Marine Pollution Bulletin 127 (2018) 73–81

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Baseline

Concentrations of selected radionuclides and their spatial distribution in marine sediments from the northwestern Gulf, Kuwait

Saif Uddin*, Montaha Behbehani

Kuwait Institute for Scientific Research, Kuwait

ARTICLE INFO

Keywords:
Depleted uranium
^{137}Cs
^{238}U
^{235}U
$^{239+240}Pu$
^{238}Pu

ABSTRACT

This study focuses on creating a baseline for ^{40}K, ^{210}Pb, ^{137}Cs, ^{90}Sr, ^{226}Ra, ^{228}Ra, ^{238}U, ^{235}U, ^{234}U, $^{239+240}Pu$ and ^{238}Pu in marine sediments in the northwestern Gulf. The respective measured concentration ranges were 386–489, 32.3–48.8, 1.5–2.9, 4.53–5.42, 18.3–23.1, 18.8–23.0, 22.3–30.5, 0.99–1.33, 25.6–34.8, 0.30–0.93, and 0.0008–0.00018 Bq kg^{-1}. The levels of these radionuclides are generally comparable to values reported for other marine waters in the northern hemisphere. The ^{137}Cs activity in the Gulf sediments offshore Kuwait is an order of magnitude lower compared to sediments from northeastern Iran. Other than that finding, no hot spots were observed in sediments adjacent to power and desalination plants, oil and gas industrial activities or wastewater treatment facilities. These data will serve as a baseline to gauge possible future inputs of radionuclides in the northern Gulf. The calculated average ratio of $^{235}U/^{238}U$ activity in the area is in agreement with the reported figure of the natural uranium ratio, suggesting the absence of depleted uranium (DU) at all the stations. The low concentration of $^{239+240}Pu$ suggests that there is no significant source of plutonium except that from atmospheric fallout from weapon testing and possible dry deposition via long-range dust transport.

The Arabian/Persian Gulf is a semi-enclosed saline water body that is connected to the Indian Ocean. The northern shoreline is bordered by Iraq, Iran, and Kuwait, while the western and southern shorelines are along Saudi Arabia, Bahrain, Qatar, United Arab Emirates and Oman's coasts. The entire eastern shore is Iranian coast. The northern Gulf has experienced three wars including the Iran-Iraq war during 1980–1988, The Gulf War in 1991, and the invasion of Iraq in 2003 where some weapons contained depleted uranium. There are reports that between 315 and 350 tons of depleted uranium were used during 1991 Gulf War (Energy_Solutions, 2015). Also, there have been reports that munitions used during Gulf War were contaminated with highly radioactive substance like plutonium (Repacholi, 2007). This was also confirmed by US Senator Russ Feingold on Dec. 8, 2004 in his statement “The [Dept. of Defense] acknowledged that stocks of depleted uranium munitions have been contaminated with plutonium and other radioactive materials which are extremely toxic and carcinogenic.”

The Gulf being an oil exporting region also experiences frequent localized operational oil spills, besides catastrophic spills like the 1991 Gulf War incident where 11 million barrels of oil was spilled into sea. This was preceded by the Nowruz oil spill with 1.9 million barrels in 1983 and the Sea Star spill in 1972 which discharged 937,000 barrels into the Sea of Oman.

The Gulf region has also experienced unprecedented coastal and offshore development in last few decades with the establishment of new refineries, power and desalination plants, coastal townships, ports, marinas, offshore oil facilities and nuclear power plants. Therefore it is very important to establish an environmental baseline for both the anthropogenic and naturally occurring radionuclides in marine sediments and a number of studies in the region have begun to focus on radioactivity measurements in marine sediments (Al-Ghadban et al., 2011; Al-Qaradawi et al., 2015; Al-Zamel et al., 2005; Fowler, 1993; Patiris et al., 2016; Pourahmad et al., 2008; Saad and Al-Azmi, 2002; Uddin et al., 2015).

Radionuclides in marine sediments are often used as radiotracers for understanding oceanographic processes and for historical reconstruction of pollution events. Besides, sediments act as a sink for most contaminants including radionuclides. The aim of this study is to provide baseline information on the activity of natural and anthropogenic radionuclides in the northern Gulf. The significance of the study increases considering the fact that marine area in the region is a source of drinking water and provides seafood that constitutes a significant portion of the local diet. The marine sediments in the region are also a sink for effluent discharge from Power and desalination, wastewater treatment facility, industries including the oil industry that is considered a source of NORMs and TENORMs (OGP, 2008; Uddin et al., 2017b). The Gulf region is rapidly developing nuclear power with a

* Corresponding author.
E-mail address: sdin@kisr.edu.kw (S. Uddin).

https://doi.org/10.1016/j.marpolbul.2017.11.052
Received 29 October 2017; Received in revised form 15 November 2017; Accepted 22 November 2017

