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Measuring the level of Radioactive contamination of selected samples of Sugar and Salt available in the local markets in Najaf governorate / Iraq

To cite this article: Shatha F. Alhous *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **928** 072097

Measuring the level of Radioactive contamination of selected samples of Sugar and Salt available in the local markets in Najaf governorate / Iraq

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Abstract. Natural radioactivity has attracted a lot of attention in the world due to its crucial role in human safety. Sugar is compound, which is the generic name for sweet, soluble carbohydrates, many of which are used in food while salt is commonly used as a condiment and food preservative. Sugar and salt are very important for human beings, as well as their proven benefits to the general health of human beings. Therefore, the measurement of natural radioactivity is a critical because of its direct impact on human safety. In this research, quantification has been made of natural radionuclide concentrations using NaI(Tl) gamma-ray spectrometry. The analyses of samples reveal the mean activity concentrations of ^{226}Ra, ^{232}Th, ^{40}K and $\mathcal{R}a_{eq}$ are found to 5.833±1.008, 5.922±0.721 ,138.656±0.826, and 24.980(Bq.Kg^{-1}), respectively .also, calculated I_α, I_γ and H_{in} the values were less than one, it was clear that the ratio of three nuclides concentrations were higher than internationally allowed limits. the estimated annual gonadal equivalent dose (AGED) resulting with an average 86.321*10^{-3}(mSv.y^{-1}) where lower than globally limits. The data were statistically processed and Pearson's factor with p–value were calculated for concentrations of ^{226}Ra, ^{232}Th and ^{40}K with annual ingestion dose for these nuclides where correlations of ^{226}Ra were more a high increase statistical significance, direct, and positive with other parameters .The consumption of sugar and salt for adult, children and infant , where found the maximum value of cancer risk (ELCR) 0.2421*10^{-3} in adult for consumption of sugar while the minimum value 0.0005*10^{-3}in infant from consumption of salt ,which is less than the global value 2.5*10^{-3} that assessed by the united nations scientific committee on the effects of atomic radiation to be due to food and water intake.

keywords: Hazard indices , AGED , ELCR , sugar ,salt.

1.Introduction

Natural radionuclide concentrations in environmental samples varies according to geographical and geological factors radionuclide's are found throughout nature and it exist in the soil ,water and food ,these radionuclide's have half-lives that are approximately Earth's age or greater (about four to five billion year) [1]. The radioactivity present on air or in the agricultural land and soil may moves to the crops grown on it .However, that an amount of some radioactive elements find their way directly to human[2]. Most importantly for the ingestion dose comes from the radionuclides and their progeny. Ingestion involves the intake of the radionuclides through water and food (considering that sugar and salt are found in most foods) [3]. Where sugar is found in the biscuit cakes, candy and other sweets also it is added to many processed products foods such as ketchup, processed meats, biscuits, bread, soups, cereals .. .etc. .either for infant most processed foods contain sugar or lactose where naturally present in milk and dairy products[4]. There is no constant dietary for sugar in infants and children due to the varied desire of them to eat sugars .Also, some foods always contain a high percentage of salt because of the way they are made, while others, such as bread and breakfast cereals, contribute to a lot of salt in the food, and this is not because these foods are always rich in salt but daily consumption is much[5]. The ingested radionuclides which concentrated in certain parts of the body , for examples, ^{226}Ra accumulated in human kidney ,^{232}Th in liver and skeleton tissues and ^{40}K in muscles ,sedimentation of large quantities of these radio nuclide in particular organs will affect the health condition of human such as weakening the immune system[6] , induce various types of diseases and finally the increase in mortality rate the radionuclide present the most risk to human health ,so it is important to understand effects of radionuclide movable through foods and drinks[7] .Sugar and salt intake varies widely across the globe, depending on environment , food quality and cultural dietary preferences, moreover, accurate estimates of sugar and salt consumption are not easy to obtain since there are considerable individual variations, as well as many seasonal foods and many regional consumption differences[8] .The reference dose level (RDL) of the committed effective dose was estimated to be 0.3 (mSv.y) by UNSCEAR in its guidelines for ingestion in food and water[9, 10]. The 0.3 (mSv) (RDL) is also equivalent to 30 % of the dosage level (1 mSv) recommended by both the International Commission on Radiological Protection (ICRP, 1991) and the International Basic Safety Standards (IAEA, 1996) for members of the population[11]. Therefore, there are many studies on sugar and salt because the issue is of great importance to investigate the possible radionuclides consumed in different parts of the world for example, a study of radionuclide concentrations and risk factors for different salt samples in Egypt [12]. This work investigates the natural and man-made radionuclides in foodstuff material as sugar and salt consumed by Iraqi Kurdistan region population Erbil.The measurements were carried out by using a high efficiency NaI(TI) gamma-ray spectrometer [13].Some different salt samples were collected from the local markets in Iraq for the purpose of identifying the most radioactive species using a detector NaI (Tl) [14]. Important objectives of this study were to quantify the presence of natural radionuclide in some samples of sugar and salt in markets of Najaf / Iraq , since sugar and salt are famous among all ages, therefore, sugar and salt concentrations must be carefully measured to predict any potential danger to humans .The primary purpose of this study is to determine the natural specific activity and to estimate the radiation hazard indices namely radium equivalent activity (R_{aeq}), representative level index ($I\gamma$),(I_{α}) , effective dose rate (D_{eff}), internal hazard index (H_{in}) ,Pearson's correlation with P-value , annual Gonadal equivalent dose (AGED) and cancer risk ($ELCR$) in sugar and salt samples.

