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MEASUREMENT OF RADIOISOTOPE CONCENTRATIONS IN HOSPITAL SEWAGE

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Abstract– The purpose of the study is to know the activity concentrations of naturally occurring radioactive isotopes of (238U, 232Th, and 40K) in samples collected from the wastewater treatment system of Iraqi hospitals - in 2021, and using gamma ray spectrometry technology, which showed Results (The highest value of 214Pb in the sample N3 after treatment there is an increase (0.16 ± 0.6211) higher than the global determinant (0.1Bq/l) *, the highest value of 203Hg (0.029 ± 0.103) in the sample N4, the value is higher than the global determinant, while the rest of the isotopes it was less than the international limit. The highest value of 212Pb in the sample N3 before and after treatment there was an increase, as well as Av before and after treatment (1±0.1) (0.7±0.78) higher than the international limit (0.5Bq/l). The highest value of 224Ra in N3 sample (0.79 ±1) is higher than the international limit (0.6Bq/l) before treatment... The rest of the isotopes were less than the international limit Radius equivalent (Raeq), absorbed dose rate, annual effective dose (internal and external), external risk index (Hex), internal risk index (Hin), and gamma index (Ig) mean values were determined. The Radiation Hazard Index has been determined to be safe for the general populace as well as the environment. The issue of determining radioisotope concentrations in hospital wastewater before and after treatment has never been addressed in previous research.

INTRODUCTION

Soil, air, water, and the human body all contain radionuclides. Every day of our lives, we breathe and swallow radionuclides, and radioactive materials have been present on Earth since its beginning. Internal and exterior human exposure are both protected by the natural occurrence of radioactivity in soil and water. The radioactive elements found in nature are usually derived from a "cosmic" or "terrestrial" source (Australia, 2003). Light and radio waves are examples of radiation. It is "ionizing" radiation that is being studied. Ionizing radiation can cause a substance to become electrically charged or ionize when it travels through it. Electrical ions from radiation can interfere with normal biological processes in living tissues, causing harm or even death. of cells that live Ionizing radiation cannot be seen or felt, but it can be detected and measured in very minute levels with simple radiometric instruments, and it has long been recognized that it causes cancer. Human tissue is harmed. To create an appropriate framework for radiation protection, various private organizations have been formed in response to the necessity to limit exposure. Ionizing radiation has different biological consequences depending on the kind, intensity, and energy of the radiation (Nations, 2000). The radiation dose received by the tissue is one indicator of the risk of biological harm. [Effective dose unit (Sievert)]. The radiation doses present are commonly represented in millisieverts (mSv) or microsieverts (Sv), which are one-thousandth and one-millionth of sieverts, respectively, when the number of sieverts is considerable. Radiation protection techniques are employed all around the world. ICRP Any exposures above typical background radiation should be kept to a minimum, while not exceeding individual dose limits. Radiation Workers' Maximum Single Annual Dose is an average of 5 years (20 mSv) and for the public (1 mSv per year). The most common radionuclide emitted into the human body through external exposure is 235U.

232Th and 40K (UNSCEAR, 2000). Surface waters are more susceptible to pollution in different ways due to human and agro-industrial effluent events and activations, as well as pollution from soil leaching as a result of rains

Measurement of natural background level levels of 238U, 232Th radioactivity, activities of primitive radionuclide 40K, and artificially created fission product 137Cs are essential parameters for determining the natural radioactivity concentration level and its behavior in the environment (Matiullah, *et al*., 2004).

The aim of this study was to determine the specific activity of 238U, 232Th and 40K radionuclides in water samples and to evaluate possible health hazards from natural sources of radiation from the wastewater treatment system of Iraqi hospitals

MATERIALS AND METHODS

Sample Collection and Preparation

Where wastewater samples were taken before and after hospital treatment systems and placed in a nine-liter bottle, where the bottle was previously sterilized to avoid it in advance with distilled water and chlorine to avoid the presence of any contaminants inside that affect the samples and nitric acid is placed in it to preserve the radiation it contains. The sample will not interfere with the radiation components of the vial. The samples were placed in a special protective container to preserve them on the way to Baghdad.

