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Modeling the Biological Environmental Impacts of Some Radionuclides at Abou-Qir Bay

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Abstract:

This present aims to study the biological environmental impacts of radionuclides, in aquatic and marine environments, as numerous aquatic species can move over considerable distances than terrestrial species. Using specific simulating modeling code (RESRAD-BIOTA 1.5), some biological and environmental impacts factors such as Biota Concentration Guide BCG and the tissue of concentration of aquatic animals, which are determined when exposing to some radionuclides (^{40}K and Uranium series) at the selected area of Abou- Qir bay. The study showed that there is an increase in mean average value of ^{40}K at the selected area of Abou-Qir bay (16.58 Bq/l). This can attributed to the location of Abou-Qir fertilizer company at studying area. Also the results showed that the different aquatic animals have Highest BCG (Biota Concentration Guide) value in case of U-238 than U-235,U-234 and U-233. On the other hand, the study showed that the highest value of tissue concentration of aquatic animals was 0.15 Bq/Kg, this value related to the increase in mean average value of radioactivity of K-40 which obtained in the selected area at Abou-Qir Bay.

Key words: radionuclides, RESRAD-BIOTA code, Abou-Qir Bay, biological impacts

INTRODUCTION

The concentration of a radionuclide can change much faster with time in aquatic ecosystems than in terrestrial systems (1).

Radioactive compounds can affect productivity, reproduction and survival of marine organisms and can be hazardous to human health. Coastal monitoring programs are valuable for assessing the current state of coastal environments [(2)] The most dominant radionuclides are ^{40}K and also decay products of the ^{238} U and ^{232}Th series [(3)]. Environmental assessment models are used for evaluating the radiological impact of actual and potential releases of radionuclides to the environment. It is important to check, to the extent possible, the reliability of the predictions of such models by comparison with measured values in the environment or by comparing with the predictions of other models[(4)]. Abu-Qir Drain receives and discharges industrial wastewaters from 22 different factories of food processing and canning, paper, fertilizer and textile manufacturing industries.[(5)]. EPA estimate that 20 μg/l would typically correspond to radioactivity. certain area in Abou qir bay has been selected to study the effects of radioactivity in the living biota[(6)]. The RESRAD-BIOTA code provides a complete spectrum of biota dose evaluation capabilities, from methods for general screening, to comprehensive receptor-specific dose estimation. The code was designed to be consistent with and provide a tool for implementing the DOE (U.S. Department of Energy) "Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota[(7)].

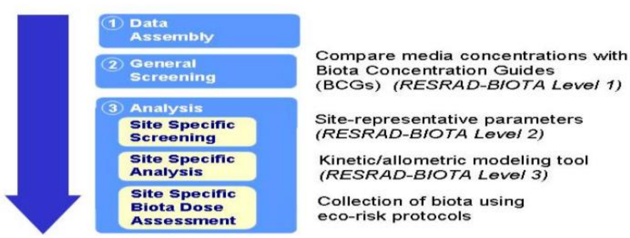
MATERIAL AND METHODS

This study aims to use simulating software code (RESRADBIOTA1.5)[(6)] (fig.1) for determining the aquatic, Detection of ^{233}U,^{234}U,^{235}U,^{238}U and ^{40}K along Abou –Qir bay had been measured by National Institute of Oceanography and Fisheries team to know the sources of these radionuclides[(3)]. The selected area is lies at El Tarh, at Abou-Qir bay 3 km far from –tabia pumping station and 20m off shore[(5)] as shown in Fig(2). This selected site located near the different industrial companies like rakat, Abou-qir fertilizer and Abou-qir thermal power station to show if there is any release from any of these companies, samples was taken from January till July 2015. Thus, previous studied showed that sea water has a radioactivity of about 12.6 Bq kg_1, marine sand has a radioactivity of 200–400 Bq kg_1, and mud 700– 1000 Bq kg_1, in parts of the world [6,8]. Using RESRAD-BIOTA code , also for determination of BCG (Biota Concentration Guide) , which are determined by following equation:

BCG = Dose Limit (rad/year) /Internal + External Dose (Rad /year per PCi/Kg).

