International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org ||Volume 7 Issue 4 Ver. IV|| April 2018 || PP 51-63

Evaluation of Natural Radioactivity and Physico-Chemical Characteristics alongEl-Salam Canal, Egypt

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Abstract:*The presence of primordial radionuclides in human habitats has always been a source of prolonged nuclear radiation exposure. Measurements of naturally occurring radionuclides in the environment can be used as a baseline to evaluate the impact caused by non-nuclear activities. This study aimedfor evaluation of the radioactivity assessment of El-Salam* Canal *as a source of irrigation water and assesses the possible potential radiation risk to the public around it. The samples were prepared and the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in surface water and shoresediment samples collected along El-Salam* Canal *were measured usingHpGe detector.The results for the measurementsof natural radioactivity revealed that,the mean average of absorbed dose rate (D), annual effective dose rate (AEDE), radium equivalent (Raeq), external and internal hazard indices and the total hazard index (H_{ex}+H_{in}) fall within the worldwide averages. The recorded and calculated values were lower than the acceptable limits published in the different localities around the world. The electrical conductivity(EC) values of El-Salam* Canal samples *increased after mixing with Hadous drain compared with after mixing with El-Serw drain. Soluble cations, anions and the Sodium Adsorption Ratio(SAR)in different water locations, increased progressively with increasing salinity content of the water. All trace elements in water samples showed significant increase compared to Nile water concentrations of these pollutants especially at the end of the canal.The results of the shore sediments analysis showed that the SAR values were ranged from 1.15 to 2.85 whereas; the corresponding values for exchangeable sodium percent(ESP) were ranged from 69.20 and 77.90 %. The obtained data could be used as reference data for any future use for modeling purposes.*

keywords*:El-Salam* Canal,*Physico-Chemical analysis,Radiological hazard indices.*

Date of Submission: 05-03-2018 Date of acceptance: 20-04-2018

I. Introduction:

El-Salam Canal is one of the national promising projects for reusing drainage water in irrigation. Namely, drainage water from Hadous drain (1.905 Bm^3/year) and El-Serwdrain (0.435 Bm^3/year) in a1:1 mixing ratio with the Nile river water (2.11 Bm^3/year) delivered from Damietta branch**[1]**. The total length of El-Salam Canal is 242 km, 87 km in the west and 155 km in the east side of the Suez Canalsiphon. The water in the canal from Bir El-Abd to El-Manarah will be under pressure in pipes to allow lifting of water to the area of El-Sir and El-Quarir, and to avoid the sand dunes in this area**[2]**. Some of the objectives and benefits that are gained from implementing El-Salam Canal are: redistributing population in Egypt, protecting the eastern borders of the country, strengthening the Egyptian agricultural policy through increasing the cultivated areas and agricultural yield, increasing agricultural national production and thus increasing exporting vegetables and fruits while decreasing food import, benefiting and making good use of agricultural drainage water as an important water re-source, creating work opportunities for the youth and establishing tourism, industrial and mining projects **[3]**. Aquatic contamination by heavy metals is very harmful since these elements are not degradable in the environment and may accumulate in the living organisms **[4]**. Industrial residues are presently one of the greatest and most diversified sources to heavy metal introduction in the water environment, and their concentration in this medium varies with the type of effluent treatment. Discharge of metal effluents into rivers may cause deleterious effects to the health. Chemical analysis for heavy metals parameters of El-Salam Canal water indicated that concentrations of all measure parameters are within the permissible levels for irrigation, livestock and fisheries water**[5]**, except Al concentration exceeded the permissible levels, which is the most contribution for percentage of poor for fisheries activities **[6 &7]**. While Hafez**[8]**study remarked that heavy metal concentrations limit in the studying area are not acceptable for animal drinking or irrigation purposes. The sources of the anthropogenic radionuclides in the aquatic environment are divided into nuclear and non- nuclear activities. Phosphate fertilizers manufacture, agricultural applications, coal combustion, cement production,

street construction and other human activities are non-nuclear industries which have produced and redistributed increasing amounts of radioactive matter leading to a considerable contribution to the radio-ecological pollution **[9&10]**. Most radionuclides are absorbed directly to sediments or to sinking particles within 1-2 years **[11]**. However, some of these radionuclides may later be remobilized from the sediments to the water column and subsequently be taken up by biota or exported hydrologically from the system **[12]**. The measurement of radioactivity levels of both natural and artificial radionuclides in the stream water of Suez Canal and related bottom sediments was found that the fate of released radionuclides will strongly dependent on the chemical affinity to particulate matter in suspended loads and bottom sediments**[13]**. In the natural environments, living organisms are chronically exposed to low doses and dose rates of ionizing radiation **[14]**. The wastewater canals and lakes are subjected to active process of contamination with different kinds of pollutants. Consequently, they act as recipients of domestic sewage, industrial wastes, and agricultural wastewater **[15]**. In order to evaluate risks to human and environmental health, it isimportant to monitor the export of radionuclides from the different water canals. The quality of El-Salam Canal water should be addressed to help monitoring and mitigating the negative impacts of the reused drainage water of the canal on the surrounding environment of north Sinai. So far, most of the follow up studies were carried out to some extent on the western part of the canal before crossing the Suez Canal to north Sinai **[16-18]**. Therefore, the present study completes the picture and focus on the eastern part extending in north Sinai.

This was undertaken by radiological and chemical analysis of surface water and shoresedimentsamples from different selected locations along El-SalamCanal to investigate the radioactivity levels of both natural and artificial radionuclides and physico-chemical characteristics.The obtained data will used to determine the radiological hazards due to the different anthropogenic stress by calculating the absorbed dose rate, annual effective dose rate and the total hazard index [external and internal].

II. Experimental Work

1. Sampling and Sample Preparation for Gamma Spectrometry:

Sampling process was conducted during the period in November 2015 and December 2016 in two samples campaigns.The samples selected to cover the different geomorphic and other observed features in the canal.Fifteen water samplesand ten shore sediment sampleswere collected along El-Salam Canal.Preparation of the sediment samples for γ-ray measurements were carried out by drying the samples in an oven at a constant temperature. The volumes of the prepared samples were weighed at the Central Laboratory for Environmental Radioactivity Measurements, Inter-Comparison and Training (CLERMIT), Nuclear and Radiological Regulatory Authority (NRRA) in Cairo. The water samples were prepared volumetrically packed in polyethylene containers sealed and left nearly one month to reach secular equilibrium between radium and thorium and theirprogenies **[19]**. Measurements of the activity concentrations of ^{238}U, ^{232}Th and ^{40}K in $Bqkg^{-1}$ dry wt. of the collected samples were carried out using gamma-rayspectrometry based on a highly pure germanium coaxial detector (HPGe) of40% relative efficiency **[19].** The resolving power of the spectrometer wasfound to be 1.92*keV* for 1332*keV*gamma-ray line of ^{60}Co. The gamma-ray spectrometer was calibrated forenergy using point source of ^{60}Co (1172 and1332.3*keV*The detector wascoupled with an 8192-channels computer analyzer and genie 2000 software.The measurement time for gamma spectrometry was 80,000s **[20]**. TheIAEAstandard gamma-ray spectrometry reference materials RGU-1, IAEA-375,IAEA-312 and IAEA-314 were used for the spectrometer efficiency calibration in the geometry of the sample measurements. The gamma transition used foractivity calculation of ^{40}K was 1460.7 *keV* **[10].**

III. Calculation Of Radiological Effects:

2.1 Dose rate calculation:

The absorbed dose rate was calculated from the measured activities of ^{238}U, ^{232}Th and ^{40}K in the shore sediment samples using the formula **[21].**

$$\mathbf{D}(\boldsymbol{nGyh^{-1}}) = \mathbf{0.462}\boldsymbol{C_u} + \mathbf{0.604}\boldsymbol{C_{Th}} + \mathbf{0.042}\boldsymbol{C_K} \qquad \textbf{(1)}$$

where**D**, is the absorbed dose rate ($nGyh^{-1}$). C_U, $C_{th}$and $C_K$are the activity concentrations ($Bqkg^{-1}$) of^{238}U, $^{232}Th$and^{40}Krespectively.