2.Methodology

2.1.Sample Collection and Preparation

This study was conducted on sugar and salt consumed by the overall public in Najaf governorate, Iraq. Sixteen types of sugar and salt (local and imported), as shown in table (1).To determine the concentration of radionuclides in the sugar and salt, samples were immediately brought to the laboratory for preparation and storage. Each sample was with weight (500 gm), placing the samples in a tightly closed plastic container, then storing them separately for (35) day to allow a radiative equilibrium between 226Ra and then 232Th and short-lived degradation products[15]. Radionuclides of 226Ra, 232 Th and 40K were measured in as sugar and salt samples using NaI (Tl) gamma ray spectrometer detector.

Table1. List of sugar and salt samples used in the present study

ID	Name of the sample(Sugar)	origin	ID	Name of the sample(Salt)	origin
Su_{01}	Iraq	Iraq	Sa_{01}	Nawras	Turkey
Su_{02}	Khazra	Iraq	Sa_{02}	Zer	Turkey
Su_{03}	Alosra	Saudi	Sa_{03}	Al-Ameen	Iraq
Su_{04}	Kasih	Jordan	Sa_{04}	Solty	Saudi
Su_{05}	Alrahmoun	Syria	Sa_{05}	Korjia	Turkey
Su_{06}	Safa	Emirates	Sa_{06}	Salva	Iran
Su_{07}	Top-Top	Saudi	Sa_{07}	Al-mansour	Iraq
Su_{08}	Etihad	Iraq	Sa_{08}	Pousan	Iran

2.2.Statistical Analysis

Statistical descriptions were performed using SPSS by windows system, standard version 20.0. analysis of the data was carried out by frequency distributions (Pearson correlation) to assess the statistical significance depending on P-value in all parameters measured in the three nuclides in sugar and salt samples.

2.3.Gamma spectrum analysis

The concentration of radioisotopes present in the sugar and salt such as and ^{226}Ra, ^{232} Th and ^{40} K were determined using the gamma ray spectroscopy technique on the high ability of this radiation to penetrate different materials. This spectrometer consists of a NaI(Tl) luster detector with crystal dimensions (3"x 3"), supplied by Alpha spectra, Inc.-12I12/ 3, and equipped with a multi-channel analyzer (MCA) (ORTEC-Digi base) with a range of 4096 channel connected to ADC (analog to digital converter), through the interface. Measurements and spectroscopy are calculated using the MAESTRO -32 software on a windows computer .An energy calibration for this detector was performed with standard sources ^{22}Na,^{60}Co and ^{137}Cs.To reach the lowest radiation background , the detector was protected by a cylindrical lead shield as shown in figure (1).