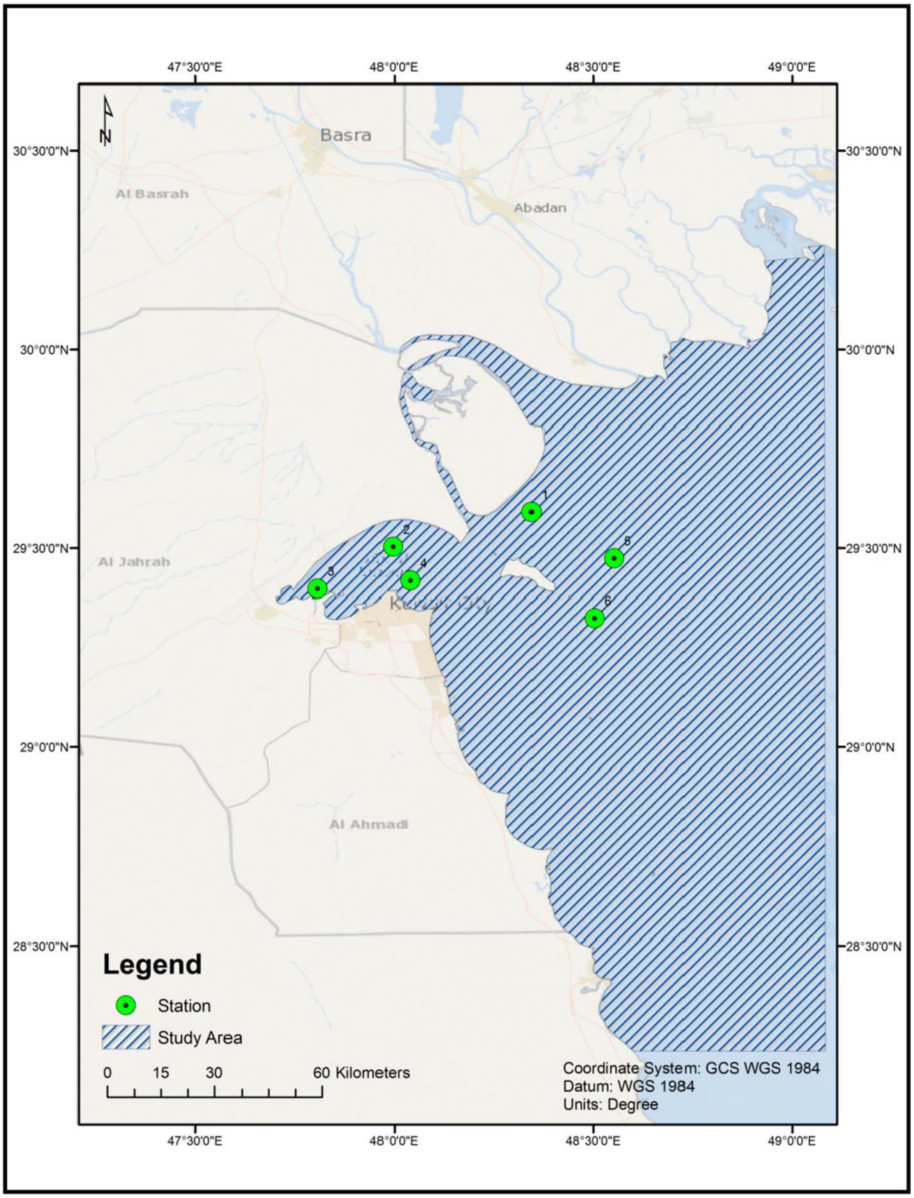

Fig. 1. Location of seawater sample collection.

plant in Bushehr, Iran operational since 2011, and four units in Barakah, UAE soon to be operational. Saudi Arabia also has plans to add 16 NPPs in next two decades. These developments necessitate obtaining a reliable pre-nuclear baseline in marine sediments. Moreover, this will also serve to better understand fluxes of radioactive materials to and from sediments into the aqueous phase.

The samples were collected from Kuwaiti waters. The study area receives a substantial quantity of sediment from the Shaat Al-Arab, Karun river and Khor Zubair (Third River), making the northern portion of the study area quite turbid (Uddin et al., 2011). Bottom sediment samples were collected from six sites within the Kuwait bay embayment and the open waters (Fig. 1). The depth at sampling locations varied between 3 and 28 m. From each sampling site, five subsamples were collected to make a composite sample. A Van Veen grab sampler was used for collection of sediment samples. The samples were packed in watertight containers for transport to a laboratory for analyses.

The samples were prepared for activity concentration measurement by gamma-ray spectrometry according to the methodology proposed by IAEA (IAEA, 2003). An Ultra-low background Gamma-spectrometry system equipped with Canberra Broad Energy Ge series (BEGe) detectors were used to measure the gamma emissions. The detector efficiency was calibrated using mixed gamma standard solution QCYB NG1 and NG4 prepared by Eckert and Ziegler. This calibration source covered the energy ranges from 46 keV to 1.8 MeV. The correction for cascade summing was performed by the Genie 2000 analysis software. The specific activities of ^{214}Pb, ^{214}Bi, ^{226}Ra, ^{210}Pb and ^{137}Cs radionuclides were determined using the spectral lines presented in Table 1 (Aba et al., 2014). ^{226}Ra activity was indirectly estimated based on the weighted average activity for the strongest peaks of ^{226}Ra radiogenic

Table 1
Gamma spectral lines and the relative intensities used in the gamma spectrum analysis, with yield uncertainty in brackets.

Radionuclide	Energy (keV)	Gamma yield (%)
^{210}Pb	46.5	4.25 (4)
^{226}Ra	186.2	3.51 (6)
^{214}Pb	295.2	18.41 (36)
	351.9	35.6 (7)
^{214}Bi	609.3	45.49 (19)
	1120.3	14.91 (3)
	1764.5	15.31 (5)
^{137}Cs	661.6	84.99 (20)