The BCG used to evaluate for unit concentration (e.g, 1 Pci Kg^{-1}) for single media (e.g., water), as sum of fractions approach for multiple media(e.g., sediment, water) and radionuclides[7]. Figure (1) shows the ResRad Biota levels of analysis corresponding to the graded approach[6] .

Figure(1) RESRAD Biota levels of analysis corresponding to the graded approach[6]



On the other hand (BCG) for aquatic animal could be Calculated by the following equation :

$$BCG\ (water)_{i,aquatic\ animal} = \text{ﬁ}\ 365.25\,\text{ﬁ}\,DL_{aa} / CF_{aa}\,\text{ﬁ}[(00.01\ \text{ﬁ}\ B_{iv,aa,I}\ \text{ﬁ}\ DCF)_{internal,I}\ (DCF_{external\ water})]$$

where;

BCG(water) $_{i,aquatic\ animal}$: is the concentration of nuclide in water which based on the screening level assumption, numerically equates to a dose rate of DL_{aa} (0.01 Gyd^{-1}) to the aquatic animal,

DL_{aa} (0.01 Gyd^{-1}): is the dose, limit for aquatic animals, 0.001 is the conversion factor for L to m^3,

B_{iv},aa,$_I$ (LKg^{-1}) : is The fresh mass aquatic animals to water concentration factor for nuclides,

$DCF_{internal,i}$ (Gyy-1perBqKg-1) : is the dose conversion used to estimate the dose conversion factor used to estimate the dose rate to the aquatic animal for submersions in contaminated water and all other terms have been defined,

$DCF_{external\ water}$: is the dose conversion used to estimate the dose conversion factor used to estimate the dose rate to the water.

On the other hand for calculating the dose conversion factors (DCFs), to be used in the RESRAD-BIOTA code the following assumptions are made:

1) Uniform concentration in source medium and exposed organism,

2) Source medium is infinite in extent ,

3) Exposed organisms are of different sizes and

4) Radiation considered include : dose factors for different organisms are: a) Calculation of absorbed fractions for photons and beta particles (electrons) of different energies for different organisms (dimensions) using MCNP (Monte Carlo Transport Code), b) Calculation of effective absorbed beta and photon fraction for each radionuclide, c) Comparison of absorbed fractions with available data, d) The absorbed fraction for alpha radiation for all geometries is assumed unity, e) Calculation of internal and external DCFs for alpha, high energy beta, photons, and low energy beta, and f) DCFs for all progenies of a parent nuclide are included[7]. For the derivation of dose factors (DFs) to be used in the RESRAD-BIOTA code, there are 8 representative geometries are listed in code for example: receptors, specific geometry dimensions applied, and specific mass also [7].

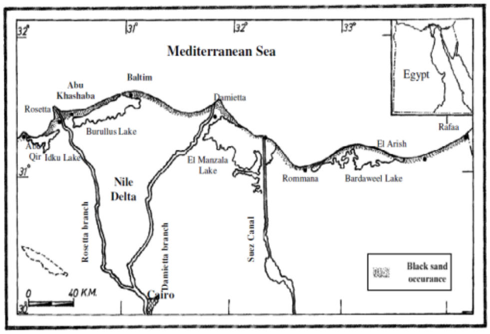


Fig.(2) Map of Abou-Qir bay showing the mediterain costal black sand[3]

