Study of the impact of offshore oil production, refinery and export from Basra Governorate- Iraq on non-human Biota

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Abstract

This article discussed the major marine pollution arising from offshore petroleum production, refinery and exporting. The sources of marine pollution from offshore activities like; production gases, oil spill, drilling fluid, production water and naturally occurring radioactive materials (NORM). All these activities produced extra radiation doses to human and non-human biota in the marine system. The distribution of natural gamma emitting ^{238}U, ^{232}Th,^{40}K and radon gas (^{222}Rn) radionuclides in biota of Northern west of Arabian Gulf, South of Iraq have been carried out using a NaI(Tl) gamma ray spectrometric technique and Solid State Nuclear Detectors SSNTDS. Data from the current investigation will be useful for tracking and assessing any accentual pollution in the marine environment in the region.

Keywords: Biota, Radionuclides, Radon, SSNTD, RAD7, NaI(Tl), absorbed dose rate.

دراسة تأثير إنتاج وتكرير وتصدير النفط البحري من محافظة البصرة ـ العراق على الكائنات الحية غير البشرية

الخلاصة

ناقش هذا المقال التلوث البحري الكبير الناشئ عن إنتاج البترول البحري وتكريره وتصديره. مصادر التلوث البحري من الأنشطة البحرية مثل ؛ غازات الإنتاج ، تسرب النفط ، سائل الحفر ، إنتاج المياه والمواد المشعة التي تحدث بشكل طبيعي (NORM). أنتجت كل هذه الأنشطة جرعات إشعاعية إضافية للكائنات الحية البشرية وغير البشرية في النظام البحري. تم تنفيذ توزيع النويدات المشعة التي تنتج 238 غ ، 232 ث ، 40 ك وجزيئات غاز الرادون (Rn222) في الكائنات الحية في شمال غرب الخليج العربي ، جنوب العراق باستخدام تقنية الطيف

الشعاعي لأشعة غاما NaI (Tl) وجهاز الكشف عن الحالة الصلبة في الحالة الصلبة SSNTDS . ستكون بيانات الاستقصاء الحالي مفيدة لتتبع وتقييم أي تلوث لهجة في البيئة البحرية في المنطقة.

الكلمات المفتاحية: الكائنات الحية ، النويدات المشعة ، الرادون ، SSNTD، RAD7، NaI (Tl) ، معدل الجرعة الممتصة.

Introduction

Marine environment can be effected by the offshore development activities included drilling fluids, produced sludge, production water, oil spill and naturally occurring radioactive materials (NORM). The naturally occurring radionuclides are relatively and uniformly distributed in the seas and the oceans. Human activities like mining and milling of mineral ores, ore processing 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 [1-3]. Most of the radioactivity deposited on surface sediments is 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 beings [4, 5]. 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, sea sediments and marine organisms) and to assess radiological impacts of the detected radionuclides on human health. Beach sediments are mineral deposits formed through weathering and erosion of either igneous or metamorphic rocks. Among the rock constituent minerals are some natural radionuclides that contribute to ionizing radiation exposure on Earth. Natural radioactivity in soils comes from U and Th series and natural K. The study of the distribution of primordial radionuclides allows the understanding of the radiological implication of these elements due to the gamma-ray exposure of the body and

irradiation of lung tissue from inhalation of radon and its daughters [6-8]. The present work investigate the impact of oil production activities on the non-human biota collected from the northern south of the gulf.

2. Materials and Methods

2.1 Area of Study

The aria of study presented in Figure1, which include Khor Abdullah, Umqaser Port and the north west of the Gulf. The daily variation in the salinity and sediment participation come from the Shutt Al-Basrah canal in the northwest of the study area. Khor-Abdullah bay is a semi-closed funnel shape, the lower part has a width 17 km while, and the upper width is 6.5 km. The Iraqi coast has a mild decline relative to high decline at Kuwaiti coast. The average depth is 10m in the area. The longitudinal hub (bevel) of the channel is 40km in the direction of the Arabian Gulf with a width between (6-17) km [9, 10]. Salinity value between 32‰ to 38‰ is regarded as a saline lagoon. The tidal system is the same as in the northern part of the Gulf, which is named as semidiurnal; the tidal range value is (2-3) m at spring tide. The maximum value of the surface current, in the downstream, is greater than it is like in the root, in both phases (spring & neap tide). The reversible situation is in the upstream and the value was 1.5m/s in the root.