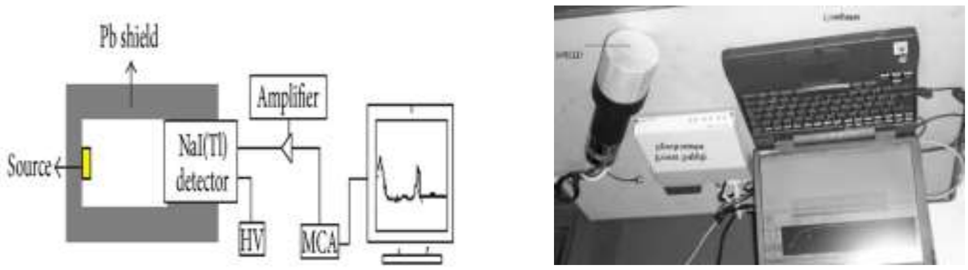

Figure 1. System detector gamma ray spectroscopy (3 "x 3") NaI (Tl)

3.Calculation of concentration of Radionuclide and Hazard indices

3.1. Concentration of Radionuclides

The radionuclide concentrations of ^{226}Ra, ^{232}Th and ^{40}K were calculated in a unit of (Bq.kg^{-1}) using the equation(1) [16]:

$$A_n = \frac{(C_n - C_b)}{t \varepsilon_\gamma I_\gamma m_s} \quad (1)$$

Where$\mathcal{A}_n$: is the specific activity of each radionuclide in(Bq.kg^{-1}), C_n: the count rate in CPS for sample, C_b: the count rate in CPS for background, t: is the checking time , ε_γ : detection efficiency, I_γ:emission probability of γ:ray , m_s :is the mass of the sample in (Kg).

3.2.Hazard Indices

The relationship between natural radionuclides can be determined ^{226}Ra,^{232} Th and ^{40} K and the risks resulting from them by a set of indicators. In this study, excess life-time cancer risk (ELCR), annual gonadal equivalent dose (AGED) and nine hazard indicators were calculated as follows:

3.2.1.The radium equivalent: activity (Ra_{eq})

It is used to describe gamma output from different mixtures of Radium, Thorium and Potassium in substances. It was calculated using special equation depending on activity concentrations $\mathcal{A}_{Ra}.\mathcal{A}_{Th}\mathcal{A}_K$ for ^{226}Ra, ^{232}Th,and ^{40}K respectively[16].

3.2.2.The internal hazard indices ($\mathcal{H}_{in}$)

It is one of the internal risk factors and calculate from activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K.values of ($\mathcal{H}_{\text{in}}$) should be less than unity in order not to pose a threat of the population [17].

3.2.3. Representative Alpha index(I_α)

The excess Alpha radiation due to the Radon inhalation originating from the sugar and salt samples were assessed through Alpha index, must be little than one. Alpha index (I_α) was calculated as follow [16, 18, 19]:

$$\text{I}\alpha = \frac{\mathcal{A}_{Ra}}{\mathbf{200}} \quad (2)$$

3.2.4. Representative gamma index(Iγ)

This indicator was used to calculate the risk arising from gamma radiation associated with radioactive natural nuclei in the studied samples and calculated from equation depending on activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K [16] .Its value must be less than one in order not to causes any risk to human health.