2.2 Annual Effective Dose Equivalent (AEDE):

To estimate the annual effective dose rates, the conversion coefficient from absorbed dose to effective dose, 0.7 $SvGy^{-1}$and outdoor occupancy factor of 0.2 were used**[22]**.The annual effectivedose ($mSvy^{-1}$) was calculated by the formula **[23]**:

$$\mathbf{AEDE}(\boldsymbol{mSvy^{-1}}) = \mathbf{D}(\boldsymbol{nGyh^{-1}})\mathbf{x8760}\boldsymbol{h}\mathbf{x0.2x0.7}\boldsymbol{SvGy^{-1}}\mathbf{x10^{6}}\mathbf{(2)}$$

where, 0.2 is The occupancy factor for outdoor, 8760 is the total time of the year in hours and 0.7 $SvGy^{-1}$is the conversion factor for external gamma irradiation.

Calculation of Hazard Indexes:

3.1 External hazard index (H_{ex}) and internal hazard index (H_{in}):

The external hazard index (H_{ex}) represents the external radiation exposure associated with gamma irradiation from radionuclides of concern. The value of H_{ex}should not exceed the maximum acceptable value of one in order to keep the hazard insignificant. The external hazard index (H_{ex}) and internal hazard index (H_{in}) were defined by Eqs. {3, 4}**[24]:**

$$\boldsymbol{H_{ex} = (C_{Ra}/370 + C_{Th}/259 + C_K/4810) \leq 1} \quad \mathbf{(3)}$$

$$\boldsymbol{H_{in} = C_{Ra}/185 + C_{Th}/259 + C_K/4810 \leq 1} \quad \mathbf{(4)}$$

3.2 Representative level index($I\gamma$)*:*

Itis used to estimate the gamma radiation hazard associated with the natural radionuclide in specific investigated samples. It is given by the equation:

$$\boldsymbol{I\gamma = C_{Ra}/150 + C_{Th}/100 + C_K/1500} \ \mathbf{(5)}$$

where C_{Ra}, C_{Th}andC_K are the radioactivity concentrations in $Bqkg^{-1}$of ^{238}U, ^{232}Th, and ^{40}K**[25]**.

3.3 Radium equivalent activity (Ra_{eq}):

The distribution of ^{238}U, $^{232}Th$and ^{40}Kin sediments is not uniform. Uniformity with respect to exposure to radiation has been defined in terms of radium equivalent activity (Ra_{eq}) in $Bqkg^{-1}$to compare the specific activity of materialcontaining different amounts of ^{238}U, $^{232}Th$and ^{40}K. This radium equivalent activity represents a weighted sum of activities of ^{40}K, $^{238}U$and ^{232}Thradionuclides and is based on the estimation that1$Bqkg^{-1}$of ^{226}Ra, 0.7$Bqkg^{-1}$of ^{232}Th, and 13$Bqkg^{-1}$of ^{40}KProduce the same radiation dose rates. It is calculated from the following relation **[25]**:

$$\boldsymbol{Ra_{eq} = C_{Ra} + 1.43C_{Th} + 0.077C_K} \quad \mathbf{(6)}$$

where C_{Ra}, C_{Th}And C_K are the radioactivity concentrations in $Bqkg^{-1}$of ^{238}U, ^{232}Th, and ^{40}K, respectively.

2. Sample Preparation for Physico-Chemical Characteristics:

For analysis, the samples were stored in a polyethylene bottle in the dark at a temperature of 4°C.Half of sample was used for metal analysis (Acidification); the second half of samples (pure sample) was used for the analysis of anions. All samples were filtrated before analysis through a 0.45µm filter (GHP-Filer, Pall, Germany). The anions and cations were analysed with a single column chromatographic system (Metrohm Company, Germany). After calibration the area counts of ions were used to determine the concentration. To check the validity of the calibration to each sample sequence several standard samples were considered. The heavy metals in the water and sediment samples were determined using ICP-OEs (Varian Liberty 150) and AAS (Septraa-800, Varian, Germany). Calibration standards were prepared from 1000 ppm solutions (VWR Company, Darmstadt, Germany). If necessary the samples were diluted with 5.0 % HNO3 (Nitric Acid).

IV. Results and Discussion

1. The specific activities of^{238}U (^{226}Ra), ^{232}Th, and ^{40}K ($Bqkg^{-1}$) for the studied samples:

1.1 Water Samples:

The ^{238}U(^{226}Ra) specific activities **Table(1)**ranged between *ULD*and 25.54 ± 7.10 $Bqkg^{-1}$with an average value of 7.56 ± 1.88 $Bqkg^{-1}$. The ^{232}Thspecific activities ranged between *ULD*and 14.13 ± 1.26 $Bqkg^{-1}$ with an average value of 3.42± 0.78$Bqkg^{-1}$. The ^{40}Kspecific activities ranged between 14.49 ± 4.41 and 114.88 ± 5.61 $Bqkg^{-1}$with an average value of 39.97 ± 4.44 $Bqkg^{-1}$. These data indicate that the activity concentration values of naturally occurring radionuclides in the water samples within the world average ranges, which are7.56 ± 1.88 (10-35), 3.42± 0.78(10-30) and 39.96± 4.44 (100-400) $Bqkg^{-1}$for ^{238}U(^{226}Ra), $^{232}Th$and ^{40}K,

respectively**[25]**. The lowest detected specific activity value (1.35 ± 0.55$Bqkg^{-1}$) for $^{238}U(^{226}Ra)$ was found in sample W10, this could be attributedto the nature of the sample itself, it is after the SuezCanal (after the lift station), and the highest detected specific activity value (25.54 ± 7.10 $Bqkg^{-1}$) for$^{238}U(^{226}Ra)$ was found in sample W11(after the Suez Canal siphon directly). For ^{232}Th the lowest detected specific activity value (2.24 ± 1.16 $Bqkg^{-1}$) was found in sample W6before El-Serw drainage, and the highest detected specific activity value (14.13 ± 1.26 $Bqkg^{-1}$) was found in sample W5 which is after the Hadous drainage, for ^{40}K(14.49 ± 4.41 $Bqkg^{-1}$) was found in sample W11, which has the highestdetected specific activity for $^{238}U(^{226}Ra)$. This could be attributed for the nature of the sample itself and the highest specific activity value (114.88 ± 5.61$Bqkg^{-1}$) for $^{40}K$was found in sample W4 which is after the Hadous drainage directly.

The contour map of the activity concentrations of $^{238}U(^{226}Ra)$, $^{232}Th$and $^{40}K$for fifteen water samples with their locations are shown in **Figs. (1.1:1.3)**.

