International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

Assessment of Heavy Metals and Natural Radionuclides Accumulation for Marine Organisms at Alexandria, Egypt

Atta E. R.[1], Madbouly A. M.[2], Zakaria Kh. M.[3]

Egyptian Nuclear and Radiological Regulatory Authority, Postal code: Nasr City 11762, P.O.Box. 7551., Cairo, Egypt

Abstract: ***The present study aims to quantify the distribution of some heavy metals (Pb, Cd, Ni, Mn, Cr, Cu, Co and Zn ions) and natural radionuclides (^{238}U-series, ^{232}Th-series and ^{40}K) in some marine organisms and water samples in the Alexandria Mediterranean Sea coastline. As well as assessment the heavy metals impacts and the radiological impacts of the detected radionuclides on Marine organism. Five locations are selected for this study and they are El-Mex, Eastern Harbour, El-Dekhila, Abu-Qir and Rashid. The investigated marine organisms areFish (Engraulisencrasicolus), Sepia Officianalis, Crabs, Diatom Amphora, Om-Elkhlol "Donaxtrunculus, and Gandofelly" Tapes decussates. Determination of heavy metals in the investigated organisms and water samples has been carried out using atomic absorption spectrophotometer. Also the laboratory investigations for radionuclides in the organism and the water samples have been carried out using a HpGe gamma ray spectrometric technique. The seawater samples in all studied locations have very high concentration of Zn and Mn ions, and the concentrations of the investigated heavy metal ions have the following order: Zn> Mn> Pb> Co> Cr> Cu> Ni> Cd. In all locations, the concentrations of Cr ions nearly coincident with that of worldwide average values, while other heavy metal ions are very high than the worldwide average values, USEPA. The concentrations of heavy metals in the investigated marine organisms discernthat Mn ions do not accumulated in any investigated marine organisms in compared to worldwide average values by the USEPA. Fish (Engraulisencrasicolus), Sepia OfficianalisandOm-Elkhlol "Donaxtrunculusareable to highly accumulate Ni and Co ions. Crab and Diatom Amphoraareable to highly accumulate Pb, Cd, Ni, Cr and Co ions.Cu ions do not accumulate in any investigated marine organism except Diatom Amphora in Rashid and Abu-Qir locations. Diatom Amphorais able to accumulate Zn ions than any investigated marine organisms. High levels of ^{238}U-series, ^{232}Th-series and ^{40}K in water samples are recorded in Rashid location and they equal 15.71±0.83, 13.8±1.27 and 185.8±8.42 mBq/l, respectively. Also in this location Fish Engraulisencrasicolus has high level of ^{238}U equals 55mBq/kgbut Sepia Officianalis has high level of both ^{238}Uequals 34 mBq/kgand ^{232}Th equals 35 mBq/kgas well as the Diatom Amphora record high activity of ^{40}Kequals 340±19mBq/kg, than other organisms. Bioconcentration factors (BCF) of the investigated heavy metals and radionuclides for the studied organisms were calculated. The investigated marine organisms have bio-accumulative properties towards most of the investigated heavy metals and radionuclides. The concentration levels of the heavy metals found in this study do not constitute a risk factor for the marine organisms and appear to be accommodating with the worldwide values by the USEPA. Concentrations of ^{238}U-series, ^{232}Th-series and ^{40}K in both water and marine organisms are accommodate with worldwide values.***

Keywords: Heavy metals, Radionuclides, Marine Organisms, Bioconcentration factor

1. Introduction

Marine organisms can accumulate trace metals from the dissolved phase and from ingested food [1]. Metals enter the environment naturally as a result of chemical and physical weathering of rocks, leaching of soils, vegetation, and volcanic activity [2]. Both anthropogenic and natural processes can contribute to the trace metal contamination in the coastal sediments [3].Marine food such as fish, prawn, crab and mussel are delicacies and form an important staple part of daily food chain [4]. The tendency of heavy metals to get is of scientific interest in heavy metals chemistry. The bioavailability and accumulation of heavy metals in marine organisms is the key factor for determining tissue metal levels in the marine biota [5].A number of natural disturbances influence the marine environment of Mediterranean- Alexandria area including the pollution by: oil spills, wastewater discharge, effluents of desalination plants, building activities along the seashore, marine traffic, landfilling and dredging operations. Several studies on marine organisms and marine-sediments of the Egyptian Mediterranean Sea have been carried out [6].The bioaccumulation of radioactive materials refers to a process by accumulating in various tissues of a living organism. The naturally occurring radionuclides are relatively and uniformly distributed in the seas and the oceans [7].Human activities like mining and milling of mineral ores, reprocessing and enrichment, nuclear fuel fabrication and handling of the fuel cycle tail end products cause release of additional amounts of natural radionuclides into the environment. Also, the discharge into the sea of low level waste from nuclear industry has become a source of contamination in the marine coastal environment of countries possessing nuclear power plants and nuclear reprocessing plants [8].Most of the radioactivity deposited on surface sediments are washed by rains and drained through rivers to the oceans. Part of the ground deposited activity is absorbed in the soils and percolates with the underground waters to the oceans. Radionuclides reaching the ocean become part of the marine ecosystem (water, sediments, and biota) and may transfer through seawater-sediment-biota interface to human [9]**.** Accumulation of such substances in the marine costal environment raises many problems concerning safety of biotic life, food chain and ultimately humans. To address these problems, assessment of radioactivity concentration in the marine environment is essential. It is necessary to quantify the distribution of radionuclides in the main marine constituents (sea water and marine organisms) and to assess radiological impacts of the detected radionuclides on human health. Bioconcentration

Licensed Under Creative Commons Attribution CC BY

factor of an organism can be calculated to estimate the amount of heavy metal input to the organism from the surrounding environment. Bioconcentration is defined as the net result of the absorption, distribution and elimination of a substance in an organism, after an exposure via water. The bioconcentration factor is the ratio between the chemical concentration in the organism and the chemical concentration in water, at equilibrium [10].

$$BCF_{organism} = \frac{C_{organism}}{C_{water}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where: $BCF_{organism}$ is the bioconcentration factor for the test organism,
$C_{organism}$ is the chemical concentration in organism in mg/kg, and
C_{water} is the chemical concentration in water, in mg/l(OECD)[11].
The present study aims to quantify the distribution of some heavy metals and natural radionuclides (^{238}U-series, ^{232}Th-series and ^{40}K) in some marine organisms and water samples in the Alexandria Mediterranean Sea coastline. As well as assessment the heavy metals impacts in addition toradiological impacts of the detected radionuclides on human health.

2. Materials and Methods

2.1. Study area

The investigated area (110km along) expanded along the coast of Alexandria, from Al-Max 31^o.08' .11" N to 29^o. 5'. 02" E in west to Abu-Qir 31^o .17' . 20"N to30^o . 08'.23" E in east and stretches to Rashid coast city 31^o.21' .18" N to 30^o.18' .20" E.

2.2. Sampling and sample preparation

Collected samples in the coastline study area occurred during spring 2013. Five representative water samples were collected by using water sampler. The marine organisms samples of Fish (Engraulisencrasicolus), Sepia Officianalis, Crabs, Diatom *Amphora*, Om-Elkhlol "Donaxtrunculus" and Gandofelly, Tapes decussates were collected in the study area and transported to the laboratory in ice boxes and stored at (-10^{o}C) until subjected for further analysis, about 15 individuals of each species were collected from the study area; at the same locations of the selected water samples. The samples of marine organisms were then cut into smaller pieces to ensure effective grinding .The cleaned samples were dried in an oven at70 ^{o}C for five days (until there was no detectable change in the mass of the samples)to ensure that the sample were completely moisture free, a constant dry weight being obtained. Dried samples were ground to fine grain sizes by using a stainless steel cutter blender, and sieved in order to obtain homogeneity. All homogenized samples were then transferred into 250 ml sizes Marneli beaker, sealed hermetically, and left for about 4 weeks at room temperature in order to attain secular equilibrium among the ^{238}U-series and ^{232}Th-series precursors with their short–lived progenies[12].

2.3. Determination of heavy metals in Sea water and marine organisms samples

The heavy metals concentrations in the investigated sea water and marine organisms samples were measured using computer controlled Atomic Absorption Spectrophotometer (Shimadzu 6701F System manufactured in Germany). The instrument setting and operational conditions were done in accordance with the manufacturers 'specifications. All determinations were in triplicates.