3.2.5.The annual effective dose

Equivalent from outdoor terrestrial gamma radiation was [16, 20]:

$$D_{eff} = \text{Outdoor dose}(\text{nGy. h}^{-1}) * 0.7(\text{Sv .Gy}^{-1}) * 8760(\text{h y}^{-1}) *0.2 \quad (3)$$

While for indoor exposure, by using an occupancy factor of 0.8, the annual effective dose equivalent was:

$$D_{eff1} = \text{Indoor dose } (\text{nGy. h}^{-1}) * 0.7\ (\text{Sv.Gy}^{-1}) * 8760\ (\text{h.y}^{-1}) \times 0.8 \quad (4)$$

3.2.6.Annual Gonadal Equivalent Dose (AGED)

The gonads, the bone marrow and the bone surface cells are considered as organs of one of the important things that UNSCEAR has attached great importance because of their sensitivity to radiation. An increase in (AGED) has been known to affect the bone marrow, causing destruction of the red blood cells that are then replaced by white blood cells, The equivalent annual dose of gonads (AGED) from ($\mathcal{A}_{\text{Ra}}.\mathcal{A}_{\text{Th}}\mathcal{A}_{\text{K}}$)activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K, respectively ,then we would must calculate annual gonadal equivalent dose for sugar and salt samples [21].

4. annual ingestion dose and Excess lifetime cancer risk

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The annual ingestion dose(E_{ING}) for human was coming from consumption of sugar and salt, the (E_{ING}) was calculated using following equation given by [22, 23]:

$$E_{ING} = A_I * I_P * FDC_{ING} \quad (5)$$

Where E_{ING} :is the annual ingestion dose ($mSv.Bq^{-1}$), A_I :is the activity concentration ($Bq.Kg^{-1}$) of the investigated radionuclides in the sugar and salt , I_P: is the consumption rate ($Kg.y^{-1}$) and $FDC_{ING:}$ is the ingestion dose coefficient of the ^{226}Ra, ^{232}Th and ^{40}K which was represented in table(7) UNSCEAR(2000).

Cancer risk due to radiation effects which is called excess lifetime cancer risk (ELCR) can be calculated from the following equation [24].

$$ELCR = AEDE * LS * RF \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

AEDE: The average Annual Effective Dose Equivalent.

LS: is a mean life span for adult (50 years),for children (10 years) and infant (less than 2 year).

By offsetting these variables we will get the (ELCR) of ^{226}Ra, ^{232}Th and ^{40}K in the sugar and salt samples .The value of risk factor (RF) for stochastic effects in the population is 0.05 per Sievert as recommended by ICRP [25]. By using equation (6) to estimate the risk cancer for an adult ,children and infant in sugar and salt samples.

5.Result and Discussion

The concentration activity of ^{226}Ra, ^{232}Th and ^{40}K sixteen samples of sugar and salt available in the Iraqi market were measured using NaI(Tl) gamma-ray spectrometry .The results of the natural radioactivity are presented in table(2),the maximum concentration avtivity of ^{226}Ra, ^{232}Th were found in (Su_{03}) from 22.373±2.385 ($Bq.Kg^{-1}$), 10.049±0.971 ($Bq.Kg^{-1}$),respectively, which was the Saudi sugar Alosra (white sugar), it could be that the additives are used to filter the sugar from impurities In addition to the nature of the soil where sugar cane is grown, while the maximum concentration activity of ^{40}K was found 239.981±8.150 ($Bq.Kg^{-1}$) from in (Sa_{08}) Iranian Pousan salt, the reason may be the method of treating salt extracted from mines (mineral salt) and using it to produce food salt by dissolving it in water and the degree of purification from the sediments .The minimum value of ^{226}Ra was found in (Sa_{02}) Zer Turkish salt, and minimum value of ^{232}Th ,^{40}K were found in the Iraqi Khazra sugar (Su_{02}) and the Saudi Top -Top sugar (Sa_{07}) ,respectively. Concentrations of radionuclides found in sugar and salt samples do not exceed the internationally recommended limits.
The ratios were used to provide a simple explanation of the relationship between the three natural radionuclide concentrations. The ratios of (^{232}Th - ^{226}Ra) in table (3) show that there is a convergence between the values of Thorium and Radium at a rate of 4.862 but both are lower than concentration of ^{40}K concentrations due to the large increase in Potassium concentration. also, the ratio between the concentrations of (^{40}K - ^{226}Ra) Radium is found to be much lower than potassium ,also the ratio (^{40}K - ^{232}Th) is confirm the big difference between concentrations Potassium and Thorium , concentration ratios are (^{232}Th - ^{226}Ra) , (^{40}K - ^{226}Ra) and (^{40}K - ^{232}Th) with an average 4.862, 98.204 and 36.422 respectively .where all three ratios were well above the average worldwide UNSCEAR(2000).
From table(4), we find that the highest values of Iα, I_γ and $\mathcal{R}a_{eq}$, in Sample (Su_{03}) with values 0.111, 0.384 and 52.303 ($Bq.Kg^{-1}$) respectively , but the lower value of Iα , $\mathcal{R}a_{eq}$were found in Sample (Su_{02}) with value 0.084 , 10.142 ($Bq.Kg^{-1}$) respectively ,and the lower value of I_γ in sample (Sa_{05}) .Also we note the highest values at the sample (Su_{03}) , which is the Saudi sugar Alosra (white sugar), and as we mentioned earlier, the reasons may be the additives for the purpose of liquidation, all values