Table (1): Specific activities ($Bqkg^{-1}$) of $^{238}U(^{226}Ra)$,$^{232}Th$and $^{40}K$for water samples.

Sample Code	U-238 (^{226}Ra)	^{232}Th	^{40}K
W1	3.916 ± 1.87	3.27 ± 0.90	20.42 ± 2.87
W2	5.560 ± 1.12	3.01 ± 0.99	22.00 ± 3.01
W3	5.440 ± 1.17	2.41 ± 0.46	17.40 ± 3.45
W4	12.010 ± 1.69	6.93 ± 1.14	114.88 ± 5.61
W5	7.850 ± 1.21	14.13 ± 1.26	69.76 ± 4.39
W6	4.690 ± 1.51	2.24 ± 1.16	21.64 ± 4.19
W7	13.180± 1.73	8.00 ± 1.58	108.25 ± 6.07
W8	9.420 ± 1.17	7.81 ± 1.63	106.66 ± 5.83
W9	2.800 ± 0.89	*UDL**	16.47 ± 4.06
W10	1.350 ± 0.55	3.56 ± 2.5	15.07 ± 2.5
W11	25.540 ± 7.10	*ULD*	14.49 ± 4.41
W12	*ULD*	*ULD*	20.05 ± 4.19
W13	2.760 ± 1.59	*ULD*	18.24 ± 4.55
W14	18.860 ± 6.56	*ULD*	15.56 ± 4.49
W15	*ULD*	*ULD*	18.63 ± 07.02
Average	**7.56 ±1.88**	**3.42± 0.78**	**39.97± 4.44**

*ULD**: Under Limit of Detection

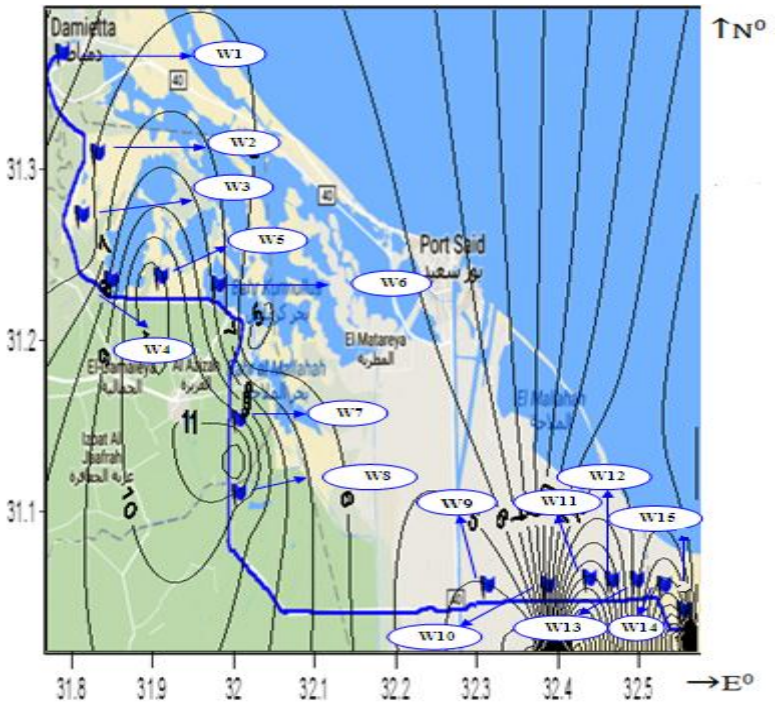

Fig.(1.1): Contour map: Distribution of $^{238}U(^{226}Ra)$ ($Bqkg^{-1}$) for the water samples along El- Salam Canal.

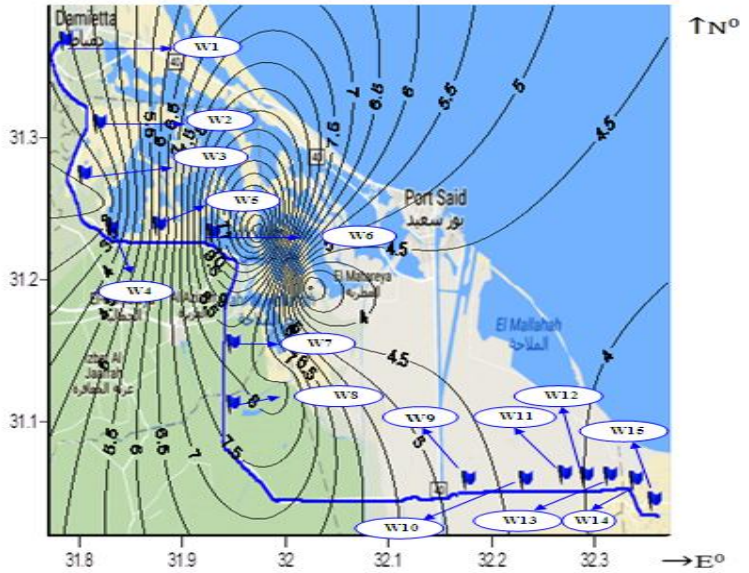

Fig. (1.2): Contour map: Distribution of $^{232}Th(Bqkg^{-1})$ for the water samples along El- Salam Canal.

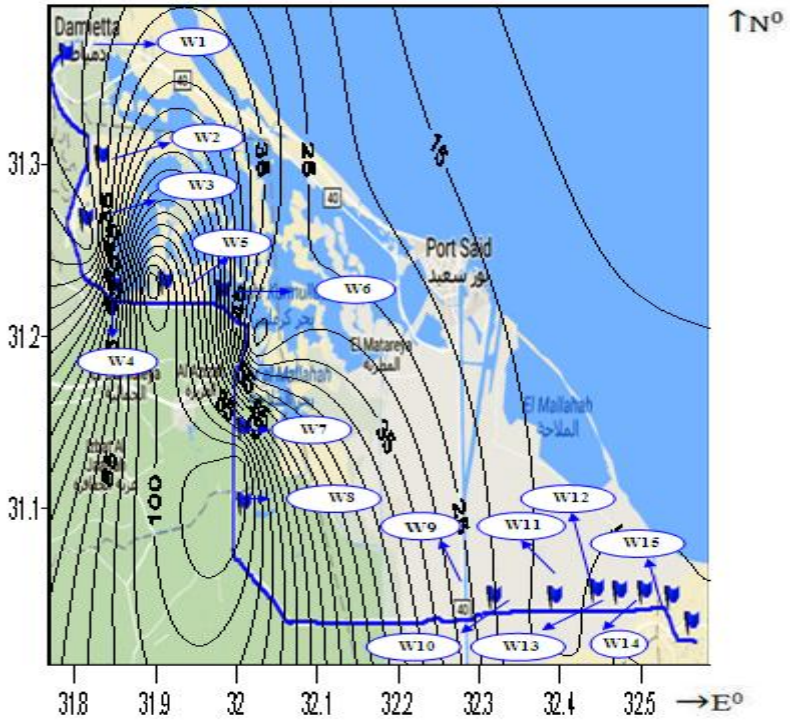

Fig. (1.3): Contour map: Distribution of $^{40}K(Bqkg^{-1})$ for the water samples along El- Salam Canal.