2.4- Radioactivity measurements for Sea water and marine organism's samples

A gamma ray spectrometer in the laboratory of Egyptian Nuclear and Radiological Regulatory Authority was used to estimate the activity levels of the ^{238}U-series, ^{232}Th-series and ^{40}K in the investigated sea water and organism samples..The γ -ray spectra of the samples were collected using a high resolution CANBERRA coaxial hyper pure germanium (HpGe) detector. Standard sources of natural Uranium (1997.56Bq), natural Thorium (1237.28 Bq) and KCl (5181.59 Bq) with a standard 250ml container from International Atomic Energy Agency (IAEA) were used for calibrating the gamma ray spectrometer. For the ^{238}U- series they are 351.9 keV (^{214}Pb), 609.3 keV (^{214}Bi), 1120.3 keV (^{214}Bi) and 1764.5 keV (^{214}Bi). For the ^{232}Th-series, they are 338.4 keV (^{228}Ac), 583 keV (^{208}Tl), 911.1 keV (^{228}Ac), and 968.9 keV (^{228}Ac)[13].

3. Results and Discussion

1- Activity of radionuclides in the investigated sea water samples

Table 1 shows the radionuclide activities of ^{238}U-series, ^{232}Th-series and ^{40}K in different locations at Alexandria coastline. It is clear that high levels of ^{238}U-series, ^{232}Th-series and ^{40}K are recorded in Rashid location and this could be explained as due to the presence of black sands, which are enriched in the mineral monazite containing a significant amount of ^{238}U-series, ^{232}Th-series and ^{40}K. The concentrations of ^{238}U-series nuclides in Rashid are15.71mBq/L. On the other hand decreased concentration value of ^{238}U-series , ^{232}Th-series and ^{40}K in marine water are recorded in El-Mex and Eastern Harboursites and this may be due to the presence of some organic and polymers discharged from industrial facilities into these area, so these compounds acting chelating materials and scavengers for radionuclides. This reaction lead to radionuclide remediation specially of low level contamination, and take place under physical and chemical marine environmental condition as , pH, temperature, salinity, tidal waves and other geo-chemical factors [14]. It is also the table reveals that the activity of ^{232}Thin El-Mex , Eastern Harbour, El-Dekhila, Abu-Qir and Rashid locations are 4.18 ±0.02, 7.3±0.33, 9.24±0.55, 6.86±0.04and 13.8±1.2 mBq/L respectively, and the results show that the mean activity of ^{40}K in El-Mex , Eastern Harbour, El-Dekhila, Abu-Qir, Rashidlocations are 98.04mBq/L, 125.33mBq/L, 88.24mBq/L, 130.55mBq/L, 185.8mBq/L consequently, this values are low when compared with worldwide average values, where ^{40}K recorded 350mBq/L in the Mediterranean Sea [15, 16].The obtained results were compared with published data from

Licensed Under Creative Commons Attribution CC BY

some countries [15, 16], where the ^{238}U-series level recorded in the Mediterranean Sea 22mBq/L, also ^{238}U recorded in Caribbean Sea, Black Sea, Red Sea and Baltic Sea 25mBq/L, 27mBq/L, 25 mBq/L and 30mBq/L, consequently. It is important to note that the sea water and ocean contain large quantities of radionuclides, both naturally occurring and originating from the atmospheric testing of nuclear weapons. The occurrence of such nuclides is, of course, of no direct relevance the calculations made for radiological protection purposes, but, nevertheless, such data provide a useful background to the use of the oceans for radioactive waste disposal [17]. Boissonet al, 1997 reported that large variation of radionuclides in marine water may be due to the continuous wave action, as the waves reaches up to about 10m from the waterline during high tide and results in the fresh deposition of heavy minerals along the seashore [18].

Table 1: Concentration of ^{238}U-series, ^{232}Th-series and ^{40}Kin seawater samples

	Locations				
	El-Mex	Eastern Harbour	El-Dekhila	Abu-Qir	Rashid
Radionuclides	Water (mBq/L)	Water (mBq/L)	Water (mBq/L)	Water (mBq/L)	Water (mBq/L)
^{238}U-series	6.08 ±0.01	5.33±0.03	11.18±0.94	9.22±0.88	15.71±0.83
^{232}Th-series	4.18 ±0.02	7.3±0.33	9.24±0.55	6.86±0.04	13.8±1.27
^{40}K	98.04±2.4	125.33±4.1	88.24±5.2	130.55±4.52	185.8±8.42

Table 2: Worldwide average values of ^{238}U, ^{232}Th and ^{40}K in sea water(IAEA, 2000& US EPA, 1997)

Location	Mean activity		
	^{238}U-series (mBq/L)	^{232}Th-series (mBq/L)	^{40}K (mBq/L)
The Mediterranean Sea	22	30	350
The Caribbean Sea	25	35	320
The Black Sea	27	37	275
The Red Sea	25	36	325
The Baltic Sea	30	33	400

2- Activity of radionuclides in the investigated marine organisms

Figures (1, 3, 5, 7, 9) show the activity of ^{238}U-series and^{232}Th-series in the studied marine organisms at different investigated locations. It is recognize that Gandofelly "Tapes decussates, Craband, Sepia Officianalis are preferentially accumulate naturally occurring ^{238}U-series compared to Om-Elkhlol "Donaxtrunculus, Fish and Diatom *Amphora*. The concentration of ^{238}U-series in Gandofelly, Crab, Sepia, Om-Elkhlol, Fish and Diatom *Amphora* are9.3±1.1 mBq/kg, 8.7±0.74 mBq/kg, 6.2±0.52mBq/kg, 3.2±0.12mBq/kg, 4.5±0.43mBq/kg and 4.9±0.46mBq/kg, respectively. Also the activity of^{232}Th-series in Fish, Sepia Officianalis, Crab, DiatomAmphora, Om-Elkhlol "Donaxtrunculus and Gandofelly "Tapes decussates are 1.82±0.21 mBq/kg, 2.4±0.32 mBq/kg, 1.42±0.22 mBq/kg, 2.7±0.33mBq/kg, 1.3±0.11mBq/kgand 3.2±0.42mBq/kg, respectively. Also it is clear that the investigated marine organisms have low concentration of ^{232}Th-series in compared to worldwide average values. By comparing the obtained results with that in table 3; it can be speculated that such differences may be attributable to a number of biological, ecological and physicochemical factors [19]. Other biological reasons may be evoked such as the position of the marine organisms in the food-chain that may result in different susceptibilities to accumulate nuclides and the physiology of the fish itself. This may combined with the specific affinities of the radionuclides for some tissues and/or species leads to a singular biological availability for each nuclide in each marine organisms species [20].The present study also shows the activity of ^{40}K in marine organisms in different locations at coastline of Alexandria, Figures (2, 4, 6, 8, 10), the data reveals higher activity of ^{40}K in Rashid fig (6), El-Dekhila fig. (8) and Eastern Harbor fig. (10) locations than El-Mexfig(2) and Abu-Qir fig(4)locations. The Diatom Amphora, Crab and Sepia Officianalis, record high activity in ^{40}K at Rashid location and they are340±19.4 mBq/Kg, 305±17.6 mBq/Kg and 255±13.5 mBq/Kg, respectively. Also ^{40}KinEl-Dekhilalocationrecord high activity in Diatom *Amphora*, Crab and SepiaOfficianalis 355±19.8 mBq/Kg, 310±16.3 mBq/Kg and340±19.5 mBq/Kg. Increasing the activity of^{40}K in Rashid may be due to presence black sand in this site contained more ^{40}K quantity than other sites, also in El-Dekhila site, the industrial activities and the processing of shipping harbours enhancement ^{40}K concentration. These results agreement with that reported by confirmed Mohanty et al., 2004, which they had shown that the shipping Harbors activities and also petroleum industry in marine sea enhancement^{40}K concentration and with remarkable concentration for NORM and TENORM activity[21, 22, 23].