for these three indicators were less than the permissible limit, note that the relationship between I_γ and Iα is shown in figure (2).

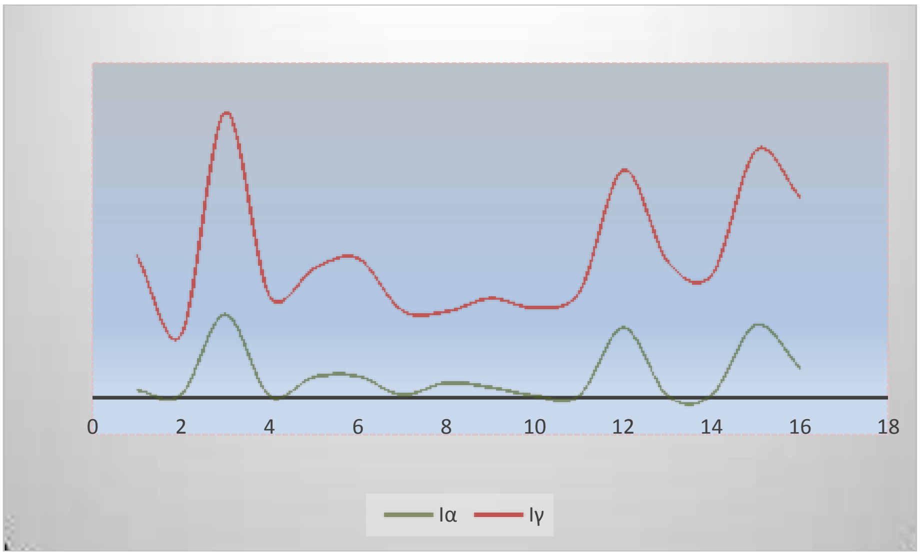

Figure 2. Comparison between Alpha index(I_α) and Gamma index(Iγ)

Table (5).All parameters; annual ingestion dose of(^{226}Ra , ^{232}Th and ^{40}K) ,H_{int} have a maximum value at the sample (Su_{03}) , which is the Saudi sugar Alosra (white sugar) with values(0.0281, 0.064698 and 0.035065) (mSv.y^{-1}), 0.201,respectively .While the minimum values of annual ingestion dose of ^{226}Ra , ^{232}Th were found in (Sa_{05}) with values 5.01E-05, 0.002413(mSv.y^{-1}), respectively ,and the minimum value of annual ingestion dose of ^{40}K 0.001079 (mSv.y^{-1})in sample (Sa_{03}) while the minimum value for internal hazard indices H_{int} in sample (Su_{02}) with values 0.029.
It is important to point out that the gonads has a sensitivity to radiation ,an increase in (AGED) causing negative health complications so it is necessary to calculate the annual the equivalent annual dose of gonads (AGED) from ^{226}Ra, ^{232}Th and ^{40}K concentration, and found its maximum value in (Su_{03}) equal to 174.587(mSv.y^{-1}) while the minimum value 39.520*10^{-3} (mSv.y^{-1}) in sample (Su_{02}), these values were safe and within the global recommended limits[21] .