1.2 Shore Sediment Samples:

The activity concentrations of $^{238}U(^{226}Ra)$, $^{232}Th$and $^{40}K$for theten samplesare shown in**Table (2)**. The $^{238}U(^{226}Ra)$ specific activities ranged between 3.52 ± 0.57 and 31.37 ± 1.78 $Bqkg^{-1}$with an average value of 16.18 ± 1.65 $Bqkg^{-1}$.The ^{232}Thspecific activities ranged between 2.41 ± 0.43 and 28.79 ± 1.66 $Bqkg^{-1}$with an average value of 13.66 ± 1.60$Bqkg^{-1}$. Also, the specific activities of^{40}Kranged between 113.9 ± 5.79 and 480.47 ± 8.25$Bqkg^{-1}$with an average value of 264.42 ± 6.98$Bqkg^{-1}$. The results indicate that the average activity concentration values of naturally occurring radionuclides in the Shore sediment samples within the world average ranges **[25&26].**

Table (2): Specific activities of $^{238}U(^{226}Ra)$, $^{232}Th$and^{40}k ($Bqkg^{-1}$) in the collected Shore sediment samples.

Sample Code	*U-238* (^{226}Ra)	^{232}Th	^{40}K
S.S2	11.19 ± 1.19	7.61 ± 0.84	185.07 ± 4.92
S.S3	23.5 ± 6.40	21.15 ± 6.37	269.1 ± 7.08
S.S4	12.72 ± 1.19	10.73 ± 1.23	174.6 ± 5.83
S.S5	30.09 ± 1.82	25.65 ± 1.79	434.70 ± 8.27
S.S6	31.37 ± 1.78	28.79 ± 1.66	480.47 ± 8.25
S.S7	27.27 ± 1.55	26.44 ± 1.72	421.02 ± 7.50
S.S9	11.29 ± 0.70	5.83 ± 0.73	228.5 ± 9.16
S.S11	7.27 ± 0.82	4.74 ± 0.67	209.6 ± 9.61
S.S13	3.52 ± 0.57	3.20 ± 0.51	127.27 ± 3.38
S.S15	3.59 ± 0.52	2.41 ± 0.43	113.9 ± 5.79
Average	**16.18 ± 1.65**	**13.66 ± 1.60**	**264.42 ± 6.98**

The average specific activity values for$^{232}Th$and $^{40}K$are increased and multiplied bytwo times for water samples than the lowest values W6 and W11, while the average specific activity values for*U-238* (^{226}Ra) and$^{232}Th$are increased and multiplied by fivetimes for Shore sediment samples than the lowest values S.S13and S.S15. The specific activity increased also after the mixing of Hadous drainage water with the canal. It's clear from the results that the specific activity values of $^{238}U(^{226}Ra)$,$^{232}Th$and ^{40}K in the studied samples increased after mixing theNile river water in the canal with the drainages water which contain phosphate residues and other wastes and may be due to the evaporation factor.

The contour map of the activity concentrations of$^{238}U(^{226}Ra)$, $^{232}Th$and $^{40}K$for ten Shore sediment samples with their locations are shown in **Figs.(2.1:2.3)**.

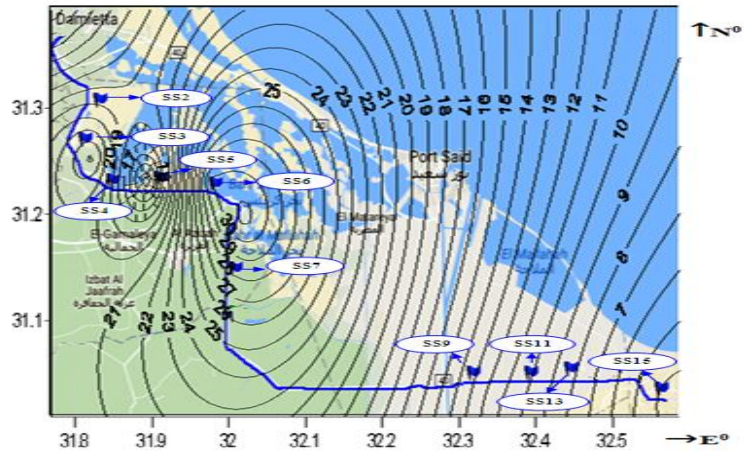

Fig. (2.1): Contour map: Distribution of $^{238}U(^{226}Ra)$ ($Bqkg^{-1}$) in the Shore sediment samples of the studied area.

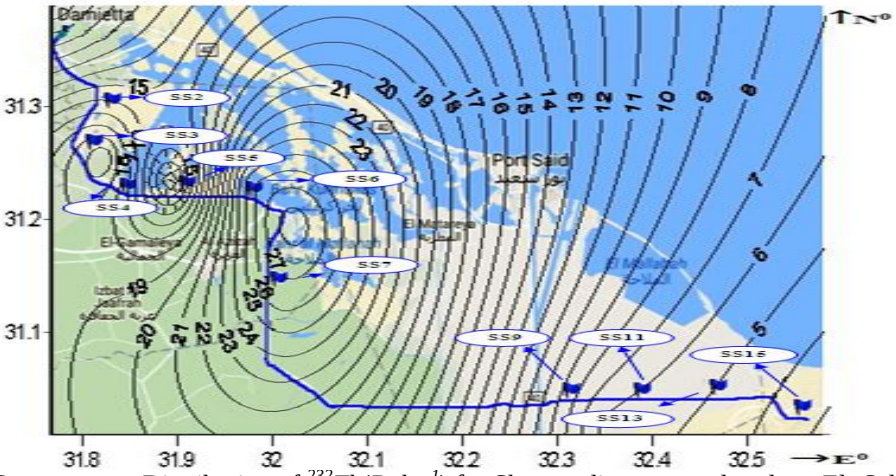

Fig. (2.2): Contour map: Distribution of $^{232}Th(Bqkg^{-1})$ for Shore sediment samples along El- Salam Canal.

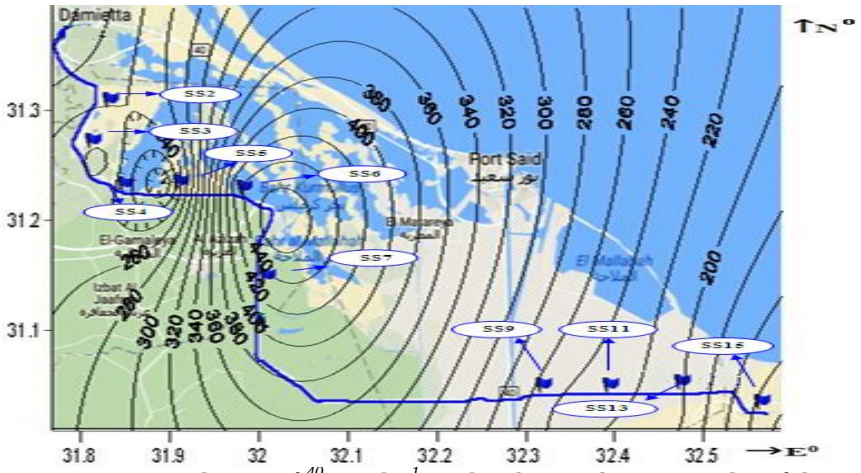

Fig (2.3): Contour map: Distribution of $^{40}K(Bqkg^{-1})$ in the Shore sediment samples of the studied area.