Samples	Location hospital
N1. N1."	Al-Sadr
N2. N2."	AL - Sadiq
N3. N3."	AL- Ramadi
N4. N4."	Fallujah - Al
N5. N5."	AL - Husseini
N6. N6."	AL - Women's and Children's
N7. N7."	Al - Zahraa
N8. N8."	Al - Furat

Calibration of the energy detector

The energy detector is an initial step that must be done in order to find the relationship between the energy of the photon and the output amplitude of the pulse when using multiple radioactive sources, including cesium (Cs137), by emitting a photon energy of 662 KeV with radioactivity (The cobalt (Co60) emits a photon energy of (1332 Kev) and (1173KeV) with a radioactivity (37 kbq).The calibration was made using the (SPECTREJ) program found in the existing electronic calculator (Madkour, *et al*., 2013).

High purity germanium detector (HPGe)

The high purity germanium detector (HPGe) was used, which is a P-type semiconductor material detector made by GCD-model 40 190 N 1734-11, BSI (this detector operates at an operating voltage of 400 V). (With an efficiency (Efficiency) 40%). This type of detector cools nitrogen to -196 °C when operating the detector is surrounded by a lead wall with a thickness of (4.5 cm) background radiation and the dimensions of the crystal were 2 * 2 in)) and a thin layer of copper. Its thickness is 0.4 mm to attenuate X-rays resulting from the interaction of gamma rays with lead. The amplifier attached to the detector. This program is distinguished by its ability to calculate a single function that represents the full continuous component of the spectrum. The isolated peaks' areas are then computed by subtracting the calculated baseline from the experimental spectrum and then adding the net content of the channels that make up the peak period defined by SPECTREJ, a form of the high-purity germanium detector array. In this detector, the sample was placed inside the Marinelli Beaker vessel, and it was placed inside the detector for a period of 600 sec for the purpose of detecting radionuclides, the number of channels (6094) (Daza, *et al*., 2001).

Equation for calculating radioactivity (specific activity)

The specific effectiveness of the radionuclides is measured in the samples that were withdrawn from the selected hospitals, where a high-purity germanium system was used, emitting gamma rays, based on the strength of its penetration into materials, and the equation is:

$$A = \frac{\text{Nnet}}{\varepsilon.I\gamma.mt} \pm \frac{\sqrt{Nnet}}{\varepsilon.I\gamma.mt} \left[Bq.krg^{-1}\right] \text{.....(1—)}$$

Where each element in the equation is:

Nnet: represents the net area under the optical peak curve.

ε: represents the efficiency that is calculated for the gamma line at certain energies.

Iγ: represents the concentration factor of activity.

M: the mass of the model (Kg).

Hazard coefficients for gamma rays

Where the specific effectiveness of each of (Uranium U238)
(Thorium Th 232) is relied upon.
And (potassium k40), where the following is calculated:
D is the rate of dose absorption into the air at a height of one meter above the earth's surface in units of. μ Sv/ h (according to the following equation:-

$= (0.462A_{Ra} + 0.604A_{Th} + 0.0417A_{K})* 0.001+ 0.7\ h^{-1}D$ μ S.(2-

Where (AK, ATh, ARa) are the effective radioactivity concentrations of the radioactive elements
40K, 232Th, Ra 226) in (Bq kg^{-1}) units where (0.0417, 0.604, 0.462) are the conversion factors for the radioactive elements.
40K), 232Th, Ra 226) with the next unit (Bq kg^{-1}/ nGy $.hr^{-1}$
And (0.7 Sμ/Gy) represents a coefficient between the absorbed dose and the effective dose [8].
Calculating the radium equivalent (Ra eq) is the sum of the radioactivity concentration of the radioactive elements
(40K, 232Th, Ra 226).
Ra eq = A Ra + 1.43 ATh + 0.077 A K .. (3)
Where (AK, ATh, ARa) are the effective radioactivity concentrations of the radioactive elements