Licensed Under Creative Commons Attribution CC BY

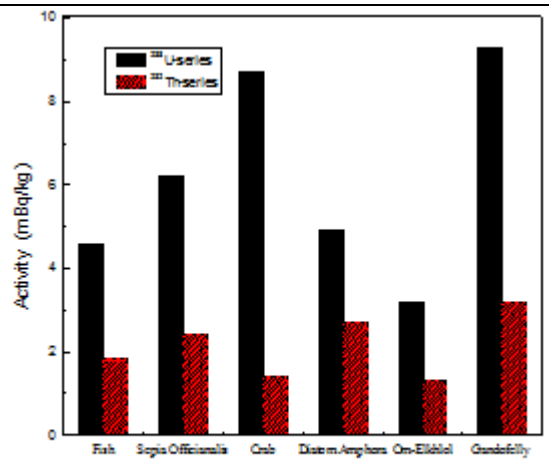

Fig.(1): Activity of ^{238}U -series and ^{232}Th-series in marine organisms at El-Mex location.

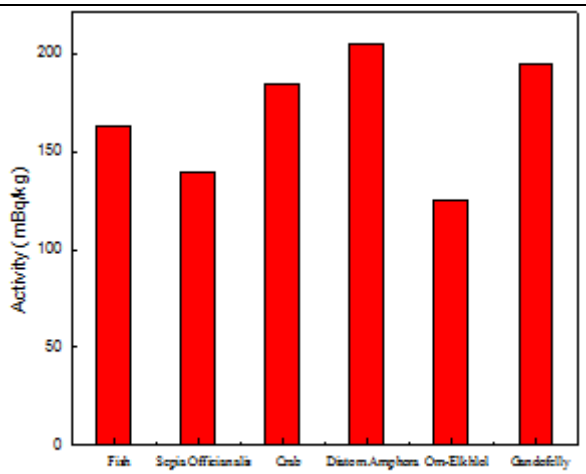

Fig.(2):- Concentrations of ^{40}K in marine organisms from El-Mex site

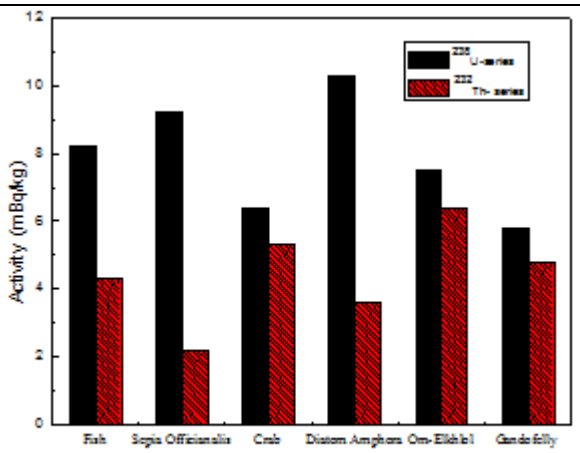

Fig.(3): Concentrations of ^{238}U-series and ^{232}Th series for marine organisms in Abu-Qir site.

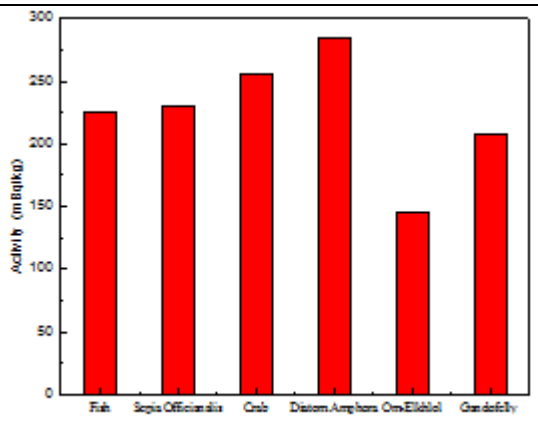

Fig.(4): Concentrations of ^{40}K activities from some marine organisms in Abu-Qir site.

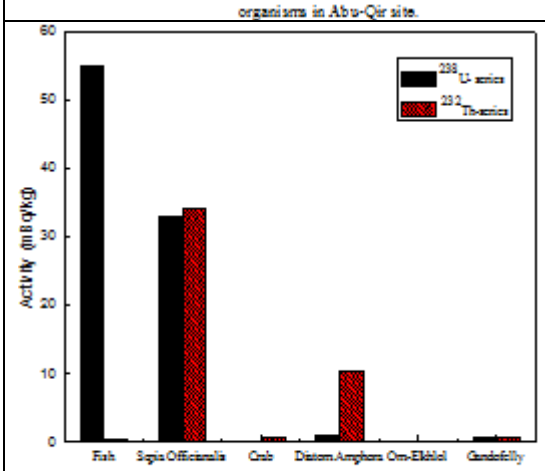

Fig. (5): Concentration of ^{238}U series and ^{232}Th series for marine organisms in Rashid site.

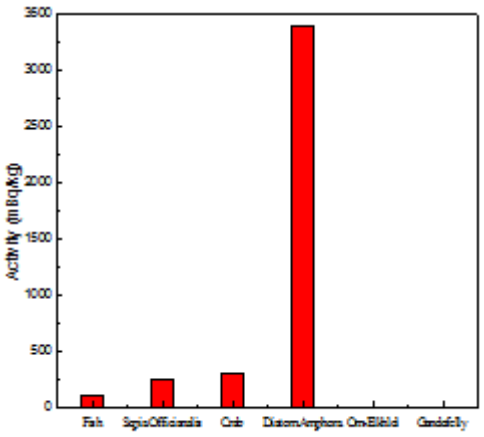

Fig (6): Concentrations of ^{40}K for marine organisms in Rashid site

Licensed Under Creative Commons Attribution CC BY

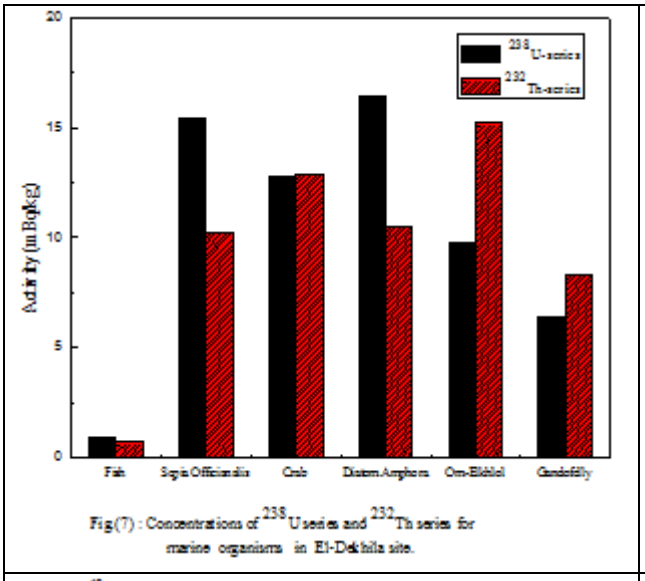

Fig.(7) : Concentrations of ^{238}U series and ^{232}Th series for marine organisms in El-Dekhila site.

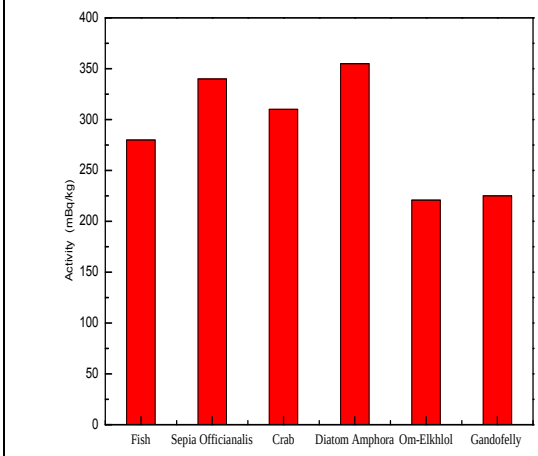

Fig.(8): Concentrations of ^{40}K. for marine organisms in El-Dekhila site.

