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Radioactivity in the Kuwait marine environment — Baseline measurements and review

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ABSTRACT

The Arabian Gulf region is moving towards a nuclear energy option with the first nuclear power plant now operational in Bushehr, Iran, and others soon to be constructed in Abu Dhabi and Saudi Arabia. Radiological safety is becoming a prime concern in the region. This study compiles available data and presents recent radionuclide data for the northern Gulf waters, considered as pre-nuclear which will be a valuable dataset for future monitoring work in this region. Radionuclide monitoring in the marine environment is a matter of prime concern for Kuwait, and an assessment of the potential impact of radionuclides requires the establishment and regular updating of baseline levels of artificial and natural radionuclides in various environmental compartments. Here we present baseline measurements for ^{210}Po, ^{210}Pb, ^{137}Cs, ^{90}Sr, and ^{3}H in Kuwait waters. The seawater concentration of ^{3}H, ^{210}Po, ^{210}Pb, ^{137}Cs, and ^{90}Sr vary between 130–146, 0.48–0.68, 0.75–0.89, 1.25–1.38 and 0.57–0.78 mBq L^{-1}, respectively. The ^{40}K concentration in seawater varies between 8.9–9.3 Bq L^{-1}. The concentration of ^{40}K, total ^{210}Pb, ^{137}Cs, ^{90}Sr, ^{226}Ra, ^{228}Ra, ^{238}U, ^{235}U, ^{234}U, $^{239+240}$Pu and ^{238}Pu were determined in sediments and range, respectively, between 353–445, 23.6–44.3, 1.0–3.1, 4.8–5.29, 17.3–20.5, 15–16.4, 28.7–31.4, 1.26–1.30, 29.7–30.0, 0.045–0.21 and 0.028–0.03 Bq kg^{-1} dry weight. Since, radionuclides are concentrated in marine biota, a large number of marine biota samples covering several trophic levels, from microalgae to sharks, were analyzed. The whole fish concentration of ^{40}K, ^{226}Ra, ^{224}Ra, ^{228}Ra, ^{137}Cs, ^{210}Po and ^{90}Sr range between 230–447, 0.7–7.3, <0.5–6.6, <0.5–15.80, <0.17, 0.88–4.26 and 1.86–5.34 Bq kg^{-1} dry weight, respectively. ^{210}Po was found to be highly concentrated in several marine organisms with the highest ^{210}Po concentration found in *Marica marmorata* (193.5–215.6 Bq kg^{-1} dry weight). ^{210}Po in most dissected fish samples shows increasing concentrations in the following order: edible tissue, gills, digestive system, liver and fecal matter. Fish fecal pellets had ^{210}Po concentrations several orders of magnitude higher than the seawater, fish muscle, and the fishes' ingested food. The high ^{210}Po concentration in fish fecal matter, suggest that the bulk of ^{210}Po content in fish was eventually excreted back into the environment as fecal pellets. In most fish high concentrations were noted in liver, with the highest ^{210}Po concentration recorded in shark liver (126.2–141.5 Bq kg^{-1} wet). Moreover, ^{210}Po concentration in the soft tissue of molluscs (10.36–215.60 Bq kg^{-1} dry weight) was far higher than that in fish muscle (0.05–7.49 Bq kg^{-1} wet weight). A seasonal drop in ^{210}Po concentration in seawater was observed to vary with the abundance of phytoplankton and macroalgae due possibly to biological dilution. ^{137}Cs concentration in all the fish sampled was below the detection limit, and the concentration in seawater was also low; hence such low levels provide an opportunity to use this radionuclide as an indicator for any future radiocesium releases in this region.

1. Introduction

There is a growing interest in the utilization of nuclear power among the countries in the Gulf Cooperation Council (GCC) (Huber, 2007). The GCC Nuclear Summit reiterated the need for nuclear energy in order to meet the increasing energy demands in the Arab League states (Ameinfo, 2009). With a single nuclear power plant operational at Bushehr (Iran) and several others shortly coming on line in the United Arab Emirates (UAE) and Kingdom of Saudi Arabia (KSA), the establishment of environmental baselines for naturally occurring radioactive material (NORMs) and anthropogenic radionuclides and subsequent monitoring of the marine environment are very important activities. The marine environment in Kuwait is critical for power and desalination, food stocks, and sea transportation. Kuwait's geographic location makes it vulnerable to receiving a wide variety of pollutants from around the Gulf due to the counterclockwise water circulation in this area (Al Ghadban et al., 2008). There is limited information available on radionuclides in the marine environment in this region. Thus, this