(40K, 232Th, Ra 226) in unit (Bq kg^{-1})

Expression (Raeq) by assuming that the maximum allowable value (the unit equals the upper limit of Raeq (370Bq/kg) A conversion factor was used to get the estimated annual effective dosage in humans.. (0.7Sv/Gy) which was used to convert the absorption rate to the equivalent of a human effective dose with outdoor 20% and 80% indoor occupancy using the following relationships
(AED)in(mSv/y)=D(nGy/h)×10-6×8760h/y×0.80×0.7Sv/Gy
(AED)out(mSv/y)=Dc^(nGy/h)×10-6×8760h/y×0.20×0.7Sv/Gy (4-)
External Annual Effective Dose (EAD)
The following relationship was used to calculate the external annual effective dose:
(5—) ……EAD= (0.92AU+1.1ATh+0.08AK)*(10-9Gy/h)*(0.7Sv/Gy) * * (24×365) h/y×0.8
Gamma Index (Icγ)
The following relationship was used to calculate the gamma activity coefficient (Ig) for water samples.

(A Ra)/150+(ATh)/100+(A K)/1500 .. (6)=γI

External (Hex) and Internal (Hin) Hazards of Radioactivity
Hazard Index H is defined as a radioactive coefficient used to determine the external radiation hazards
And the interior. The Hex and the Hin can be calculated using ex H ≤ 1 .

(A Ra)/370+(ATh)/259+(A K)/ 4810.....(7) = H ex

The internal exposure to radon 222Rn and the radioactive substance is controlled by the internal risk index (Hin) and is given by the connection
in H ≤ 1
(A Ra)/185+(ATh)/259+(A K)/4810..... (8) =
H in
Increased duration of cancer risk gives the lifetime probability of developing cancer at a certain exposure level, a value that shows the amount of extra malignancies present in a specific number of people when exposed to a carcinogen at a given dose (ElCR)

Table 1. Specific Activity Concentrations Bq / L sewage Befter treatment 238U (Bq / L)

Nt	^{226}Ra	^{214}Pb	^{214}Bi	^{218}Rn	^{137}Cs	K^{40}	^{203}Hg
N1	bdl	bdl	0.007±0.007	bdl	bdl	bdl	Bdl
N2	bdl	0.010±0.038	0.056±0.0253	bdl	0.020±0.082	bdl	Bdl
N3	bdl	bdl	0.021±0.0121	0.020±0.0117	bdl	0.071±0.0029	Bdl
N4	dlb	0.0146±0.0461	0.07±0.07	0.042±0.0188	bdl	bdl	0.103±0.029
N5	bdl	0.075±0.012	0.01±0.01	0.027±0.0135	bdl	bdl	Bdl
N6	bdl	bdl	bdl	0.020±0.012	bdl	bdl	0.079±0.025
N7	bdl	0.0245±0.00927	0.026±0.026	0.013±0.0096	bdl	0.073 ±0.074	Bdl
N8	± 0.10.4	bdl	0.007±0.007	0.027±0.0135	bdl	bdl	Bdl
M ax	±0.10.4	0.075±0.012	0.056±0.0253	0.042±0.0188	0.020±0.082	.073 ±00.074	0.103±0.029
Min	bdl	bdl	bdl	bdl	bdl	bdl	Bdl
0.05±0.01	Av	0.009±0.0015	0.007±0.003	0.019±0.01	0.0025±0.01	0.018±0.018	0.022±0.0061

ELCR = AEDE xDLx RF..... (9)

Since (AEDE): is the equivalent of the annual effective dose, which is calculated from the equation

AEDE = ADx1.23x10^{-3}

DL: Average human lifespan (estimated at 70 years)

RF: the risk factor in units (Sv-1) and the risk of developing a fatal cancer per sievert, and that low-dose radiation generates random effects, and the International Committee ICRP (60)

Actual value (0.05) for public exposure (Al-Nihmi *et al.*, 2020).