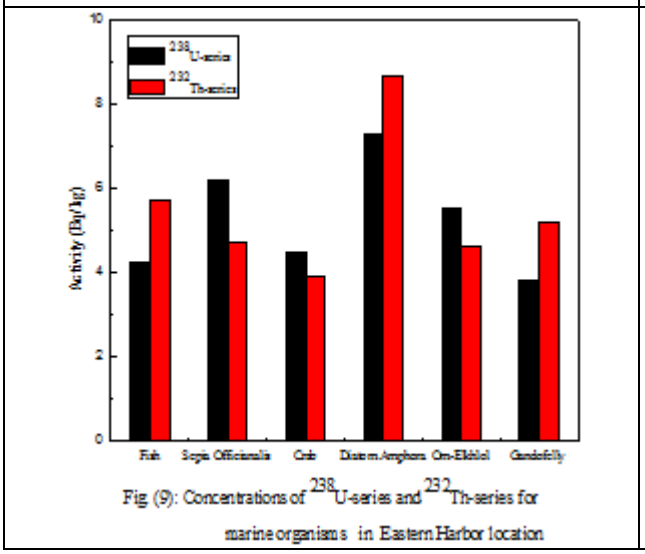

Fig. (9): Concentrations of ^{238}U-series and ^{232}Th-series for marine organisms in Eastern Harbor location

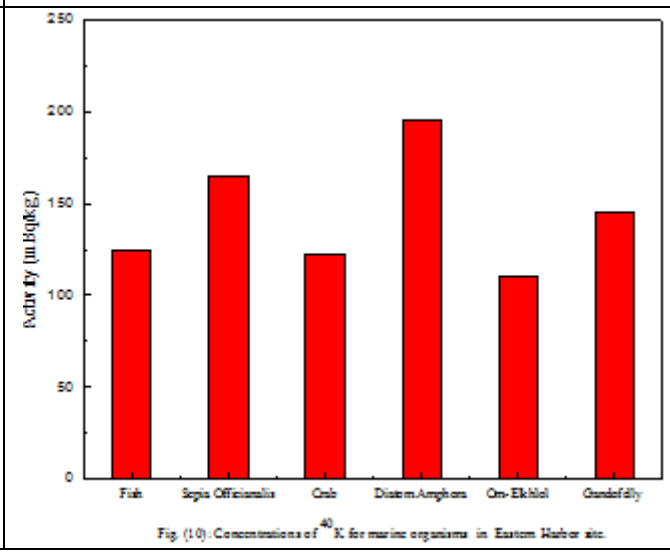

Fig. (10): Concentrations of ^{40}K for marine organisms in Eastern Harbor site.

Table 3: worldwide average values of ^{238}U, ^{232}Th and ^{40}K in some marine biota in Mediterranean sea water, (IAEA, 2000&USEPA, 1997)

Location	Marine organisms	Activity concentrations (mBq/kg dry weight)		
		^{238}U-series	^{232}Th-series	^{40}K
Mediterranean Sea	Fish (Engraulisencrasicolus)	22	43	101
	Sepia Officianalis	35	38	125
	Crab	30	45	112
	Diatom Amphora	18	47	120
	Om-Elkhlol "Donaxtrunculus	9	55	135
	Gandofelly "Tapes decussates	25	60	140

3- Bio concentration factor (BCF) for the investigated radionuclides in the investigated marine organisms

BCF for natural radioactive material lin an organism= $\frac{C_{\text{natural radioactivity in organism}}}{C_{\text{natural radioactivity in water}}}$ ---------- (2)

The bio concentration factors for the investigated radioactive materials in marine organisms in El-Mix and Abu-Qir locations are illustrated in figs (11, 12).The figures reveal that all the investigated marine organisms have highly bio concentration factors for ^{238}U-series, on the other hand the lowest values of bioconcentration factors for ^{232}Th-series in all the investigated marine organisms are recognized, while they have intermediate values of bio concentration factors for ^{40}K. The bio concentration factors are ranged between 0.20and 0.6 l.Kg^{-1}. At El-Mex location, Crab and Gandofelly have higher BCF for ^{238}U than all the other marine organisms and they reached up to 0.6 Kg^{-1}. At Abu-Qir location, Diatom *Amphora* and Sepia Officianalis have higher BCF for ^{238}U than all the other marine organisms and they reached up to 0.6 lKg^{-1}.The bio concentration factors for the investigated radioactive materials in marine organisms in Rashid and Eastern Harbour locations are illustrated in figs (13, 14).The figures reveal that all the investigated marine organisms have highly bio concentration factors for^{232}Th, on the other hand the lowest values of bio

Licensed Under Creative Commons Attribution CC BY

concentration factors for ^{40}Kin all the investigated marine organisms are recognized, while they have intermediate values of bio concentration factors for^{238}U-series. At Rashid location recorded highly BCF for^{232}Th-series this may be due to presence black sand sedimentations which contain large quantity of^{232}Th-series.Diatom*Amphora*and Carb recorded highly bio concentration factor. At Eastern Harbour location Diatom *Amphora* and Om-Elkhlol recorded highly bio concentration factor.The bioconcentration factors for the investigated radioactive materials in marine organisms in El-Dekhila location are illustrated in fig (15).The figure reveals that all the investigated marine organisms have highly bio concentration factors for^{238}U, on the other hand the lowest values of bio concentration factors for ^{40}K in all the investigated marine organisms are recognized, while they have intermediate values of bio concentration factors for^{232}Th-series.Diatom *Amphora*, Sepia Officianalis have highly value of bio concentration factor for ^{238}U-series. The obtained results are agreement with that reported with Friedlander et al., 2005[24].For most radionuclides, the food chain is assumed to be the primary uptake pathway **[25].** The bioaccumulation capabilities of this biota were expressed by Bioconcentration Factor (BCF). Bioaccumulation factors (BAFs) are commonly used to predict contaminant concentrations in biota from concentrations in water. Concentration factors (CFs) or Bioconcentration Factor (BCFs) for aquatic biota as defined in IAEA are equivalent to BAFs (bioaccumulation factors [26].

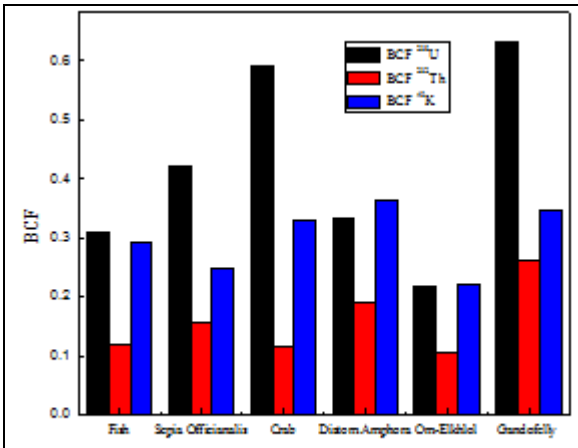

Fig.(11) :Bio concentration factors (BCF) for natural radioactivity in marine organisms at El-Mex site.

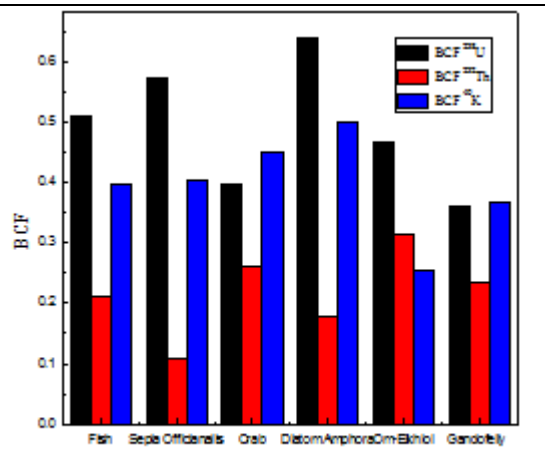

Fig.(12): Bio concentration factors (BCF) for natural radioactivity in marine organisms at, Abu-Qir.

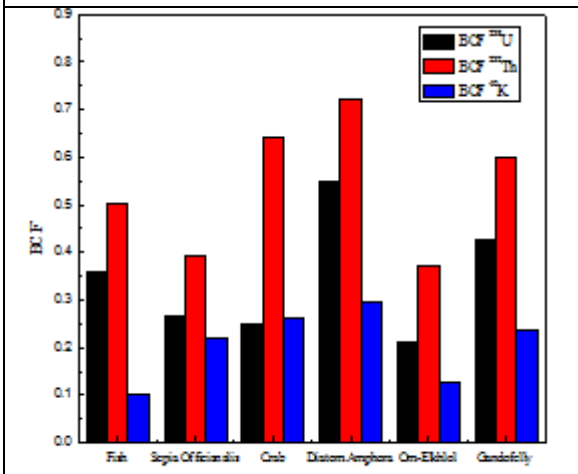

Fig. (13): Bio concentration factors (BCF) for natural radioactivity in marine organisms at Rashid sites.