Figure 1, the area of study.

2.2. Samples Collection

The biota samples used for this study were collected from the Iraqi part of the Gulf. The samples were collected using fishing net. The collected samples were immediately transferred to polythene bags in order to avoid contact with atmosphere. In the laboratory, samples were separated from the contamination materials and air-dried at room temperature for a week. Then the samples dried to 105^{o}C, milled and sieved through 0.2 mm mesh. The dried samples were put inside cylindrical can. The cans were sealed, gas-tight and stored for four week for secular equilibrium.

Figure 2. The samples collections.

2.3. Radon Measurements

(i) Active method

RAD7 (DURRIDGE Company USA) analyser is an active, high performance, continuous radon- measuring technique was used to measure radon exposure from the sediment samples. The RAD7 radon monitor apparatus uses an air pump and solid state alpha detector which consist of a semiconductor material. The samples were put inside

can (7cmx15cm) to produce 4cm depth and the can sealed with silicon. The chamber made of polyvinyl chloride (PVC) and radon accumulation inside 7 cmx 11 cm chamber. The schematic diagram of RAD7 connected online with the cylindrical can is shown in Figure 3. The can connected to the RAD7 through the laboratory drying unit using plastic tubes to produce a closed loop configuration. The chamber and the system purged for 20min to reduce the humidity to less than 10%. The instrument draws air from the accumulation chamber, through the desiccant and an inlet filter in a rate 1*l*/m, into the measured chamber. The air is then returned to the enclosure from the RAD7 outlet. A high voltage of 2500 V is applied to the measuring chamber wall. The alpha RAD7 detector was operated in grab mode for1 to 2days protocols, with cycle 1h and recycle 48 for 1 day protocol. The solid-state silicon detector inside RAD7 detection unit converts alpha radiation directly to an electrical signal discriminating the electrical pulses generated by α-particles from the polonium isotopes (^{218}Po, ^{216}Po, ^{214}Po, ^{212}Po) with energies of 6.0, 6.7, 7.7 and 8.8 MeV, respectively. Inlet filter at the top of RAD7 remove the progenies of ^{220}Rn and ^{222}Rn, so that only the concentration of the gas is measured. The experiments were performed under dry condition (relative humidity ~6%) and room temperature from 21^{o}C to 28^{o}C.

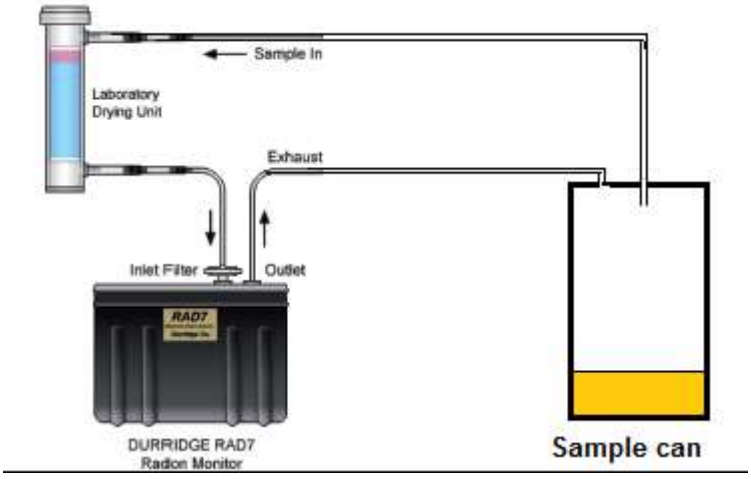

Figure 3 Schematic diagram of RAD7 instrument online with sample can.

