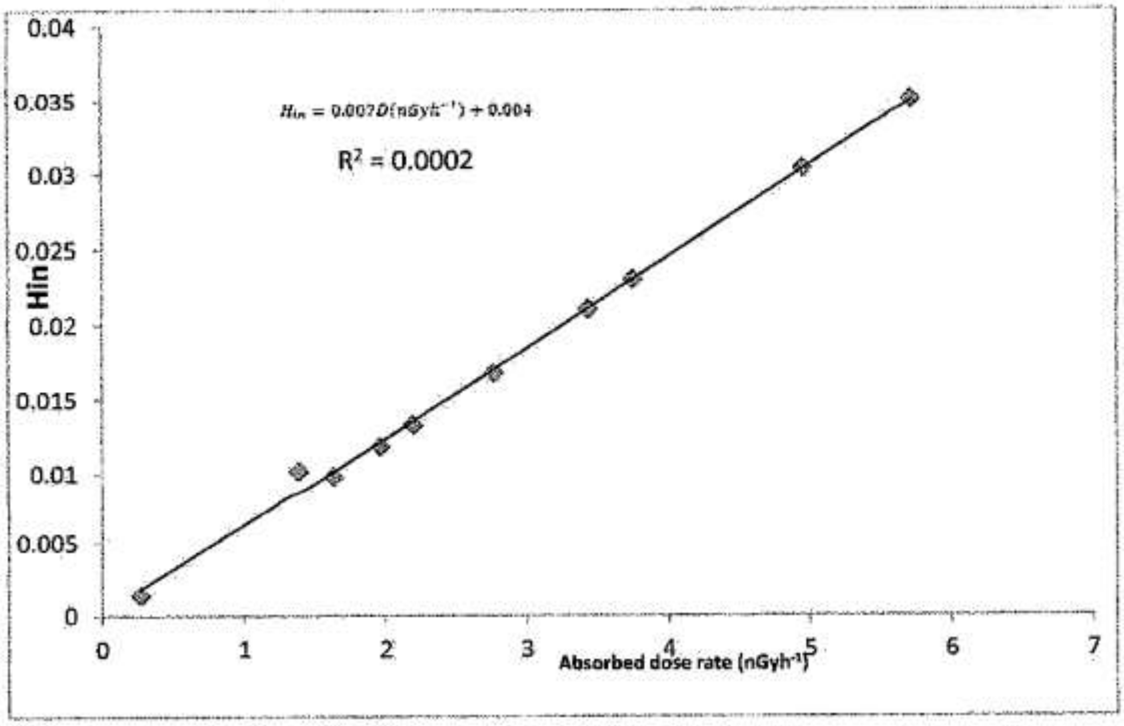

Fig. 11-10: The (Hin) as a function of (D (nGyh^{-1})).

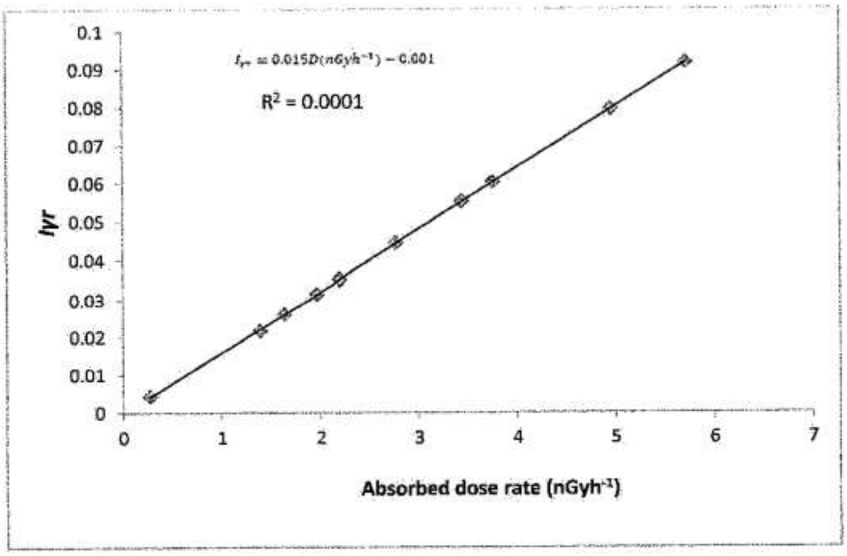

Fig. 11-11: The gamma level index (lyr) as a function of (D (nGyh-1)).

1-12 Conclusions

The conclusions of this work are as following:

The natural radionuclides concentrations were measured in this study for soil samples. The measured values are within the worldwide average concentrations. This can be explained by what Al-Amirya city ails the presence of a large underground water and sewage water underneath the soil or as a result of its abundance in the earth crust. This implies that the chances of having cancer by the populace in general are insignificant. Therefore, soil from these areas of Al-Amirya city does not effect on the health and safe.

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