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2. Elemental Correlations For Natural Radionuclides:

2.1 In Water Samples:

The correlations between the activity concentrations of $^{238}U(^{226}Ra)$,$^{232}Th$and $^{40}K$for water samples are shown in **Figs. (3.1:3.3)**.Relationships between the concentration of $^{238}U(^{226}Ra)$ with both$^{232}Th$and ^{40}K are weak correlation for water samples, while there is a good correlation between $^{232}Th$and ^{40}K. Theaverages of$^{238}U/^{40}K$and $^{232}Th/^{40}K$ratios are 0.32and 0.08, respectively, The world average value for both quotients being 0.084 for $^{238}U/^{40}K$and 0.10 for $^{232}Th/^{40}K$**[9]**.

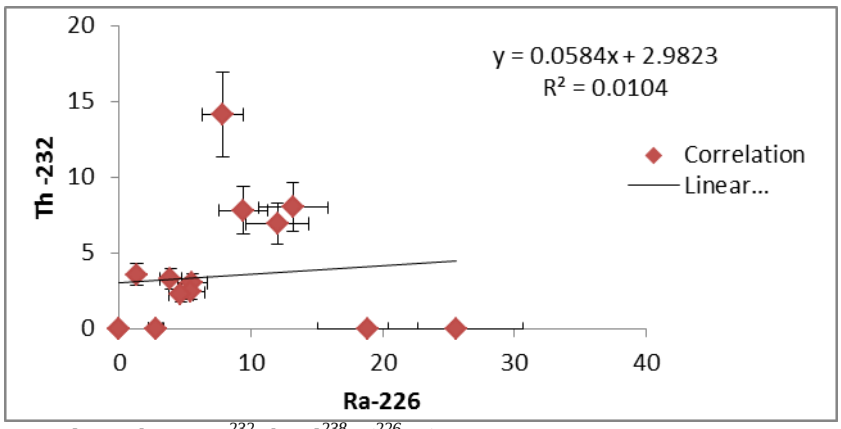

Fig. (3.1): Correlation between$^{232}Th$and$^{238}U(^{226}Ra)$ activity concentrations in water samples.

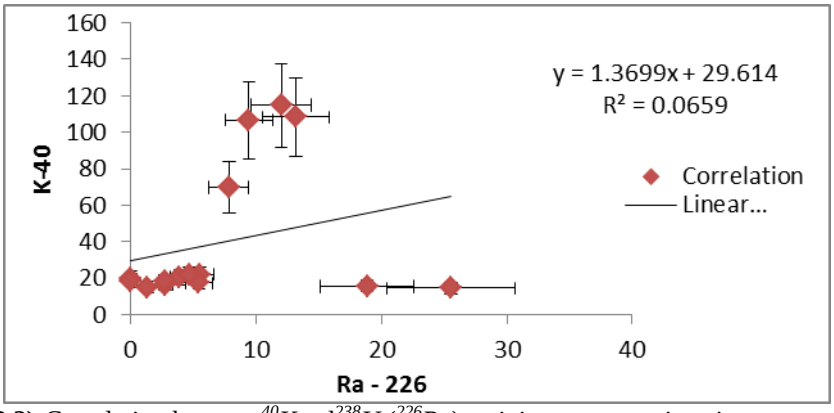

Fig. (3.2): Correlation between$^{40}K$and^{238}U (^{226}Ra) activity concentrations in water samples.

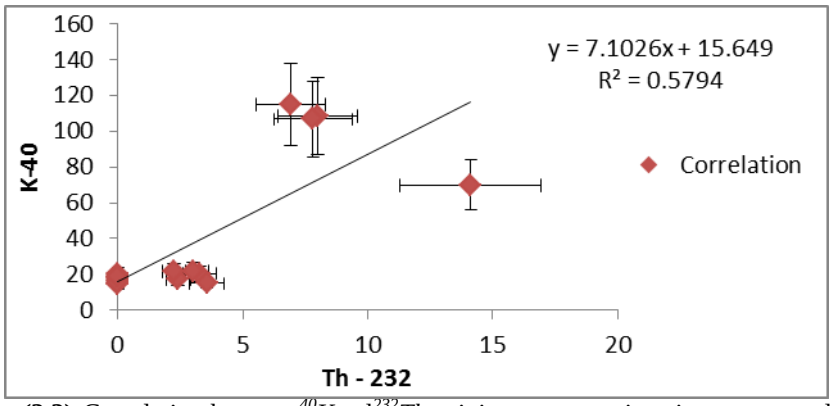

Fig. (3.3): Correlation between $^{40}K$and ^{232}Thactivity concentrations in water samples.

2.2 In Shore Sediment Samples:

The correlation between the activity concentrations of $^{238}U(^{226}Ra)$, $^{232}Th$and $^{40}K$for Shore sediment samples are shown in**Figs. (4.1:4.3)**. There is good correlations between $^{238}U(^{226}Ra)$ with both ^{232}Th&$^{40}K$and between ^{232}Th&$^{40}K$for Shore sediment samples. The averages of $^{238}U/^{40}K$and $^{232}Th/^{40}K$ratios are 0.051and 0.041, respectively.These results are within the world average values recommended by UNSCEAR,2008**[9]**.

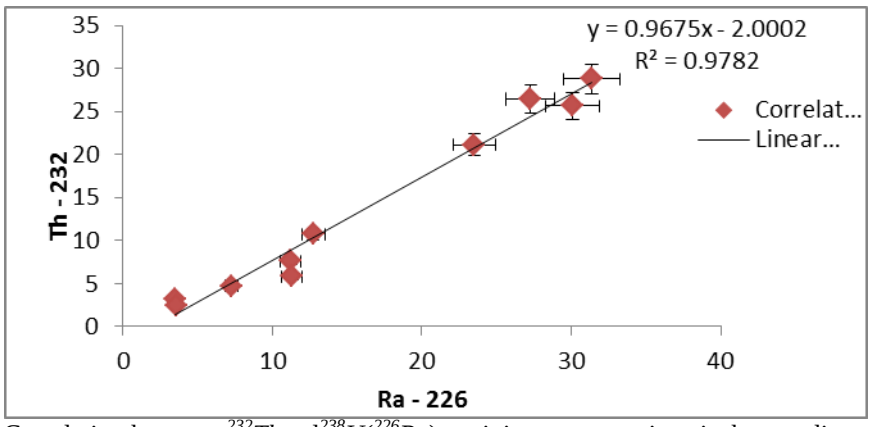

Fig. (4.1): Correlation between $^{232}Th$and$^{238}U(^{226}Ra)$ activity concentrations inshore sediment samples.

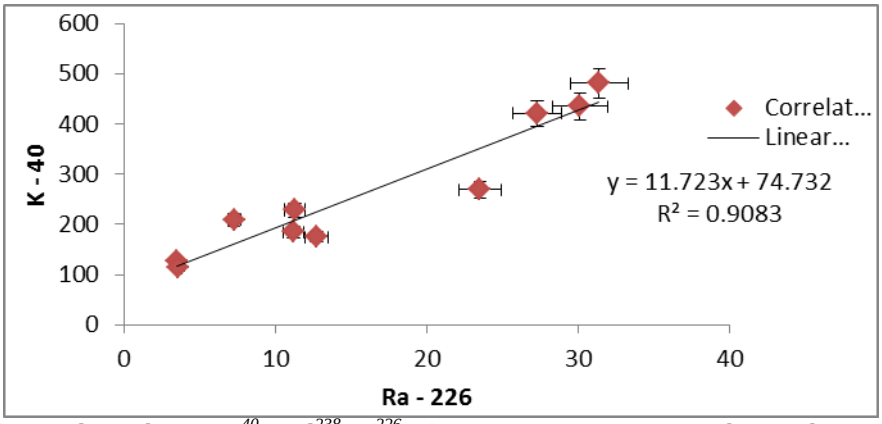

Fig. (4.2): Correlation between $^{40}K$and^{238}U (^{226}Ra) activity concentrations inshore sediment samples.