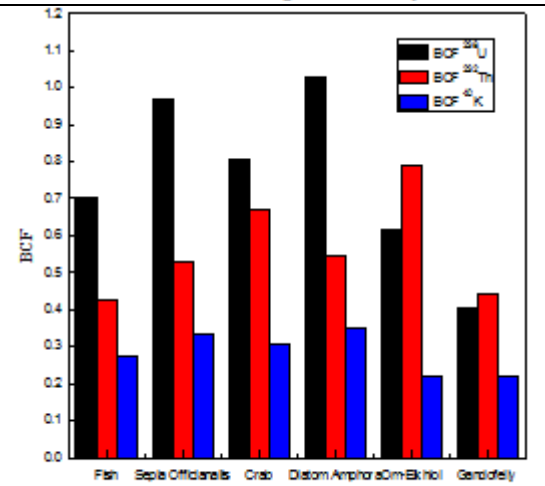

Fig.(14): Bio concentration factors (BCF) for natural radioactivity in marine organisms at El-Dekhila site.

Licensed Under Creative Commons Attribution CC BY

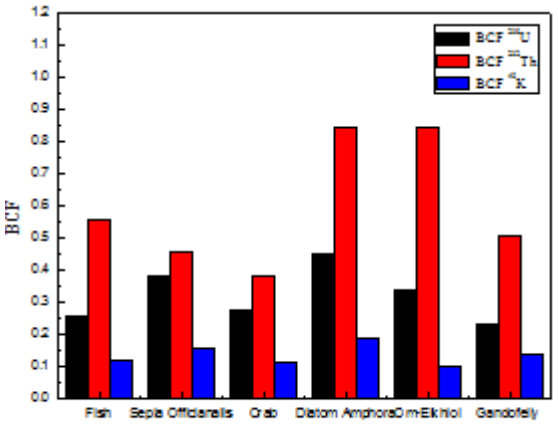

Fig. (15): Bio concentration factors (BCF) for natural radioactivity in marine organisms at Eastern Harbor sites

4- Concentrations of heavy metals in the investigated sea water samples

Some heavy metals concentrations of the investigated seawater samples in Alexandria coastline are shown in table (4). It is recognizable that the concentrations of the investigated ions have the following order: Zn>Mn>Pb>Co>Cr> Cu>Ni>Cd. It is noticeable that concentrations of Cr ions in all locations nearly coincident with that of worldwide average values, table (5). The Pb, Cd, Ni, Mn, Cu, Co and Zn ions are highly concentrated in all investigated locations than worldwide values.

It is clear that Zn and Mn ions are very high concentration in all investigated locations. Concentrations of Cd ions are the lowest in all locations. Ni and Cu ions are record the same concentration levels, and they are very high at Rashid and El-Dekhila locations. The concentration of both Pb and Cr ions are consonantin all locations and they are very high at Rashid and El-Dekhila locations. Increasing of heavy metal ions in El-Dekhila and Rashid locations may be attributed to industrial and agricultural discharge [27]. Increasing of heavy metals in Eastern Harbor location may be due to the effect of ships discharges which used antifouling paints. In Abu-Qir and El-Mex locations it is recognizable that most of the investigated heavy metals are decreased in concentration and this can be interpreted in the light of the effect of sediment texture, clay content, organic carbon, iron hydrous oxides and carbonates; the two locations contain large sediment and clay content [28].

Table 4: Concentration of the investigated heavy metals (µg/L)in marine water samples

Heavy metal µg/L	Site				
	El-Mex	Abu-Qir	Rashid	El-Dekhila	Eastern Harbor
	Mean± S.D	Mean± S.D	Mean± S.D	Mean± S.D	Mean±S.D
Pb	34.6±7.2	25.3±4.1	38.7±4.8	40.5±5.1	22.7±4.6
Cd	2.4 ±0.2	3.8±0.9	4.8± 1.1	6.7± 1.4	1.4± 0.05
Ni	16.2±2.3	13.7±2.1	15.4± 1.9	21.8± 3.2	10.5± 1.2
Mn	170.4±11.1	155.6±9.2	188.4±12.8	140.7±8.2	195.2±15.7
Cr	22.7±2.1	15.9 ±1.8	13.5 ±1.2	35.9 ±4.6	21.8 ±1.9
Cu	15.3±2.3	18.4±3.1	22.7±4.2	36.8±4.8	12.3±1.6
Co	34.6±7.2	22.8±2.8	15.7±2.3	45.6±8.5	18.2±1.9
Zn	223.5±13.8	280.7±15.6	190.4± 11.6	176.8± 9.5	166.3± 8.7

Table 5: worldwide average values for heavy metals in sea water, US EPA (1997).

Location	Mean concentration of Heavy metal ions, µg/L							
	Pb	Cd	Ni	Mn	Cr	Cu	Co	Zn
The Mediterranean Sea	0.19	0.22	12.4	4.7	22.4	0.92	10.3	42.7
The Caribbean Sea	0.21	0.34	10.2	3.2	25.2	0.47	8.2	45.2
The Black Sea	0.18	0.38	13.7	6.2	33.7	0.83	7.7	39.4
The Red Sea	0.16	0.21	11.3	8.4	19.4	0.57	9.2	40.2
The Baltic Sea	0.34	0.42	17.4	9.7	38.2	1.24	15.7	52.8

5- Concentration of heavy metals in marine organisms

The concentrations of heavy metals in the investigated marine organisms are illustrated in tables (6-10).Generally it is recognize that Mn ions do not accumulated in any investigated marine organisms in compared to worldwide average values table (11). Fish (Engraulisencrasicolus), Sepia Officianalis and Om-Elkhlol "Donaxtrunculus are able to highly accumulate Ni and Co ions in compared to worldwide average values. The highly concentrations for Ni and Co ions are spreading in industrial locations [29].Crab and Diatom *Amphora* are able to highly accumulate Pb, Cd, Ni, Cr and Co ions in compared to worldwide average values. Cu ions do not accumulate in any investigated

Licensed Under Creative Commons Attribution CC BY

marine organism except Diatom *Amphora* in Rashid and Abu-Qir locations. Diatom *Amphora* is able to accumulate Zn ions than any investigated marine organisms. These results agreement with that reported with Chouba, et al., 2007 and MacFarlane & Burchettt, 2000; [30, 31]. The contribution of the obtained results of the toxic heavy metals concentrations in the investigated marine organisms may be due to the action bioavailability and physical/chemical forms of those metals with feeding network in marine ecosystem [32, 33].

Table 6: Concentration of heavy metal in the investigated marine organisms in El-Mexsitelocation

Marine organisms	Concentration of heavy metal (µg/g dry weight)							
	Pb	Cd	Ni	Mn	Cr	Cu	Co	Zn
Fish (Engraulisencrasicolus)	0.14 ±0.002	0.59 ±0.006	8.55 ±0.011	1.35 ±0.058	9.47 ±0.052	1.55 ±0.013	1.45 ±0.021	22.31 ±2.3
Sepia Officianalis	0.24 ±0.004	0.68 ±0.007	4.5 ±0.025	0.65 ±0.0012	6.25 ±0.038	2.37 ±0.015	2.85 ±0.03	25.78 ±0.85
Crab	0.33 ±0.002	0.95 ±0.008	33.47 ±0.24	2.38 ±0.066	37.44 ±0.68	5.66 ±0.029	11.52 ±0.081	8.62 ±0.42
Diatom *Amphora*	0.75 ±0.005	0.92 ±0.007	43.65 ±0.57	1.22 ±0.043	48.24 ±0.75	7.58 ±0.038	15.27 ±0.092	18.66 ±1.74
Om-Elkhlol "Donaxtrunculus	0.5 ±0.001	0.18 ±0.003	6.55 ±0.031	0.35 ±0.0027	6.66 ±0.047	4.22 ±0.031	4.32 ±0.025	5.53 ±0.35
(Gandofelly "Tapes decussates	0.6 ±0.002	0.25 ±0.003	9.27 ±0.014	0.57 ±0.0049	4.55 ±0.011	5.69 ±0.037	5.19 ±0.022	2.74 ±0.12