RESULTS AND DISCUSSION

Table (1) showed the measured uranium radioactivity series of the Abou- bay which are ranged from 4.2 to 10.2 mBq/l (mBequrel/liter) with mean average 7.6 mBq/l. These limits are confirmed with Abeer Elsharty [3] which had observed that the limits of urnium series in Abou-Qir bay were $1.8x10^{-4}$ Bq/l but different with E.R. Atta and Kh. M. Zakaria [9] (14.1 Bq/l) .On the other hand table (1) showed that the measured radioactivity of ^{40}K is ranged from 8 to 33.4 Bequrel/ liter with mean average 16.58Bq/l. This limit is confirmed with Abeer Elshary [3] which had found that the limit of ^{40}K at abou qir bay was 14.0 $\pm$1.9 Bq/l but different with E.R. Atta and Kh. M. Zakaria [9] which had found that the average of K-40 at Abou –Qir Bay may reached 1273 Bq/l. This increasing of ^{40}K than the natural occurring radioactivity of sea water which is 11.6 Bq/l [10], may be related to potassium is an alkali metal, it behaves as a true soluble element and varies in proportion with respect to salinity. So the distribution of ^{40}K in surface seawater and in sediments has differences in their patterns due to the effect of salinity on the behavior of ^{40}K in surface seawater. Also this increase may be also related to the location of Abou-Qir fertilizer company, because there is a certain relation between fertilizers plant production and potassium isotopes release to environment. It was observed that the health hazard of K-40 is associated with cell damage caused by the ionizing radiation that resulted from radioactive decay, with general potential for subsequent cancer induction [3,7]. The Marine biota radionuclide concentration data, in conjunction with

Table (1) Measuring radioactivity concentration of uranium series and K-40 in the selected area in Abou-Qir Bay during Jan- Jul 2015

Time of measurement	Uranium series Radioactivity concentration In mBq/l	K-40 Radioactivity concentration In Bq/l
Jan	4.2	9
Feb	7.8	20.1
March	9.3	23
April	5.9	14
May	10.2	9
Jun	8.8	33
Jul	7.6	8
Mean average	7.68	16.58
Range	4.2-10.2	8-33
Standard deviation	$\pm$2.2	$\pm$9.2

It shows the relation between different uranium series in aquatic animal water and dose rate in Gy/d as shown in figure (3) , which exploring an increase of U-233 dose rate in different aquatic animals with $1x10^{-5}$ Gy/d than U-234(0.9×10^{-6}),U-235($0.87 x10^{-6}$) and U-238 the most smaller value with $0.83x 10^{-6}$ Gy/d . On the other hand figure (6) shows that the dose rate of K-40 in different aquatic animals is $15x10^{-10}$. Figure (4) shows that the different aquatic animals have Highest BCG (Biota Concentration Guide) value in case of U-238 with 8000 Bq/kg than U-235(7800 Bq/kg,U-234(7500 Bq/Kg) and U-233 with 7300 Bq/Kg . Figure (5) shows the determination of tissue concentration in case of K-40 it was found that the highest value of tissue concentration of aquatic animals was 0.15 Bq/Kg this related to the mean average radioactivity K-40 value of the selected area at Abou-Qir Bay which was 16.58 Bq/l. Figure (7) shows that the BCG of K-40 in different aquatic animals at selected area is $1x10^5$ Bq/m^3 .

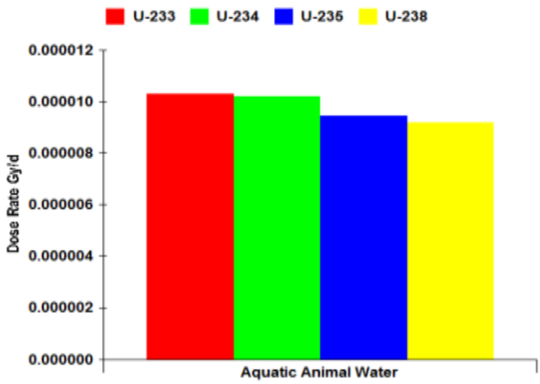


Figure (3) Relation between different dose rate of uranium series In different aquatic animal water

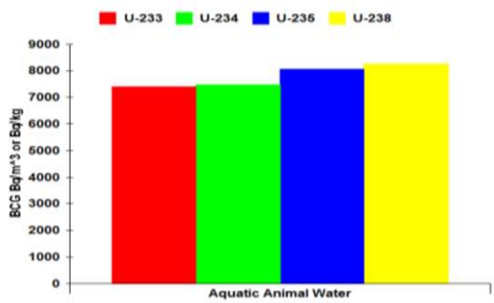


Figure (4) Relation between different BCG in Bq/m^3 of different Uranium series in different aquatic animals