Table (6) explains the relationship between analysis of laboratory data and natural radionuclide concentrations and hazard indicators for the studied sugar and salt samples. Where we found Pearson's correlation was very direct strong relation and positive between the Potassium, Radium and Thorium concentrations with their counterparts. While Pearson's correlation showed significant middle positive where it was statistically significant (p -value < 0.05) it turns out that there is a high increase statistical significance between(^{40}K , ^{226}Ra) also (^{226}Ra ^{40}K). while Pearson's correlation for ^{40}K ,^{232}Th variables indicates was non-significant which mean high decrease statistical significance (p -value = 0.986) , inverse relationship .There is no relationship between ^{226}Ra and ^{232}Th there is non-significant which mean high decrease statistical significance (p -value > 0.05),the relationship between ^{232}Th and ^{226}Ra direct positivity is weak and there is non- statistical significance .Show up annual ingestion dose of ^{40}K a positive relationship is weak with concentration activity of ^{40}K and ^{226}Ra while the relationship is inverse with ^{232}Th and there is non- statistical significance (p -value > 0.05) with these nuclides .Which relationship among annual ingestion dose of ^{226}Ra a positive direct and weak with ^{40}K and ^{232}Th and there is non- statistical significance (p -value > 0.05) with these nuclides, while the

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relationship is positive direct strong with ^{226}Ra , high increase statistical significance ,which relationship among annual ingestion dose of ^{232}Th a positive direct and very weak and non- statistical significance (p -value > 0.05).

From table (8) we note that the maximum value of the risk cancer ($ELCR$) due to consumption of sugars for adults as a result of the daily use of sugar in their diet where it is known that adults eat sugar in different foods such as drinks and sweets where we Where we noted that the risk of cancer for adults > children> infants) , also we noticed the lowest value of the risk of cancer is in the salt for infants, and that is because the infants are mainly dependent on mother's milk or formula milk and eating salt with foods like soups is relatively few, Where we noted that the risk of cancer for (adults > children> infants) .Finally we found the maximum value of cancer risk 0.2421*10^{-3}(mSv.y-1)in adult for consumption of sugar while the minimum value 0.0005*10^{-3}(mSv.y^{-1}) in infant, from the results that we obtained that the risk cancer of developing is less than the internationally recommended limits therefore, sugar and salt samples are healthy for consumers.

6.Conclousion

The present study estimated the natural radionuclides of ^{226}Ra, ^{232}Th and ^{40}K by means of gamma ray spectrometry in different samples of sugar and salt that are regularly consumed by the population of Najaf governorate/ Iraq. From our results are confirm that the relatively high concentrations of ^{40}K in sugar and salt samples from Najaf markets are still considered very low from a radiological protection perspective. Annual gonadal equivalent dose (AGED) was calculated to evaluate the radiation hazard of natural radioactivity it was within the permissible limits .also estimated value of cancer risk was significantly less than the ICRP 2.5 × 10^{-3} based on annual dose limit of 1(mSv) for general public. Which mean the average values of all samples is safe healthy ,which confirmed from the average radiation dose of 0.29 (mSv.y^{-1}) received per capita world through ingestion of natural radionuclides of consumption of food reported by UNSCEAR (2000) , as well as it has been much below the dose limit of (250–400)*10^{-3} (mSv .y^{-1}), recommended by WHO [20]. Finally we can say, sugar and salt samples pose practically no radiological health concern.