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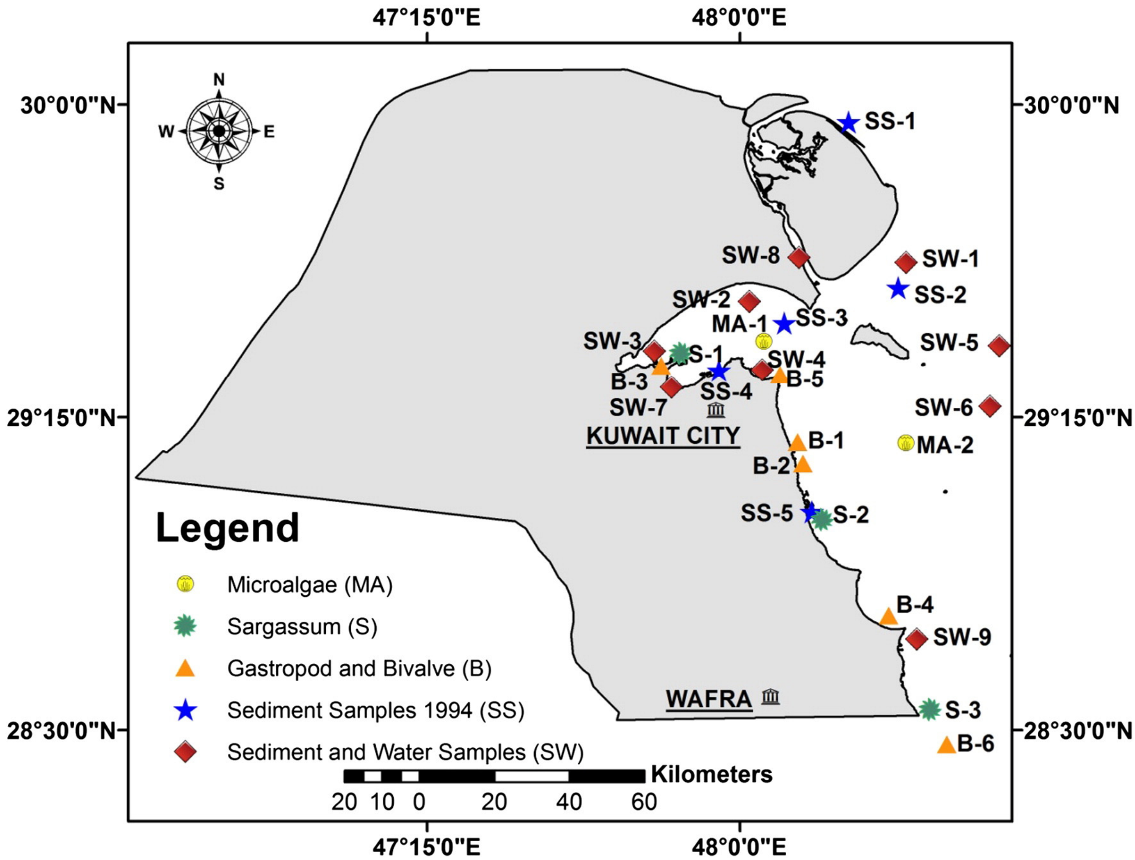

Fig. 1. Sediment, water and biota sampling locations in Kuwait's marine area.

paper presents baseline levels of radioactive lead (^{210}Pb), polonium (^{210}Po), strontium (^{90}Sr) and cesium (^{137}Cs) in sediment, seawater and biota; and for tritium (^{3}H) in seawater (Al Ghadban et al., 2010a, b). These baseline data from Kuwait are then compared with similar published information from other areas in the Gulf and elsewhere globally.

The importance of assessing radionuclides in the marine environment is due to the fact that their presence may increase ecological risk. The data on radionuclide concentrations in seawater, sediments and biota including food chain transfer (bioaccumulation and possible biomagnification), residence time and recycling in the marine environment are very important to understanding specific toxicity to organisms and radiological safety of the environment.

2. Methods

2.1. Study area

The seawater samples were collected from nine stations that were selected based on a multi-criteria evaluation (Uddin et al., 2009) considering bathymetric conditions, hydrodynamic flow regimes, sediment transport, and accessibility (Fig. 1). Biota samples were collected from different locations within Kuwait's territorial waters (Fig. 1) and from local fish markets. The study area is shallow with an average depth between 10 and 15 m, and receives a low annual precipitation of < 100 mm based on measurements made over the past five years. A large quantity of sediments drain into the study area via the Shatt Al-Arab River and the Third River, along with limited quantities of freshwater, which results in a large area of the northwestern Arabian Gulf becoming turbid with total suspended particulates ranging between 60 and 100 mg L^{-1} (Uddin et al., 2011). During the study, the sea surface temperature fluctuated between 10 °C and 35 °C over the entire year (Uddin et al., 2012a,b).

Water samples were collected at a depth of 1 m below the sea surface using 5-L Niskin bottles. The water samplers were manually

Table 1
Local, English and scientific names of the biota analyzed.

Local Name	English name	Scientific Name
Battan	Karenteen seabream	*Crenidens crenidens*
Beyah	Greenback mullet	*Liza subviridis*
Hamoor	Orange spotted grouper	*Epinephelus coioides*
Khubbat	Spanish mackerel	*Scomberomrus guttatus*
Meid	Klunzinger mullet	*Liza klunzingeri*
Nagroor	Javelin grunter	*Pomadasys kakaan*
Nuwaibi	Tigertooth croaker	*Otolithes ruber*
Sheaam	Yellowfin seabream	*Acanthopagrus latus*
Sobaity	Gilthead seabream	*Sparidentex hasta*
Zobaidy	Silver pomfret	*Pampus argenteus*
Shairy	Spangled emperor	*Lethrinus nebulosus*
Gorgofan	Haffara seabream	*Rhabdosargus haffara*
Hamra	Malabar red snapper	*Lutjanus malabaricus*
Wahar	Bartail flathead	*Platycephalus indicus*
Sheem	Fourfinger threadfin	*Eleutheronema tetradactylum*
Mezleegan	Oriental sole	*Brachirus orientalis*
Cuttlefish (squid)	Persian Gulf cuttlefish	*Sepia Arabica*
Silsa	Yellowtip halfbeak	*Hemiramphus marginatus*
Chim	Sea catfish	*Arius* spp.
Mackerel	Indian mackerel	*Rastrelliger kanagurta*
Talaha	Southern pompano	*Trachinotus africanus*
Shanak	Spotted scat	*Scatophagus argus*
Koffer	Soldier bream	*Argyrops filamentosus*
Soboor	Hilsa shad	*Tenualosa ilisha*
Moon fish	Moon fish	*Mene maculate*
Sardine	White sardine	*Escualosa thoracata*
Shark	Arabian smoothhound	*Mustelus mosis*

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