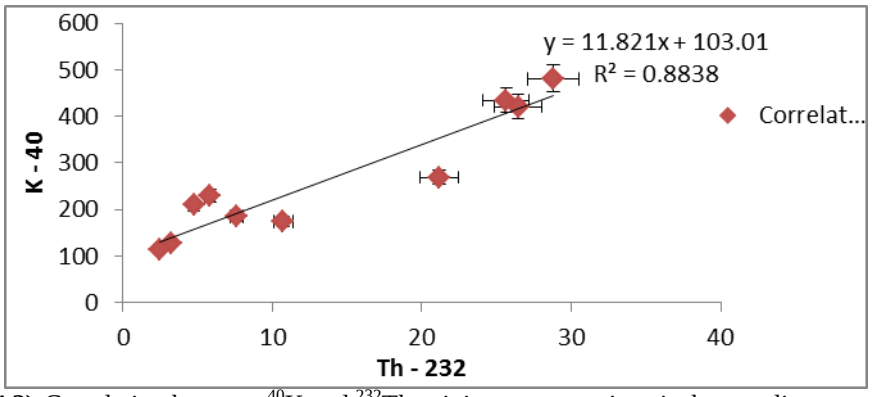

Fig. (4.3): Correlation between ^{40}K and ^{232}Thactivity concentrations inshore sediment samples.

3. Radiological Hazard Indices:

The radium equivalent (Ra_{eq}),external hazard index (H_{ex}), internal hazard index (H_{in}), representative level index ($I\gamma$)and total hazard index (H_{in}+H_{ex})values for water and shore sediment samples are shown in**Tables (3 & 4)**. The calculated values of $H_{in}$for water samples ranged from 0.003 ± 0.001to 0.14 ± 0.039$mSvy^{-1}$, with an average value of0.058 ±0.014$mSvy^{-1}$ and for the shore sediment samples, are ranged from 0.05 ± 0.005 to0.38 ± 0.017$mSvy^{-1}$, with an average value of 0.19 ± 0.01$mSvy^{-1}$. The results indicated that the values of $H_{in}$of all samples are less than the permissible level (unity).

Table (3): Radium equivalent, external and internal hazard indices, representative level index and the total hazard index (H_{ex}+H_{in}) values forwater samples.

Sample	Ra_{eq}	H_{ex}	H_{in}	$I\gamma$	H_{ex}+H_{in}
W1	10.16 ± 5.36	0.02 ± 0.009	0.03 ± 0.014	0.07 ± 0.023	0.05 ±0.023
W2	11.55 ± 4.85	0.03 ± 0.007	0.04 ± 0.010	0.08 ± 0.019	0.07 ±0.017
W3	10.22 ± 4.48	0.02 ± 0.005	0.04 ± 0.008	0.07 ± 0.014	0.06 ±0.013
W4	30.76 ± 7.63	0.08 ± 0.010	0.11 ± 0.014	0.22 ± 0.026	0.19 ±0.024
W5	33.42 ± 6.39	0.09 ± 0.009	0.11 ± 0.012	0.24 ± 0.023	0.2 ±0.021
W6	9.55 ± 6.39	0.02 ± 0.009	0.03 ± 0.013	0.06 ± 0.024	0.05 ±0.022
W7	32.95 ± 8.66	0.08 ± 0.012	0.12 ± 0.016	0.24 ± 0.031	0.2 ±0.028
W8	28.80 ± 7.99	0.07 ± 0.010	0.10 ± 0.013	0.21 ± 0.027	0.17 ±0.023
W9	-	0.01 ± 0.005	0.018±0.005	0.02 ± 0.008	0.028 ±0.01
W10	7.60 ± 6.05	0.02 ± 0.013	0.02±0.013	0.05 ± 0.030	0.04 ±0.026
W11	-	0.07 ± 0.039	0.14±0.039	0.17 ± 0.050	0.21 ±0.078
W12	-	0.004 ± 0.0008	0.004±0.0008	0.01 ± 0.002	0.008 ±0.001
W13	-	0.01 ± 0.020	0.018±0.02	0.03 ± 0.026	0.028 ±0.04
W14	-	0.05 ± 0.036	0.10±0.036	0.13 ± 0.046	0.15 ±0.072
W15	-	0.003 ± 0.001	0.003±0.001	0.01 ± 0.004	0.006 ±0.002
Average	19.44 ±10.99	0.03 ± 0.012	0.058±0.014	0.10 ±0.020	0.09 ±0.026

Table (4): Radium equivalent, external and internal hazard indices, representative level index and the total hazard index (H_{ex}+H_{in}) values forshoresediment samples.

Sample	Ra_{eq}	H_{ex}	H_{in}	$I\gamma$	H_{ex}+H_{in}
S.S2	36.32 ± 6.17	0.09 ± 0.007	0.12 ± 0.010	0.27 ± 0.019	0.21 ± 0.017
S.S3	74.46 ± 20.96	0.20 ± 0.043	0.26 ± 0.060	0.54 ± 0.111	0.46 ± 0.103
S.S4	41.50 ± 7.43	0.11 ± 0.009	0.14 ± 0.012	0.30 ± 0.024	0.25 ± 0.021
S.S5	100.24 ± 10.74	0.27 ± 0.013	0.35 ± 0.018	0.74 ± 0.035	0.62 ± 0.031
S.S6	109.53 ± 10.50	0.29 ± 0.012	0.38 ± 0.017	0.81 ± 0.033	0.67 ± 0.029
S.S7	97.49 ± 9.78	0.26 ± 0.012	0.33 ± 0.016	0.72 ± 0.032	0.59 ± 0.028
S.S9	37.22 ± 8.79	0.10 ± 0.008	0.13 ± 0.008	0.28 ± 0.018	0.23 ± 0.016
S.S11	30.18 ± 9.17	0.08 ± 0.009	0.10 ± 0.009	0.23 ± 0.018	0.18 ± 0.018
S.S13	17.89 ± 3.90	0.04 ± 0.005	0.05 ± 0.005	0.14 ± 0.011	0.09 ± 0.010

S.S15	**15.80 ± 5.59**	**0.04 ± 0.005**	**0.05 ± 0.005**	**0.12 ± 0.011**	**0.09 ± 0.010**
Average	**56.06 ± 9.30**	**0.15 ± 0.01**	**0.19 ± 0.01**	**0.42 ± 0.31**	**0.30 ± 0.02**

The external hazard index H_{ex}ranged between0.003±0.001 and 0.09±0.009 $mSvy^{-1}$with an average value 0.03 ± 0.012 $mSvy^{-1}$for water samples and ranged between 0.04 ± 0.005 and 0.29 ± 0.012$mSvy^{-1}$, with an average value of 0.15 ± 0.01$mSvy^{-1}$ for shore sediment samples.The values of H_{ex} of all samples studied in this work are less than unity.