Table 7: Concentration of heavy metal in the investigated marine organisms in Eastern Harbor location

Marine organisms	Concentration of heavy metal (µg/g dry weight)							
	Pb	Cd	Ni	Mn	Cr	Cu	Co	Zn
Fish (Engraulisencrasicolus)	0.22 ±0.001	0.57 ±0.004	30.47 ±0.25	0.55 ±0.0013	25.33 ±0.47	2.44 ±0.026	6.33 ±0.031	15.22 ±1.2
Sepia Officianalis	0.12 ±0.001	0.23 ±0.003	7.77 ±0.08	0.85 ±0.0022	33.42 ±0.75	4.64 ±0.035	2.85 ±0.009	13.65 ±0.85
Crab	0.65 ±0.008	0.12 ±0.002	9.72 ±0.058	1.77 ±0.0075	12.64 ±0.22	1.77 ±0.028	4.74 ±0.05	8.62 ±0.42
Diatom *Amphora*	0.20 ±0.003	0.85 ±0.006	6.58 ±0.024	0.96 ±0.0033	15.78 ±0.32	8.22 ±0.15	3.53 ±0.015	18.66 ±1.74
Om-Elkhlol "Donaxtrunculus	0.15 ±0.002	0.11 ±0.002	4.64 ±0.015	0.89 ±0.0044	8.99 ±0.11	3.72 ±0.027	7.66 ±0.035	5.53 ±0.35
(Gandofelly "Tapes decussates	0.11 ±0.001	0.22 ±0.001	12.59 ±0.095	0.45 ±0.0011	17.88 ±0.43	2.96 ±0.025	2.66 ±0.012	2.74 ±0.12

Table 8: Concentration of heavy metal in the investigated marine organisms in El-Dekhila location

Marine organisms	Concentration of heavy metal (µg/g dry weight)							
	Pb	Cd	Ni	Mn	Cr	Cu	Co	Zn
Fish (Engraulisencrasicolus)	0.45 ±0.007	0.59 ±0.006	8.55 ±0.011	1.35 ±0.058	9.47 ±0.052	1.55 ±0.013	1.45 ±0.021	22.31 ±1.16
Sepia Officianalis	0.74 ±0.008	0.68 ±0.007	4.5 ±0.025	0.65 ±0.0012	6.25 ±0.038	2.37 ±0.015	2.85 ±0.03	35.77 ±1.28
Crab	0.46 ±0.005	0.95 ±0.008	33.47 ±0.24	2.38 ±0.066	37.04 ±0.68	5.66 ±0.029	11.52 ±0.081	44.12 ±1.55
Diatom *Amphora*	0.83 ±0.008	0.92 ±0.007	43.65 ±0.57	1.22 ±0.043	48.14 ±0.75	7.58 ±0.038	15.27 ±0.092	65.43 ±2.38
Om-Elkhlol "Donaxtrunculus	0.15 ±0.003	0.18 ±0.003	6.55 ±0.031	0.35 ±0.0027	6.36 ±0.047	4.22 ±0.031	4.32 ±0.025	18.55 ±0.99
(Gandofelly "Tapes decussates	0.9 ±0.001	0.25 ±0.003	9.27 ±0.014	0.57 ±0.0049	4.55 ±0.011	5.69 ±0.037	5.19 ±0.022	32.85 ±1.24

Licensed Under Creative Commons Attribution CC BY

Table 9: Concentration of heavy metal in the investigated marine organisms in Abu-Qirsite location

Marine organisms	Concentration of heavy metal (µg/g dry weight)							
	Pb	Cd	Ni	Mn	Cr	Cu	Co	Zn
Fish (Engraulisencrasicolus)	0.43 ±0.002	0.22 ±0.001	14.95 ±0.11	1.20 ±0.001	12.25 ±0.21	9.55 ±0.25	1.52 ±0.002	7.88 ±0.55
SepiaOfficianalis	0.15 ±0.004	0.55 ±0.004	25.7 ±0.13	1.8 ±0.0032	10.74 ±0.20	11.85 ±0.32	2.85 ±0.009	5.44 ±0.32
Crab	0.14 ±0.003	0.78 ±0.006	18.2 ±0.12	0.95 ±0.001	15.8 ±0.34	11.85 ±0.32	4.74 ±0.05	10.77 ±0.64
Diatom *Amphora*	0.35 ±0.004	0.95 ±0.008	32.8 ±0.21	2.22 ±0.004	20.9 ±0.45	11.85 ±0.32	3.53 ±0.02	12.55 ±0.75
Om-Elkhlol "Donaxtrunculus	0.29 ±0.003	0.25 ±0.003	20.5 ±0.12	0.84 ±0.003	9.7 ±0.11	11.85 ±0.32	2.93 ±0.03	4.80 ±0.22
(Gandofelly "Tapes decussates	0.30 ±0.004	0.28 ±0.002	16.4 ±0.11	1.7 ±0.002	7.7 ±0.09	11.85 ±0.32	1.45 ±0.001	3.77 ±0.21

Table 10: Concentration of heavy metal in the investigated marine organisms in Rashid location

Marine organisms	concentration of heavy metal (µg/g dry weight)							
	Pb	Cd	Ni	Mn	Cr	Cu	Co	Zn
Fish (Engraulisencrasicolus)	0.01 ±0.009	0.01 ±0.001	5.47 ±0.07	0.86 ±0.002	5.22 ±0.37	6.33 ±0.38	1.27 ±0.03	5.22 ±0.21
Sepia Officianalis	0.12 ±0.001	0.22 ±0.001	6.58 ±0.09	1.32 ±0.001	8.96 ±0.64	12.94 ±0.42	2.47 ±0.02	8.64 ±0.43
Crab	0.022 ±0.001	0.6 ±0.005	10.66 ±0.58	0.33 ±0.002	12.74 ±0.86	5.77 ±0.28	5.62 ±0.07	4.97 ±0.28
Diatom *Amphora*	0.23 ±0.002	0.8 ±0.003	12.41 ±0.62	1.55 ±0.003	4.22 ±0.07	14.64 ±0.67	2.75 ±0.04	6.82 ±0.36
Om-Elkhlol "Donaxtrunculus	0.47 ±0.04	0.2 ±0.005	8.32 ±0.44	0.69 ±0.001	6.94 ±0.08	8.42 ±0.48	1.55 ±0.002	1.44 ±0.06
(Gandofelly "Tapes decussates	0.01 ±0.002	0.1 ±0.003	11.68 ±0.74	1.4 ±0.002	7.7 ±0.09	10.84 ±0.79	3.77 ±0.004	2.66 ±0.08

Table 11: Average values for heavy metals in the investigated marine organisms in Mediterranean Sea, USEPA (1997).

Marine organisms	Heavy metals concentration (µg/g dry weight)							
	Pb	Cd	Ni	Mn	Cr	Cu	Co	Zn
Fish (Engraulisencrasicolus)	0.99	0.65	4.2	5.8	10.2	12.3	0.89	33.2
Sepia Officianalis	0.32	0.62	4.8	4.3	9.3	14.8	0.92	25.1
Crab	0.17	0.48	4.1	6.2	12.4	10.2	0.74	18.7
Diatom Amphora	0.66	0.63	3.9	5.5	13.5	11.3	0.99	12.4
Om-Elkhlol "Donaxtrunculus	0.84	0.55	4.4	5.7	11.7	9.7	0.77	28.2

6- Bio concentration factor (BCF) for heavy metals in the investigated marine organisms