(ii) Passive Method

To measure the radon concentrations in the samples, laboratory "Can Technique" was used [11,12]. The dried samples were grinded and sieved to produce a homogenous fine powder. About 150gm of the sample was placed at the bottom of a cylindrical

emanation chamber (7.0 cm x 11 cm), shown in Figure 4. The dosimeters were stored (closed) for four weeks to reach secular equilibrium between radium and radon. After this period, CR-39 plastic detector (1.5 cm x 1.5 cm), which was previously fixed by adhesive tape to the inside surface of a second identical cover, is mounted quickly and closed the chamber. The detector expose to radon-222 for period of 105 days. After exposure time, all detectors were removed carefully and then; chemically etched using a solution of 6.25 N NaOH at 70^{o}C for 7 h. The detectors then; washed continuously by distilled water. The tracks emerge on the surface of the detector were counted using microscope 400x.

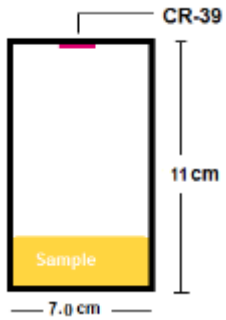

Figure 4. A schematic diagram of the dosimeter used in present work.

In this technique, the radon level of a soil placed in an emanation container can be monitored with a passive radon dosimeter based on CR-39 solid- state nuclear track detector SSNTD. The radon concentration which emanated from sample inside the closed can calculated using the following relation [13, 14];

$$A_{Rn} = \frac{\rho}{TK} \qquad (1)$$

where ρ is track density in Tr/cm^2 ,T exposure time in day and K the calibration factor in Tr/cm^2.day / Bq.m^{-3}. The value of K depends on the radius of the measuring can. In the present measurement the value of K=0.3420±0.0459 Tr cm^{-2} d^{-1} per Bq m^{-3} has been adopted [15].

At the equilibrium state, the surface exhalation rate from the sample inside the dosimeter is calculated by [16];

$$E_{ex} = \frac{A_{Rn}TV\lambda/S}{T+\lambda^{-1}(e^{-\lambda T}-1)} \qquad (2)$$

where E_x is area exhalation rate in unit Bq $m^{-2}.h^{-1}$, A is radon concentration measured by CR39 detector in unit Bq m^{-3} , λ is radon decay constant which is equal to 0.181 d^{-1}, T is the exposure time, V the volume of the air space in the can and S is the surface area of the sample.

The mass radon exhalation rate is calculated from the relation;

$$E_M = \frac{A_{Rn} T V \lambda / M}{T + \lambda^{-1}(e^{-\lambda T} - 1)} \quad (3)$$

where E_M expressed in Bq $kg^{-1}h^{-1}$ and M is the mass of the sample.

The effective radium content in the sample could be calculated from [17];

$$A_{Ra} = \frac{\rho V}{K M T_{eff}} \quad (4)$$

where $T_{eff} = T - \lambda^{-1}(1 - e^{-\lambda T})$

2.4 Natural Radioactivity in Sediments and biota

The activity concentration of ^{226}Ra, ^{228}Ra, ^{238}U, ^{232}Th and ^{40}K in sediment and biota were determined using NaI(Tl) detector which gave the count rate for each radionuclide. After measuring the count rate (area under the peak) for each peak shown in figure 1, the activity concentration for each environmental isotope calculated from [18]

$$A = \frac{Net\ count}{\varepsilon \times I_\gamma \times M \times t} \quad (5)$$

where ε is absolute gamma peak efficiency of the detector at this particular gamma-ray energy, I_γ decay intensity for the specific energy peak (including the decay branching ratio information), M the mass of the sample in kg and t is the counting time of the measurement in second.

The Radium equivalent activity (Ra_{eq}) is used to assess the hazards associated with materials that contain ^{226}Ra, ^{232}Th and ^{40}K in Bq kg^{-1}, which is, determined by assuming that 370 Bq kg^{-1} of ^{226}Ra or 260 Bq kg^{-1} of ^{232}Th or 4810 Bq kg^{-1} of ^{40}K produce the same γ dose rate. The Ra_{eq} of a sample in (Bq kg^{-1}) can be achieved using the following relation [19];

$$Ra_{eq} = (A_{Ra}) + (A_{Th} \times 1.43) + (A_K \times 0.077) \quad (6)$$

The published maximal permissible Ra_{eq} is 370 Bq kg^{-1} [20].