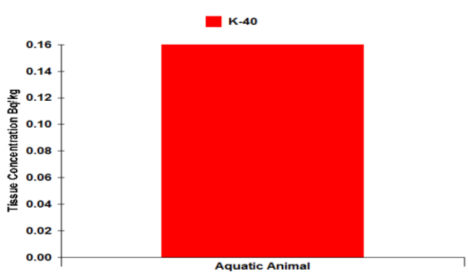


Figure (5) Determination of tissue concentration of K-40 in Bq/l in different aquatic animals

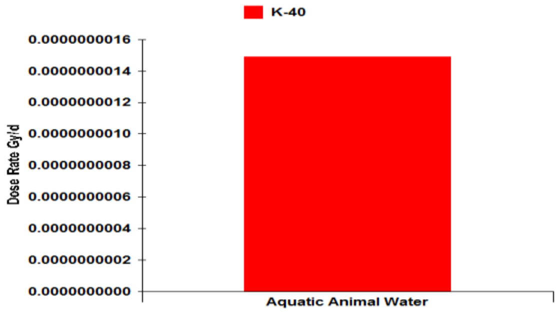


Figure (6) Determination of Dose rate of K-40 in Gy/day in different aquatic animals

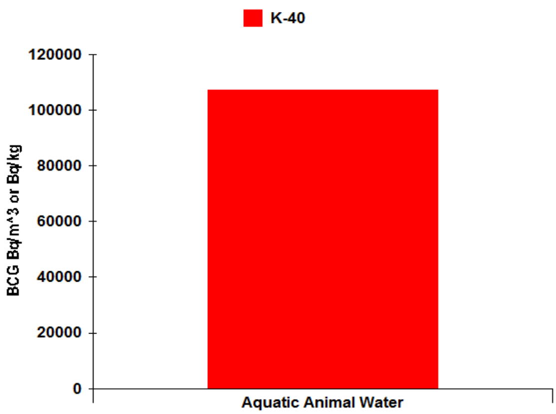


Figure (7) Determination of BCG of K-40 in Bq/ m^3 in different aquatic animal

Radionuclides present in the marine environment may then be available for biological uptake by marine biota and possible subsequent transfer through marine and marine/terrestrial webs. Indeed, some marine biota such as crustaceans, molluscs and marine algae exhibit very high uptake rates of certain anthropogenic and natural radionuclides[(12)]. while ^{137}Cs has been shown to biomagnify through marine food webs. The transfer of radionuclides in the marine environment can be quantified using concentration factors that are determined on the basis of the activity concentration ratio of a radionuclide between the organism of interest and the surrounding seawater as shown in the following equation: Concentration Factor of radionuclide = Concentration of radionuclide in biota (Bq/kg w.w.) / Concentration of radionuclide in sea water (Bq/l)[(12)].

CONCLUSION

1- Some marine biota such as crustaceans, molluscs and marine algae exhibit very high uptake rates of certain anthropogenic and natural radionuclides.
2- evaluating the tissue concentration of certain radionuclides that the marine living organism has uptake it inside its tissues using simulating software (RESRADBIOTA1.5 is an effective tool.
3- the measured uranium radioactivity series of the Abou- bay and ^{40}K showed that an increase in mean average value of ^{40}K this increase may be related to the location of Abou-Qir fertilizer company, because there is a certain relation between fertilizers plant production and potassium isotopes release to environment.
4- The modeling results showed that the different aquatic animals have highest BCG (Biota Concentration Guide) value in case of U-238 with 8000 Bq/kg than U-235(7800 Bq/kg,U-234(7500 Bq/Kg) and U-233 (7300 Bq/Kg).
5- The modeling results of tissue concentration in case of K-40, found that the highest value of tissue concentration of aquatic animals was 0.15 Bq/Kg, this value related to the mean average of radioactivity of K-40 which obtained in the selected area at Abou-Qir Bay which was 16.58 Bq/l.

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