The bio concentration factors for the investigated heavy metals in the studied marine organisms at the studied locations are shown in figs (16, 17, 18, 19, 20).At El-Mex location, Diatom *Amphora* has higher BCF for pb, Cd, Ni, Cr, Cu and Co ions but Crab has higher BCF for Cd, Ni, Mn and Cr ions, while Sepia Officianalis has higher BCF for Zn ion than other heavy metals. At Eastern Harbour location, Fish has higher BCF for Ni ions, Sepia Officianalis has higher BCF for Mn and Cr ions, Crab has higher BCF for Pb ions, Diatom *Amphora* has higher BCF Cd, Cu and Zn ions and Om-Elkhlol "Donaxtrunculus has higher BCF for Co ions than other investigated heavy metals. At El-Dekhila location, Crab has higher BCF for Mnions, Diatom *Amphora* has higher BCF for Pb, Cd, Ni, Cu, Co and Zn ions and Om-Elkhlol "Donaxtrunculus has higher BCF for Cd and Cr ions than other investigated heavy metals.At Abu-Qir location, Crab has higher BCF for Co ions, Diatom *Amphora* has higher BCF for Pb, Cd, Ni, Mn, and Cr ions and Om-Elkhlol "Donaxtrunculus has higher BCF for Pb and Cu ions than other investigated heavy metals. At Rashid location, Fish has higher BCF for Pb and Cd ions, Sepia Officianalis has higher BCF for Cr and Zn, Diatom *Amphora* has higher BCF for Ni, Mn and Cu ions, and Gandofelly "Tapes decussates has higher BCF for Pb ions than other investigated heavy metals. This may be due to interdependency of the uptake and diminution rates when sufficient levels of the essential elements for metabolism in marine organism. Higher concentration of heavy metals in the definite organisms may be due to their capability to bio-selectivity and bio-accumulation of the investigated heavy metals from the water body; and it depends on several factors such as time, temperature, age of marine organism, metabolic activity of the organisms and biological half-life of metals [34, 35, 36 and 37].

Licensed Under Creative Commons Attribution CC BY

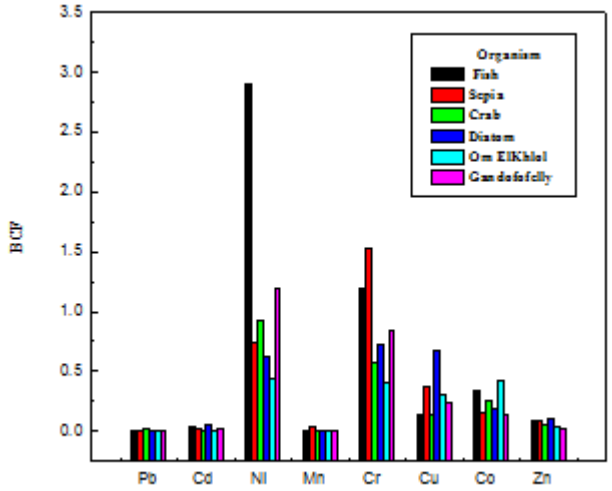

Fig. (17): Bio-concentration factors for heavy metals in marine organisms at Eastern Harbour location

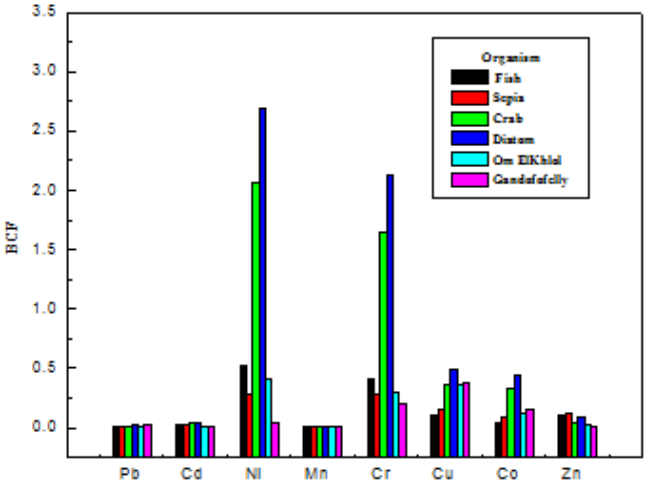

Fig. (16): Bio-concentration factors for heavy metals in marine organism at El-Mex location.

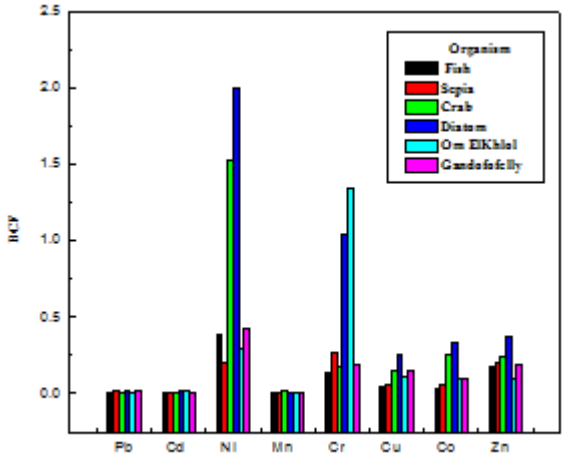

Fig. (18): Bio-concentration factors for heavy metals in marine organisms at El-Dekhila location.

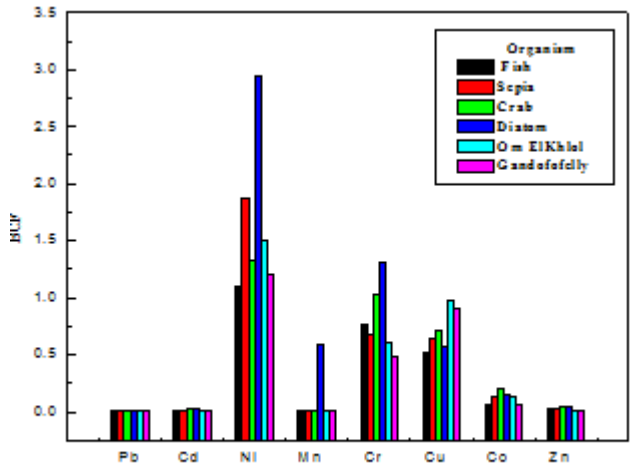

Fig. (19): Bio-concentration factors for heavy metals in marine organisms at Abu-Qir location

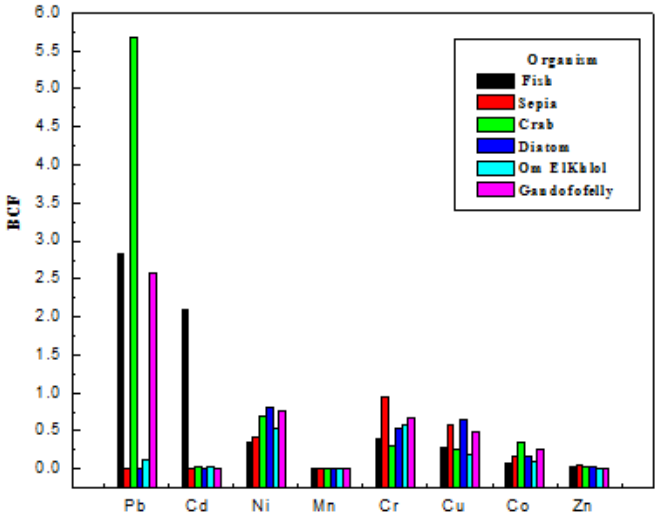

Fig.(20): Bio-concentration factors for heavy metals in marine organisms at Rashid location.

4. Conclusion

- The seawater samples in all studied locations have very high concentration of Zn and Mn ions, and the concentration of the investigated heavy metal ions have the following order: Zn>Mn>Pb> Co> Cr> Cu> Ni> Cd.
- The seawater samples at Rashid location have high levels of ^{238}U-series, ^{232}Th-series and ^{40}K.
- The investigated marine organisms have bio-accumulative properties towards most of the investigated heavy metals and radionuclides.
- The concentration levels of the heavy metals found in this study do not constitute a risk factor for marine organisms and appear to be accommodating with the worldwide values by the US EPA.
- Concentrations of ^{238}U, ^{232}Thand ^{40}K in both water and marine organisms are accommodating with worldwide values.
- The investigated marine organisms are suitable indicators of dissolved metal forms.