3. Results and discussions

3.1 Radon concentrations in Biota

The aim of this study is to determine radon concentration in marine biota in Basra (Iraq) and gives us data base about the concentration of radon in Iraqi marine biota . The passive radon method employed has been achieved by means of cylindrical time integrated technique of Solid State Nuclear Track Detectors (SSNTDs).

Table 1 shows the scientific biota name and location with sample No., from the table(1) we notice the radon concentration in the benthos , nekton and plankton distributed as shrimps > Bivalves > crab > Anemones > solid coral reef so they measured with passive method 69.52±19.33 Bq/m^3, 49.02±13.81Bq/m^3, 40.49±11.82Bq/m^3, 29.03±8.8 Bq/m^3, 29.80±9.04Bq/m^3 respectively. For mentation we bivalves without tissue so these concentration of radionuclide are different for to another place. The maximum and minimum radionuclide concentration are measured for shrimps 69.52±19.33 Bq/m^3 to Melanoides tuberculata 9.93±3.76 $Bq/^{m3}$ .The comparison between radon concentration of this study with the study of market fish , the radon concentration ranged from (309.4 Bq/m^3) to (1600 Bq/m^3) in local fish and from (507.3 Bq/m^3) to (1100 Bq/m^3) in imported fish. From the measurements all of the fish measured were within permissible level recommended by ICRP(1987) for foods. The correlation between passive and active method R^2 = 96% explain in fig (5).

Table1. Radon concentrations in biota measured by passive and active methods.

sample	position	Concentration passive Bq/m^3	Concentration active Bq/m^3
Bivalves(mussel)	Khawr Abd allah	49.02±13.81	121.10±23.1
Bivalves(mussel)	coral reef	44.57±12.65	111.20±19.1
Pinna carnea(Amberpenshell)	Khawr Abd allah	18.34±6.03	36.00±8.9
crabe	Khawr Abd allah	40.49±11.82	99.40±21.1
crabe	coral reef	38.20±11.22	71.30±16.2
coral reef	coral reef	29.80±9.04	61.70±14.3
carbicula fluminalis	coral reef	14.01±4.68	35.30±7.2
laevicardium flavum	Khawr Abd allah	16.04±5.42	21.10±5.1
Melanoides tuberculata	Um Qaser	9.93±3.76	22.80±5.2
Anemones	Um Qaser	29.03±8.84	71.10±15.3
Anemones	coral reef	25.21±7.84	41.20±9.7
shrimp	coral reef	69.52±19.33	170.20±34.3
shrimp	Khawr Abd allah	61.12±17.16	151.30±31.1
Megalapis cordela	coral reef	15.28±5.21	43.70±9.5
Alepes melanoptera	coral reef	22.16±7.03	51.20±11.2
Atolithes ruber	coral reef	16.04±5.42	31.10±6.2
Ephippus orbis	coral reef	26.74±8.24	52.10±12.4
Thunnus albacares	coral reef	19.10±6.23	49.80±11.3
Argyrops spinifer	coral reef	23.68±7.44	59.40±14.7
MIN		9.93±3.76	6.47
MAX		69.52±19.33	140.88
AVR.		28.85±9.01	51.12