RESULTS AND DISCUSSION

From the Table * (1.2) the highest value of 214Pb in sample N3 after treatment there is an increase (0.16 ± 0.6211) higher than the global limit (0.1Bq/L) (Awadallah and Imran, 2007), the highest value of 203Hg (0.029 ± 0.103) in sample N4 while the rest

Table 2. Specific Activity Concentrations Bq / L sewage After treatment238U (Bq / L)

Nt	^{226}Ra	^{214}Pb	^{214}Bi	^{218}Rn	^{137}Cs	K^{40}	^{203}Hg
N1	bdl	bdl	0.014±0.01	bdl	0.115±0.02	bdl	bdl
N2	bdl	0.018±0.053	0.026±0.026	0.047±0.018	bdl	bdl	bdl
N3	0.8±0.19	0.621±0.16	bdl	bdl	bdl	bdl	bdl
N4	0.4±0.81	0.010±0.039	bdl	bdl	bdl	bdl	bdl
N5	bdl	0.0131±0.0043	0.0140±0.01	bdl	bdl	0.0829±0.0313	bdl
N6	bdl	bdl	0.021±0.0121	bdl	bdl	bdl	bdl
N7	0.306±0.1	bdl	0.026±0.026	0.120±0.0846	bdl	0.121 ±0.16	bdl
N8	0.14 ± 0.14	bdl	0.014±0.01	0.0271±0.0135	bdl	bdl	bdl
M ax	0.8±0.19	0.6211±0.16	0.0260±0.0260	0.120±0.0846	0.1151±0.0197	0.121±0.16	bdl
Min	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Av	0.1±0.034	0.082±0.0294	0.014± 0.0018	0.024±0.014	0.0144±0.0025	0.095±0.191	bdl

Table 3. Specific Activity Concentrations Bq / L sewage Befter treatment 232Th (Bq / L)

Nt	^{212}Pb	^{212}Bi	^{208}TI	^{228}Ac	^{232}Th	^{224}Ra	^{228}Th
N1	0.26±0.07	0.0666±0.0384	0.0531±0.0307	bdl	1±1	bdl	bdl
N2	0.13±0.049	bdl	0.1±0.04	bdl	2±3	bdl	0.0216±0.01248
N3	1±0.1	0.133±0.0544	0.1814±0.055	bdl	bdl	1±0.79	bdl
N4	bdl	bdl	0.1815±0.0547	0.0393±0.0227	bdl	bdl	2.142±0.762
N5	bdl	0.0612±0.0353	bdl	bdl	bdl	bdl	0.23±0.0617
N6	bdl	0.236±0.136	bdl	0.0524±0.0262	bdl	bdl	0.033±0.0233
N7	0.1474±0.05211	0.016±0.0111	0.0354±0.025	bdl	bdl	bdl	0.0154±0.011
N8	bdl	0.0079±0.0079	bdl	bdl	bdl	bdl	0.0155±0.011
M ax	1±0.1	0.236± 0.136	0.1814±0.055	0.0524±0.0262	0.5±0.3	1±0.79	2.142± 0.762
Min	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Av	0,067± 0.0204	0.0651±0.0057	0.068±0.055	0.011 ±750.0 6	0.0625±0.081	0.12±0.094	0.3 ± 0.0194

Table 4. Specific Activity Concentrations Bq / L sewage After treatment 232Th (Bq / L) 4