The representative level index ($I\gamma$) ranged between 0.01 ± 0.002to 0.24 ± 0.031*Bq/l*with an average 0.10 ± 0.02*Bq/l*for water samples, while ranged between 0.12 ± 0.011$Bqkg^{-1}$to 0.81 ± 0.033$Bqkg^{-1}$with an average 0.42 ± 0.31$Bqkg^{-1}$for shore sediment samples.The results obtained are in good agreement with those obtained by Chad**[25]**, and lower than unity which means no radiological hazard in the area under study.

The radium equivalent mean value for water samples was 19.44 ± 10.99 *Bq/l*, which is within the UNSCEAR recommended permissible limit of 370 *Bq/l*.

4. Ambient Dose Rates from Natural Radionuclides in Soil at height of 1 M above the ground in investigatedsites:

It is observed from **Table (5)** that, the effective dose equivalent rate for water samples ranged between 0.005 ± 0.001 and 0.09 ± 0.102$mSvy^{-1}$while,for the investigated sites of shore sediment samples ranged between 0.04 ± 0.004 and 0.32± 0.013$mSvy^{-1}$which are less than the permissible dose equivalent of one $mSvy^{-1}$**[25].**

Table (5): Ambient Dose rate and effective dose equivalent values for waterand shoresediment samples

Sample Code	**Absorbed dose rate D ($nGyh^{-1}$)**	**The Annual Effective Dose Equivalent E_{air}($mSvy^{-1}$)**	**Absorbed dose rate D ($nGyh^{-1}$)**	**TheAnnual Effective Dose Equivalent E_{air}($mSvy^{-1}$)**	
	Water Samples		**ShoreSediment Samples**		**Sample Code**
W1	4.71 ± 1.52	0.02 ± 0.009	-	-	
W2	5.31 ± 1.26	0.03 ± 0.007	17.64 ± 1.27	0.10 ± 0.007	**S.S2**
W3	4.66 ± 0.95	0.02 ± 0.005	35.46 ± 7.28	0.21 ± 0.044	**S.S3**
W4	14.59 ± 1.71	0.08 ± 0.010	19.93 ± 1.57	0.12 ± 0.009	**S.S4**
W5	15.70 ± 1.54	0.09 ± 0.009	48.24 ± 2.32	0.29 ± 0.142	**S.S5**
W6	4.41 ± 1.59	0.02 ± 0.009	52.81 ± 2.21	0.32 ± 0.013	**S.S6**
W7	15.52 ± 2.04	0.09 ± 0.102	46.99 ± 2.12	0.28 ± 0.013	**S.S7**
W8	13.72 ± 1.83	0.08 ± 0.011	-	-	
W9	1.89 ± 0.55	0.01 ± 0.003	18.32 ± 1.17	0.11 ± 0.007	**S.S9**
W10	3.58 ± 2.00	0.02 ± 0.012	-	-	
W11	11.56 ± 3.23	0.07 ± 0.019	15.07 ± 1.20	0.09 ± 0.007	**S.S11**
W12	0.84 ± 0.17	0.005 ±0.001	-	-	
W13	1.95 ± 1.73	0.01 ± 0.010	8.98 ± 0.72	0.05 ± 0.004	**S.S13**
W14	8.74 ± 3.00	0.05 ± 0.018	-	-	
W15	0.78 ± 0.29	0.04 ± 0.001	7.92 ± 0.75	0.04 ± 0.004	**S.S15**

V. Physico-Chemical Characteristicsof El-Salam Canal:

5.1 ForWater Samples:

Water analyses including chemical and heavy metals were carried out in ENRRA Laboratories to investigate the situation analysis ofEl-Salam Canal. Data of the chemical properties of water as shown in **Table (6)**indicated that the electrical conductivity (EC) ranged between 0.51 to 33.1ds.m^{-1}. The EC values of El- Salam Canal increased after mixing with Hadous drain compared with after mixing with El-Serw drain and these results may be due to the high values of initial values ofHadous drain. The salinity of water is not only due to the ratio of mixing the drainage water with the Nile water 1:1 but it may be due to the evaporation factor. The other probability is filtration factor which results from the hydraulic pressure of high salinity water sources (salinity of Red sea about 43,000 mg/l) In theSuezCanal or water of saline lakes, which spread on surface and down this area. The variation in mixing ratio of Nile water and the drainage water must be considered otherwise it will lead up to negative impacts in the canal.According to the soluble cations data, results revealed that the na^{+} was the highest cation compared to K^{+}, Ca^{+2} and Mg^{+2}, meanwhile K^{+} was the lowest one as shown in**Table (6)**. Concerning the Sodium Adsorption Ratio (SAR) values, data indicated that this parameter changed through the length of the canal. At the beginning of the canal, the parameter value was 5.75 increased to 5.89 in sampleW7(Before Hadousdrainage) and the highest value observed in sample W12(after Hadous drainage). SAR is a measure of the relative preponderance of dissolved sodium in soil solution of soil paste compared to

the amount of dissolved calcium and magnesium. The data showed clearly that, increasing salinity levels in the irrigation water had led to an increase in theSAR values on all locations under study.

Table (6): Chemical properties of El- Salam Canal selected water samples.

Sample Code	pH	EC dsm^{-1}	Cations, $meql^{-1}$				Anions, $meql^{-1}$			SAR %
			Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	HCO_3	Cl^{-1}	$SO4^{-2}$	
W1	7.7	1.79	5.12	2.00	10.85	0.41	3.00	12.61	2.00	5.75
W2	7.6	0.98	2.28	1.70	5.39	0.28	3.29	4.96	1.88	3.83
W3	7.7	0.51	1.78	0.86	2.53	0.26	1.43	2.01	1.57	2.20
W4	7.5	0.93	2.31	1.03	6.23	0.29	2.92	4.91	1.64	4.86
W5	7.9	1.53	3.54	3.10	8.54	0.16	5.07	8.50	0.40	4.69
W7	7.8	1.51	2.87	2.54	9.61	0.13	5.27	7.27	0.30	5.89
W8	7.8	1.69	3.22	2.61	10.64	0.13	5.95	8.41	0.39	6.34
W12	8.2	33.10	31.07	84.70	203.93	4.24	5.60	310.00	19.05	26.96
W14	8	21.00	25.23	56.80	120.53	2.81	4.60	188.97	13.12	19.17
W15	8.2	3.62	4.88	8.04	20.64	0.98	5.90	25.90	4.21	8.12

Trace elements (defined as a small unit of presence of heavy metals in a sample)were analyzed in the irrigation water of El-Salam Canal as a main source of irrigation in the studied sites. **Table (7)**represents the heavy metals analysis foreight different elements as well as both the safe level of these elements and the analysis ofNile water. The obtained results indicated that, at selected sites all the trace elements were under the toxic levels exceptCd and Mn,the numerical values showed that in sample W8their concentrations were 0.08 and 0.612 ppm, respectively, whereas the safe levels for both of them were 0.01 and 0.2 ppm, respectively.Data of the analyzed elements shown in **Table (7)**indicated that, all the studied heavymetals in El-Salam Canal showed significant increase compared to Nile water concentrations of these pollutants especially at the end of the canal. Also, these values were much higher than those obtained by Abdel-Hamid**[5]**.