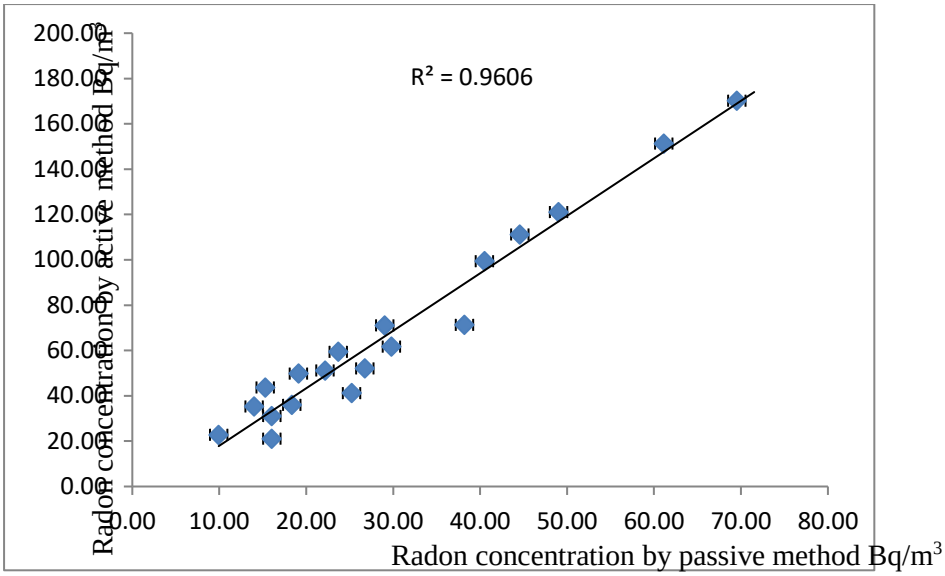

Fig5. Correlation between passive and active method.

3.2 Gamma Measurement

Radium in the sea can give humans radiation doses through plankton to fish, and from fish to humans. Radium can also be transferred to marine foodstuffs such as shrimp, crawfish and lobsters. Radium is mainly deposited in the bone tissue and shell, which are not consumed by humans. Only a fraction of the radium in the sea therefore reaches humans. Nevertheless, radium is concentrated in fish, molluscs and Crustacea in relation to its level in seawater. In the literature a concentration factor of 100 is used for this, implying that the amount of radium per gram in fish or Crustacea (wet weight) is 100 times the amount in seawater. ^{226}Ra emits alpha particles with relatively high energy, while ^{228}Ra emits beta radiation with low energy and relatively low ionization capacity, so is an important element in connection with radiation protection because of its long retention time in the human body. The activity concentration, maximum and minimum values 75.20±18.9 Bq/kg in Alepes melanoptera, 6.07±1.59Bq/kg for carbicula fluminalis.

^{40}K:

Radioactive ^{40}K is a constant component of all natural potassium and constitutes approximately 0.012 % of the total amount of potassium. The isotope emits beta

radiation with relatively low energy. The activity concentration for maximum and minimum value 397.2±61.35 Bq/kg for Argyrops spinifer, 4.83±0.38 Bq/kg for coral reef.

^{238}U:

Constitutes more than 99 % of all natural uranium. The isotope is highly chemical and radio logically toxic. The isotope emits alpha particles with relatively high energy, but there is relatively little of this isotope in seawater. The activity concentration for maximum and minimum value 37.1±18.7 Bq/kg for Alepes melanoptera , 0.20±0.05 Bq/kg for Bivalves(mussle).

^{232}Th:

The isotope emits alpha particles with relatively high energy, but there is relatively little of this isotope in seawater. The element has high affinity to particles and is therefore to a large degree associated with sediments and organisms living on the ocean floor. Thorium concentration in the water column is approximately 10 % of the radium concentration. ^{232}Th is primarily deposited in the bone tissue of living organisms. Relatively little relevant data was found for concentration factor sand concentrations in marine biota, concentration levels for ^{232}Th are relatively low. The activity concentration for maximum and minimum value 24.5±7.19 Bq/kg for carnea(Amber penshell) and Megalapis cordela, 0.02±0.24 Bq/kg for Bivalves(mussle). The correlation R^2= 78% between ^{226}Ra and ^{238}U fig (6).