Nt	^{212}Pb	^{212}Bi	^{208}TI	^{228}Ac	^{232}Th	^{224}Ra	^{228}Th
N1	0.092±0.042	0.142±0.054	0.0116±0.0086	0.031±0.0154	bdl	bdl	1.354±0.511
N2	0.0737±0.037	0.09±0.044	bdl	0.052±0.026	bdl	bdl	1.149±1.149
N3	0.7±0.78	0.157±0.111	0.031± 0.011	bdl	bdl	bdl	bdl
N4	bdl	0.078±0.078	0.214±0.059	bdl	bdl	bdl	0.0232±0.0134
N5	0.39±0.0844	bdl	bdl	0.492±0.186	bdl	bdl	0.165±0.0522
N6	bdl	bdl	0.0531±0.031	bdl	bdl	0.1214±0.0594	0.0758±0.694
N7	bdl	bdl	0.330±0.0737	bdl	bdl	bdl	0.0154±0.011
N8	bdl	0.1577± 0.111	bdl	bdl	bdl	bdl	0.40 ±0.244
M ax	0.7±0.78	0.1577± 0.111	0.330±0.0737	0.49±0.186	bdl	0.0758±0.694	1.35±0.511
Min	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Av	0.098±0.01073	0.06±0.0475	0.079±0.1045	0.0718±0.0286	bdl	0.0096±0.086	0.2658±0.0268

The isotopes were less than the international determinant. The reasons for the increase for each of: - 214Pb lead has many uses, especially in lining the walls of x-ray rooms in hospitals. Elements of lead enter into the manufacture of dyes, while 203Hg mercury is the result of use in medicines and dental fillings. From Table 3.4, the highest value of 212 Pb in the sample N3 before and after treatment there is an increase, as well as Av before and after treatment (1 ± 0.1) (0.7 ± 0.78) is higher than the global determinant (0.5Bq/L) *, that the highest value of 224Ra (0.79 ± 1) in the sample N3) is higher than the global limit (0.6Bq/L) before treatment, while the rest of the isotopes were less than the international limit Hospitals. Elements of lead are used in the manufacture of dyes. As for 224Ra, radium is an isotope of the 232Th series and the reason for the increase in deposits of 224Ra.

From the results, we note the difference between the risk factors before and after treatment

- Raeq - (radium equivalent): where the Max Min values were respectively (27.69) (0.357) (30.23) (0.8111), although there is an increase, but it is less than the international standard
- Iγ (gama hazard);- where the Max Min values ” ” Œ”-were respectively (1.0047) (0.0052) (0.328) (0.0063), although there was an increase before treatment in the sample (N4) where the AV before treatment was less than the specified international standard, but after Processing is less than the specified international standard
- Hazard Index (internal and external hazard): where the values of Max Min, respectively (0.1294) (0.0013) (0.1129) (0.0009) are less than the specified international standard.
- Absorbe absorbed dose - where the Max Min values (20.24) (0.1517) (2.258) (0.36) were respectively less than the specified international standard
- Dose (annual effective dose) - where the Max Min values (0.037) (0.037) (0.092) (0.0003) are less than the specified international standard, respectively.
- Elcd*10^{-3} cancer incidence rate) - where the Max Min values were respectively (0.322) (0.001) (0.72) (0.0014) where there was an increase in the sample N3 more than the international limit, due to deposits but AV after treatment Less than the international standard
- Ead (External Annual Effective Dose) - Where the values of Max Min, respectively (0.00136) (0.04839) (0.0219) (0.00205) are less than the specified international standard (Mahur *et al.*, 2008).

CONCLUSION

Pollution with radioactive elements after (16 samples) were withdrawn from (8) sewage water hospitals before and after the treatment process, as the examination process was to find out the natural radioactivity in these samples. Radioactive isotopes within the Th-232 Th series of thurium, where it was found through the results that there was an increase in the two elements of lead belonging to the series Pb 214, Pb 212 and 224Ra. Radium is an isotope within the 232 Th series.

Gamma ray radiation risk factors: After calculating the risk factors before and after treatment for both, the gamma ray absorption rate (Dγ) and the equivalent dose of radium (Req) were calculated, and the radioactivity concentration (Iγ) was calculated, there was an increase after treatment in N3 due to the anchors Calculation of the internal risks (Hin), and the external (Hex) of radioactivity, the annual effective internal (Ein) and external (Eout) Ead, the annual external effective dose Elcd * 10^{-3}.. The rate of cancer incidence, while the rest were within the international standards

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