Table2. Specific Activity (Bq.Kg^{-1}) in some types of sugar and salt studied

ID	Specific Activity Concentration		
	^{226}Ra	**^{232}Th**	**^{40}K**
Su_{01}	2.033±0.719	6.950±0.807	163.862±6.734
Su_{02}	0.762±0.440	0.657±0.248	109.611±5.508
Su_{03}	22.373±2.385	10.049±0.971	202.061±7.478
Su_{04}	0.508±0.859	5.071±0.690	124.557±5.871
Su_{05}	5.593±1.1925	6.292±0.768	110.441±5.528
Su_{06}	5.847±1.219	2.066±0.440	192.649±7.302
Su_{07}	0.762±0.440	6.950±0.807	64.216±4.216
Su_{08}	4.067±1.016	2.629±0.496	94.110±5.103
Sa_{01}	2.796±0.843	5.729±0.733	87.190±4.912
Sa_{02}	0.508±0.359	5.823±0.739	89.404±4.974
Sa_{03}	0.542±0.316	8.547±0.895	79.440±4.689
Sa_{04}	18.814±2.187	4.977±0.683	197.078±7.385
Sa_{05}	0.508±0.024	4.790±0.670	198.738±7.416
Sa_{06}	0.762±0.440	8.922±0.915	106.566±5.431
Sa_{07}	19.577±2.230	9.674±0.953	158.603±6.625
Sa_{08}	7.881±1.415	5.635±0.727	239.981±8.150
Max.	22.373±2.385	10.049±0.971	239.981±8.150
Min.	0.508±0.359	0.657±0.248	64.216±4.216
Ave.	5.833±1.008	5.922±0.721	138.656±0.826

Worldwide [22] UNSCEAR2000	35	30	400

Table3. The ratio of ^{226}Ra, ^{232}Th and ^{40}K in the sugar and salt samples under study

ID	The ratio of specific activity of ^{226}Ra, ^{232}Th and ^{40}K		
	^{232}Th - ^{226}Ra	^{40}K - ^{226}Ra	^{40}K - ^{232}Th
Su_{01}	3.417	80.565	23.577
Su_{02}	0.861	143.714	166.835
Su_{03}	0.449	9.031	20.105
Su_{04}	9.967	244.805	24.560
Su_{05}	1.124	19.745	17.552
Su_{06}	0.353	32.944	93.233
Su_{07}	9.112	84.195	9.239
Su_{08}	0.646	23.134	35.785
Sa_{01}	2.048	31.176	15.218
Sa_{02}	11.451	175.819	15.353
Sa_{03}	15.769	146.568	9.294
Sa_{04}	0.264	10.475	39.590
Sa_{05}	9.419	390.831	41.490
Sa_{06}	11.698	139.722	11.943
Sa_{07}	0.494	8.101	16.394
Sa_{08}	0.715	30.448	42.585
Max.	15.769	390.831	166.835
Min.	0.353	8.101	9.239
Ave.	4.862	98.204	36.422
Worldwide[26].	0.86	11.43	13.33

Table4. Radiation hazard indices of Gamma and Alpha rays in the sugar and salt Samples under study

ID	I_α(Bq.Kg^{-1})	I_γ(Bq.Kg^{-1})	$\mathcal{R}a_{eq}$(Bq.Kg^{-1})
Su_{01}	0.010	0.192	24.590
Su_{02}	0.003	0.084	10.142
Su_{03}	0.111	0.384	52.303
Su_{04}	0.002	0.137	17.352
Su_{05}	0.027	0.173	23.096
Su_{06}	0.029	0.188	23.636
Su_{07}	0.003	0.117	15.646
Su_{08}	0.020	0.116	15.075
Sa_{01}	0.013	0.134	17.703
Sa_{02}	0.002	0.121	15.719
Sa_{03}	0.002	0.142	18.847
Sa_{04}	0.094	0.306	41.107
Sa_{05}	0.0020	0.183	22.661
Sa_{06}	0.003	0.165	21.727
Sa_{07}	0.097	0.332	45.623
Sa_{08}	0.039	0.268	34.418
Max.	0.111	0.384	52.303
Min.	0.0020	0.084	10.142
Ave.	0.0291	0.190	24.980
Worldwide[27]	< 1	< 1	< 370