Table 2. Specific activity of biota sample.

sample	$^{226}RaBq/kg$	$^{232}ThBq/kg$	$^{238}UBq/kg$	$^{40}KBq/kg$	$RaeqBq/kg$
Bivalves(mussle)	8.90±2.2	0.02±0.00	0.20±0.09	118.54±9.49	18.05

Bivalves(mussle)	8.10±2.1	0.02±0.00	0.20±0.05	116.40±8.75	17.09
pinna carnea(Amber penshell)	20.40±7.23	24.5±6.2	1.9±0.5	193.0±29.6	70.35
crabe	20.10±15.7	14.85±3.60	1.11±0.17	276.2±24.9	62.60
crabe	14.20±3.2	14.50±3.45	1.10±0.16	276.2±24.7	56.20
coral reef	24.63±7.14	20.07±5.18	3.58±1.76	4.83±0.38	53.70
carbicula fluminalis	6.07±1.59	0.921±0.24	5.8±2.75	98.54±8.014	14.98
laevicardium flavum	9.60±2.47	0.92±0.24	11.27±5.5	112.30±9.13	19.57
Melanoides tuberculata	13.28±3.36	0.92±0.24	16.74±8.3	98.55±8.01	22.18
Anemones	21.10±4.5	4.39±0.46	5.65±2.87	141.58±15.	38.28
Anemones	20.40±4.1	4.39±0.46	5.65±2.87	141.58±15.6	37.58
shrimp	40.40±9.5	5.20±1.10	15.30±7.4	173.42±19.3	61.19
shrimp	30.20±10.3	6.41±1.55	18.11±8.9	392.94±43.7	69.62
Megalapis cordela	64.58±18.9	24.50±7.19	28.52±13.4	397.22±57.0	130.20
Alepes melanoptera	75.20±2.1	1.88±0.17	37.12±18.7	261.89±25.0	98.05
Otolithes ruber	30.4±17.2	4.38±0.50	2.17±0.36	138.7±16.64	47.35
Ephippus orbis	10.20±2.5	3.87±0.59	1.63±0.84	258.5±40.05	35.64
Thunnus albacares	43.04±14.	3.87±0.59	1.63±0.84	285.85±44.2	70.58

Argyrops spinifer	12.10±3.2	3.87±0.59	1.63±0.84	396.1±61.35	48.13
Max	75.20±18.9	24.5±7.19	37.1±18.7	397.2±61.35	140.88
Min	6.07±1.59	0.02±0.24	0.20±0.05	4.83±0.38	6.47
Avr.	24.89±6.9	7.34±1.70	8.39±4.02	204.3±24.3	51.12

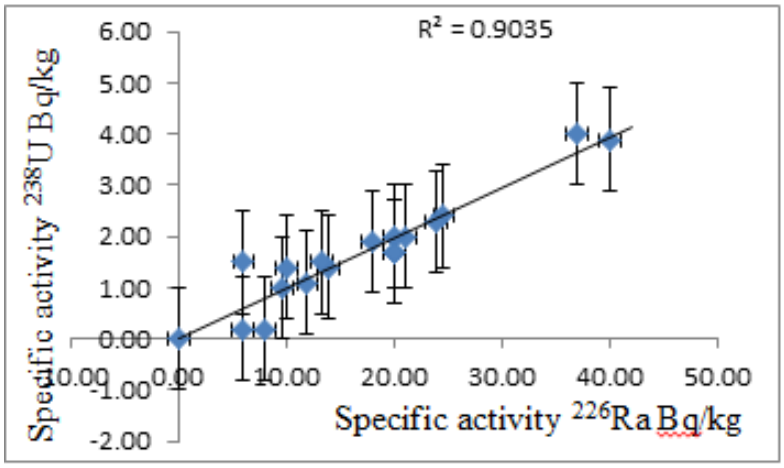

Fig 6. Correlation for biota between ^{226}Ra , ^{238}U.

4. Conclusion

Radon and gamma emitters radionuclides naturally or manmade were conduct in marine biota endemic in the northern west of the gulf. The mane made radioactivity in additions to the marine environment, appear to be relatively small. The biota samples are successfully analysed for radon and radioactive elements, namely ^{238}U, ^{232}Th, ^{226}Ra and ^{40}K. The results clearly show that the levels of radioactivity of gross biota do not exceed the limits set by the EPA. The data obtained in this work will serve as baseline data for the proper assessment of radiation exposure of the dwellers. The differences in the concentration of radon and gamma emitter radionuclides in biota are probably due to differences in lifestyle and feeding habits. Good correlation between uranium and radium were exists in selected samples of biota.

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