References

[1] Fisher, N. S., Breslin, V. T., Levandowsky, M., 1995; Accumulation of silver and lead in estuarine

Licensed Under Creative Commons Attribution CC BY

microzooplankton. Mar. Ecol. Prog. Ser., V. 116, P. 207.
[2] Al-Saad, H.T., Al-Khafaji, B.Y., Sultan, A.A., 1996; Distribution of trace metals in water, sediments and biota samples from Shatt Al-Arab estuary, Mar. Meso., V.11, P. 63.
[3] Summers JK, Wade LT, Engle VD, Malaeb ZA., 1996; Normalization of metal concentrations in estuarine sediments from the Gulf of Mexico. Estuaries; V. 19(3), P. 581.
[4] Tam NFYand Yao MWY., 1998; Normalization and heavy metal contamination in mangrove sediments. Sci Total Environ; V. 216, P.33.
[5] Depledge, M. H., Rainbow, P. S., 1990; Models of regulation and accumulation of trace metals in marine invertebrates. Comp. Biochem. Physiol. 97C: 1-7
[6] Madkour FF, Kamil A, Nasr HS, 2012; Production and nutritive value of Spirulinaplatensis in reduced cost media. Egypt. J. Aquat. Res. V.38, P. 51.
[7] Ivanovich M. I. and HarmonR.S., 1992; Uranium-series Disequilibrium: Applications to Earth, Marine and Environmental Sciences, 2nd ed., Clarendon Press, Oxford.
[8] Akram, M., Riffat, M., Ahmad N., Solaija, T.J., 2007; Determination of gamma-emitting radionuclides in the inter-tidal sediments off Baluchistan (Pakistan) coast, Arabian Sea.Radiation Protection Dosimetry. V. 123, P. 268.
[9] Akram, M., RiffatM., Ahmad N., Solaija, T.J., 2006; Gamma-emitting radionuclides in the shallow marine sediments off the Sindh Coast, Arabian Sea. Radiation Protection Dosimetry, V. 118, P. 440.
[10] Bryan, G.W., Hummerstone, L.G., 1971; Adaptation of the polychaete Nereisdiversicolor to estuarine sediments containing high concentrations of heavy metals. I. General observations and adaptation to copper. Journal of the Marine Biological Association of the United Kingdom, V. 51, P. 845.
[11] OECD, 1996; Guidelines for testing of chemicals. 305. Bioconcentration: Flow-through fish test. Paris.
[12] Ramasamy, V., Murugesan, S., Mullainathan, S., 2004; Gamma ray spectrometric analysis of primordial radionuclides in sediments of Cauvery River in Tamilnadu, India.Ecologica, V.2, P. 83.
[13] IAEA, International Atomic Energy Agency, 2004; Sediment Distribution Coefficients and Concentration Factors for Biota in the Marine Environment. Technical Report Series, International Atomic Energy Agency, Vienna.
[14] Jones, D.G., Roberts, P.D., Limburg, J., Karl, H., Chin, J.L., Shanks, W.C., Hall, R., Howard, D., 2001; Measurement of seafloor radioactivity at the Farallon Islands Radioactive Waste Dump Site, California: U.S. Geological Survey Open-File Report 01-062, p.23.
[15] IAEA, International Atomic Energy Agency, 2004; Assessing the Impact of Deep Sea Disposal of Low Level Radioactive Waste on Marine Living Resources.Technical Report Series n°288.IAEA Vienna, Austria.
[16] USEPA , 1997; The incidence and severity of sediment contamination in surface water of the United States. Volume 1-National Sediment Survey; U.S. Environmental protection Agency. Washington, DC, USA.
[17] Brown J.D., Hosseini A., Borretzen P., Thorring H., 2006, Development of a methodology for assessing the environmental impact of radioactivity in Northern Marine environments, Mar. Pollut. Bull., 52 (10), 1127–1137.
[18] Boisson F., Hutchins D.A., Fowler S.W., Fisher N. S., Teyssi´e J.-L., 1997, Influence of temperature on the accumulation and retention of 11 radionuclides by the marine alga Fucusvesiculosus, Mar. Pollut. Bull., 35 (7–12), 313–327.
[19] Miyake Y, Sugimura Y, Mayeda M (1970). The uranium content and the activity ratio 234U/238U in marine organisms and seawater in the western North Pacific. Journal of the Oceanographical Society of Japan, 26: 123-129.
[20] Fowler S.W., Teyssi´e J.-L., Cotret O., Danis B., Rouleau C., Warnau M., 2004, Applied radiotracer techniques for studying pollutant bioaccumulation in selected marine organisms (jellyfish, crabs and sea stars), Nukleonika, 49 (3), 97–100.
[21] Mohanty, A. K., Sengupta, D., Das, S. K., Vijayan, V., &Saha, S. K. (2004). Natural radioactivity in the newly discovered high background radiation area on the eastern coast of Orissa, India. Radiation Measurements, 38, 153e165.
[22] Hawkins, J.P., Roberts, C.M., 1993. Effects of NORM and TENORM on coral reefs: trampling on reef flat communities. Journal of Applied Ecology 30 (1), 25–30.
[23] Saad, H. R., & Al-Azmi, D. (2002).Radioactivity concentrations in sediments and their correlation to the coastal structure in Kuwait.Applied Radiation and Isotopes, 56, 991e997.
[24] R.Friedlander, M.Gochfeld, J.Burger, V.Vyas, CW Powers.(2005):Radionuclides in the Marine Environment. A CRESP Science Review. Consortium for Risk Evaluation with Stakeholder Participation
[25] J.T. Smith.(2006):Modelling the dispersion of radionuclides following short duration releases to rivers Part 2. Uptake by fish.*Science of the Total Environment*.368, 502–518.
[26] INTERNATIONAL ATOMIC ENERGY AGENCY, (1985).Sediment K_ds and Concentration Factors for Radionuclides in thé Marine Environment, Technical Reports Series No. 247, IAEA, Vienna
[27] LEWIS, B. L., AND W. M. LANDING. 1992. The investigation of dissolved and suspended-particulate trace metal fractionation in the Black Sea. Mar. Chem. 40: 105–141.
[28] Cobbett C. S., 2000, Phytochelatins and their roles in heavy metal detoxification, Plant Physiol., 123 (3), 825–832, doi:10.1104/pp.123.3.825.
[29] Lobban, C. S. & Harrison, P. J. 1997.Seaweed Ecology and Physiology. Cambridge University Press, Cambridge, UK
[30] Chouba, L., Kraiem, M., Njimi, W., Tissaoui, C.H., Thompson, J.R. and Flower, R.J. (2007) Seasonal variation of heavy metals (Cd, Pb and Hg) in sediments and in mullet, Mugilcephalus (Mugilidae), from the Ghar El Melh Lagoon (Tunisia). Transitional Waters Bulletin. TWB, Transit. Waters Bull. 4 (2007), 45-52.

Licensed Under Creative Commons Attribution CC BY

[31] MacFarlane, G. B., Burchettt, M. D., (2000). Cellular distribution of Cu, Pb, and Zn in the Grey Mangrove Avicemnia marina (Forsk.).Vierh Aquatic Botanic, 68: 45– 59.
[32] Mitchell, G., Mihalynuk, L., &Heaman, L. M. (2002). Age of mineralized porphyry at the logtung deposit W-Mo-Bi-Be(Beryl, Aquamarine), Northwest BC, British Columbia geological survey. Geological Fieldwork, 1, 35e40.
[33] Beliles, R. P. 1979. The lesser metals. In Oehme, F. W., Ed., Toxicity of heavy metals in the environment, Marcel Dekker, New York, pp. 547-615.
[34] Bryan, G.W. (1984): Pollution due to heavy metals and their compounds. In: Marine ecology: A comprehensive, integratedtreatise on life in the oceans and coastal waters, Vol. 5. Ocean Management. Part 3 (Ed.: O. Kinne). John Wiley and Sons New York.pp.1289-1431
[35] Reish, D.J., P.S. Oshida, A.J. Mearns, T.C. Ginn, and M. Buchman.(1999). Effects of pollution on marine organisms. Water Environmental Research 71(5): 1100-1115.
[36] DeForest, D., Brix, K., Adams, W., 2007. Assessing metal bioaccumulation in aquatic environments: The inverse relationship between bioaccumulation factors, trophic transfer factors and exposure concentration.Aquat.Toxicol. 84, 236– 246
[37] Ros A., (2010), Comparative data on the accumulation of five heavy metals (cadmium, chromium, copper, nickel, lead) in some marine species (molluscs, fish) from the Romanian sector of the Black Sea, Recherches Marines, 39, 89-108.

Licensed Under Creative Commons Attribution CC BY