Note: error range was in most cases within 6%

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Table5.The annual ingestion dose ,the annual gonadal equivalent dose and the internal hazard indices in sugar and salt Samples under study

ID	Annual ingestion dose of ^{226}Ra , ^{232}Th and ^{40}K (mSv.y^{-1})				
	^{226}Ra	**^{232}Th**	**^{40}K**	**AGED*10 $^{-3}$**	**H_{int}**
Su_{01}	0.0025	0.044742	0.028436	86.788	0.071
Su_{02}	0.0009	0.00423	0.019022	39.520	0.029
Su_{03}	0.0281	0.064698	0.035065	174.587	0.201
Su_{04}	0.0006	0.032649	0.021615	61.881	0.048
Su_{05}	0.0070	0.040506	0.019166	78.262	0.077
Su_{06}	0.0073	0.013302	0.033432	87.198	0.079
Su_{07}	0.0009	0.044744	0.011144	51.572	0.044
Su_{08}	0.0051	0.01693	0.016332	53.113	0.051
Sa_{01}	0.0002	0.002886	0.001184	59.967	0.055
Sa_{02}	5.01E-05	0.002933	0.001214	53.985	0.043
Sa_{03}	5.34E-05	0.004305	0.001079	62.345	0.052
Sa_{04}	0.0018	0.002507	0.002676	140.825	0.161
Sa_{05}	5.01E-05	0.002413	0.002698	83.997	0.062
Sa_{06}	7.52E-05	0.004494	0.001447	73.115	0.060
Sa_{07}	0.0019	0.004873	0.002154	150.731	0.176
Sa_{08}	0.0007	0.002839	0.003258	123.263	0.114
Max.	0.0281	0.064698	0.035065	174.587	0.201
Min.	5.01E-05	0.002413	0.001079	39.520	0.029
Ave.	0.0036	0.0180	0.012495	86.321	0.0715

Note: error range was in most cases within 5%

Table6. Pearson Correlation with its P-value for all parameters studied

Laboratory data				
Variables	**Correlations**	**^{40}K**	**^{226}Ra**	**^{232}Th**
^{40}K	Pearson Correlation	1	0.563*	-0.005
	P value		0.023	0.986
^{226}Ra	Pearson Correlation	0.563*	1	0.376
	P value	0.023		0.151
^{232}Th	Pearson Correlation	-0.005	0.376	1
	P value	0.986	0.151	
Annual ingestion dose of ^{40}K	Pearson Correlation	0.224	0.147	-0.205
	P value	0.404	0.588	0.447
Annual ingestion dose of ^{226}Ra	Pearson Correlation	0.338	0.611*	0.277
	P value	0.201	0.012	0.298
Annual ingestion dose of ^{232}Th	Pearson Correlation	0.007	0.200	0.311
	P value	0.979	0.459	0.241

* Correlation is significant at the 0.05 level (2-tailed).

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** Correlation is significant at the 0.01 level (2-tailed).

Table 7. Dose convection factors fordiffernt radionuclides in (nSv.Bq^{-1})[UNSCEAR 2000]

Nuclides	infant	children	adult
^{40}K	42	13	6.2
^{226}Ra	960	800	280
^{232}Th	450	290	230

Table8. Consumption rate and cancer risk in sugar and salt samples for adult, children and infant

sample Categories	Age	Consumption rate[28] (Kg.y^{-1})	Consumption rate[28] (tsp.y^{-1})	cancer risk (mSv)*10^{-3}
Sugar	Adult	27.99	6997.51	0.2421
Sugar	Children	9.125	2281.25	0.0337
Sugar	Infant	1.095	273.75	0.0014
Salt	Adult	2.19	547.5	0.0232
Salt	Children	1.46	365	0.0065
Salt	Infant	0.365	91.25	0.0005

Acknowledgements

Many thanks and praise to Dr. Murtadha Sh. Asoowd in department of Physics, college of education, university of Al- Qadisiyah, Iraq for clarifying several points in this research.

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