Table (7): Heavy metals analysis of water samples collected fromEl-Salam Canal(mg/l)

No. mg/l	V	Ni	Cu	Zn	Cd	Pb	Cr	Mn	Fe
Safe Level		0.2	0.2	2.0	0.01	5.0	0.1	0.2	5.0
Nile Water		-	0.01	0.02	-	-	0.01	-	-
W1	0.004	0.100	0.030	0.000	0.00	0.90	0.040	0.145	2.301
W2	0.005	0.065	0.038	0.411	0.07	0.80	0.051	0.088	2.402
W3	0.005	0.046	0.050	0.490	0.06	1.00	0.050	0.386	1.051
W4	0.006	0.064	0.450	0.390	0.06	1.50	0.060	0.038	2.102
W5	0.006	0.064	0.049	0.450	0.05	1.42	0.042	0.512	2.510
W7	0.005	0.0601	0.061	0.604	0.08	1.50	0.065	0.514	2.460
W8	0.005	0.066	0.055	0.645	0.08	1.71	0.061	0.612	2.500
W12	0.006	0.060	0.074	0.680	0.08	1.80	0.064	0.65	2.500

5.2 ForShoresediment samples:

Some chemical and physical properties are represented in **Table (8)**.The data indicated that, increasing the sediments clay content from about 17.2 to 24.4 %, led to increase EC from 1.9 to 2.7 $ds.m^{-1}$whereas; the electrical conductivity of the sandy sediment was ranged from 0.8 – 1.1 $ds.m^{-1}$.

Table (8): Physico-Chemical characteristics of shore sediment samples collected from El- Salam Canal

Sediment No	pH	EC ($ds.m^{-1}$)	OM %	TDS (ppm)	Sand %	Silt %	Clay %	Texture
S.S2	7.70	2.3	0.45	1622	48.8	28.7	22.5	Loam
S.S3	7.75	2.7	0.50	1648	49.5	26.1	24.4	Sand Clay Loam
S.S4	7.72	2.6	0.60	1574	51.2	25.5	23.3	Loam
S.S5	7.70	2.3	0.55	1540	48.5	29.0	20.5	Loam
S.S6	7.70	2.0	0.52	1532	53.8	27.4	18.8	Loam
S.S7	7.60	1.9	0.48	1525	58.2	24.6	17.2	Loam
S.S9	7.60	1.1	0.37	1260	65.9	24.8	9.30	SandySediment
*S.S12	7.50	0.8	0.25	285.0	70.5	24.1	5.40	Sandy Sediment

***S.S12control**

The organic matter (OM) was low, this result perhaps could be related to the scarce of apply OM in such sediments. The range of OM was from 0.37to 0.60 %. The pHvalues of the sediment samples were ranged from 7.60to7.75, while the value of the pHin the in control sediment was 7.50.

Data in **Table (9)**represent the other chemical properties of the studied sediments. It represents that the exchangeable cations were clearly higher in their values compared to the control sediment(S.S12). Significant variations were observed in the same data related with the Cation Exchange Capacity (CEC), and Exchangeable Sodium Percent (ESP) in comparing with (S.S12). The data showed that, the CEC of the samples were ranged between 11.7and 60.7 meq/100 gwhile, the control value was 6.8 meq/100 g. These significant variationsbetween the sediment samples mainly related to the presence of light components (silt and clay) higher than the sandy sediment in the control.Accordingly, the tendency of such sediments to retain the pollutants or salts is expected. the SAR and ESP of the collected sediments may explain this point. Finally, theEC of such sediments were not in hazard level. Data showed that the SAR values were ranged from 1.15 to 2.85 whereas; the corresponding values for ESPwere ranged from 69.20 to 77.90 %. This result clearly represents the effect of sediments texture on the deterioration of sediments system.

Table (9): Some chemical properties of the studied shore sediment samples collected from El- Salam Canal

Sediment No.	Exchangeable Cations				CEC (meq)/ 100 g	SAR %	ESP %
	Na^{+}	Ca^{+2}	Mg^{+2}	K^{+}			
	meq/100g						
S.S2	40.5	9.2	7.5	2.3	49.2	2.85	69.30
S.S3	42.2	9.5	6.4	1.9	60.7	2.05	72.82
S.S4	36.4	8.7	5.5	1.7	12.3	1.78	72.30
S.S5	32.5	7.7	4.9	1.5	31.1	2.00	72.40
S.S6	30.8	4.8	4.7	1.0	22.7	1.71	69.20
S.S7	29.6	4.5	4.0	0.9	33.5	1.22	77.30
S.S9	21.0	3.6	4.3	0.8	11.7	1.15	77.90
*S.S12	01.2	1.8	3.0	0.8	6.8	1.00	15.80

***S.S12control**

Heavy metals were analyzed in the shore sediment samples collected from El-SalamCanal in **Table (10)**. The obtained results indicated that Cd was found within the range from 6.5 to 12.5 ppm; Cu from 9.1 to 16.3 ppm; Fe from 49.0 to 74.0 ppm; Mn from 6.4 to 16.8 ppm;Pb from 8.9 to 14.4 ppm; Zn from 9.8 to 51.5 ppm and Ni from 7.7 to 13.5 ppm. It is clear that, analysis of heavy metals profile of the studied El-Salam Canal shore sediment samples revealed their high concentration values compared to the control sediment (S.S12).

Table (10): Heavy metals analysis of shore sediment samples collected from El-SalamCanal (ppm)

Shore Sediment Sample	Cd	Cu	Fe	Mn	Pb	Zn	Ni
S.S2	12.1	16.0	72	16.1	14.0	50.2	12.8
S.S3	12.5	16.3	74	16.8	14.4	51.5	13.5
S.S4	10.2	14.6	68.2	14.2	12.6	48.1	11.3
S.S5	9.5	11.4	63.4	12.8	11.2	43.0	10.7
S.S6	8.7	11.0	59.7	10.5	10.5	41.2	9.3
S.S7	6.9	10.3	52.0	8.7	9.7	9.8	8.1
S.S9	6.5	9.1	49.0	6.4	8.9	34.5	7.7
S.S12	6.2	8.4	47.5	5.2	8.3	31.7	6.2

***S.S12control**

VI. Conclusion:

For fifteen water samples and ten shore sediment samples taken from the studied area, the data indicate that the activity concentration values of naturally occurring radionuclides in water and shore sediment samples are within the world average ranges.Relationships between the activity concentration of ^{238}U(^{226}Ra) with both ^{232}Th and ^{40}K are weak correlation, while there is a good correlation between ^{232}Th and $^{40}K$for the studied water samples. Therelationships between the activity concentration of ^{238}U (^{226}Ra) with both $^{232}Th$and ^{40}Kandalso between $^{232}Th$and ^{40}Krevealedgood correlation for shore sediment samples.The total hazard index (H_{ex}+H_{in}) for water and shore sediment samples is less than the permissible values (unity). None of the radium equivalent values for waterand shore sediment samples exceeded the maximum allowed value for Ra_{eq}(370 $Bqkg^{-1}$).The annual effective dose for water samples and shore sediment samples were below the permissible dose equivalent.

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Abou Bakr Ramadan"Evaluation of Natural Radioactivity and Physico-Chemical Characteristics AlongEl-SalamCanal, Egypt"International Journal of Engineering Science Invention (IJESI), vol. 07, no. 04, 2018, pp 51-63