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Baseline

Baseline concentration of ^{210}Po and ^{210}Pb in *Sargassum* from the northern Gulf

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ABSTRACT

This baseline study highlights the ^{210}Po and ^{210}Pb concentration in two species of the benthic macroalgae *Sargassum* from northern Gulf, also known as the ROPME Sea Area (RSA). Within the marine environment, ^{210}Po is initially absorbed from water and concentrated by phytoplankton and macroalgae, and this concentrated ^{210}Po can then readily be passed along to the higher trophic level of the marine food web. The ^{210}Po concentration measured in *Sargassum boveanum* (22.5–25.6 Bq kg^{-1}) was higher than that in *Sargassum oligocystum* (20.2–22.5 Bq kg^{-1}), but is not statistically significant ($p > 0.064$), where as the difference between ^{210}Pb concentrations in *Sargassum boveanum* (15.3–16.8 Bq kg^{-1}) and *Sargassum oligocystum* (18.4–22.0 Bq kg^{-1}) was statistically significant ($p > 0.019$). The measured concentration factor for ^{210}Po in *Sargassum* in the northern Gulf varied between 0.55 and 1.2×10^4, values higher to the IAEA recommended value of 1×10^3. The ^{210}Po enrichment is observed in both the species of *Sargassum*, ^{210}Po/^{210}Pb ratio was >1 at all the stations for all the samples.

The concentration of the natural radionuclide ^{210}Po in the marine environment is of particular interest because of its large contribution to the natural radiation dose received by marine organisms and human populations consuming seafood (Fowler, 2011; Stewart et al., 2005). In fact, natural ^{210}Po is responsible for higher radiation doses to humans consuming marine products than is plutonium and other key man-made radionuclides (Pentreath and Allington, 1988). Many marine organisms are capable of concentrating ^{210}Po to relatively high levels in their tissues (Bowen and Dymond, 1955; Carvalho and Fowler, 1994; Fowler, 2011; Hameed et al., 1997; Lowman et al., 1971; Pentreath, 1985). ^{210}Po is an alpha emitter with a 138-day half-life in the ^{238}U series, and is supplied to sea water from ^{226}Ra decay in seawater and river runoff, however, the main source of ^{210}Po in the environment is ^{222}Rn exhalation from the ground. Assessing the impact of radionuclides in the environment requires the establishment of baseline levels in different environmental compartments. A large fraction of the total radiation exposure experienced by individuals is delivered via marine food chain transfer (Aarkrog et al., 1997; Al-Masri et al., 2000). Our study's objective was to acquire baseline data on the ^{210}Po concentrations in typical seaweeds and to determine the bioconcentration factors in these macroalgae. Therefore two of the most common benthic algal species of *Sargassum* found in the northern Gulf were analyzed for ^{210}Po and ^{210}Pb. Samples of these two seaweeds were collected from three different locations within Kuwait's territorial waters during January 2013 (Fig. 1).

Upon collection, the seaweed samples were immediately transported on ice to the laboratory. The samples were prepared for analysis in a radionuclide- and metal-clean laboratory at the Kuwait Institute for Scientific Research. Standard protocols for sample collection, preparation, and radionuclide determination were adopted (IAEA, 1989). All of the samples analyzed were homogenized composites that had been prepared by bulking several samples of similar species of *Sargassum* obtained from same location. The samples were then dried at 105 °C and pulverized. The % dry weight for each seaweed sample is shown in Table 1.

^{210}Po concentrations were determined using the standard silver disc technique (Flynn, 1968). Each sample was digested using concentrated nitric acid for at least 24 h; hydrogen peroxide was added to help oxidize the organic compounds. A clear solution was obtained and evaporated to near dryness. The resulting residue was then dissolved in 100 ml of 0.5-mol/l HCl and the solution heated on a magnetic stirrer at 80 °C. The ^{210}Po in solution was spontaneously plated onto a 0.64-mm-thick silver disc (1.2 cm dia) after iron reduction with ascorbic acid (Al-Masri et al., 2004; Fisenne, 1997). Reagent blanks were also analyzed along with the samples. The samples (2 g dry) were spiked with 100 μL of ^{209}Po

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tracer at the beginning of the digestion process to ascertain the recovery and efficiency. A Canberra twelve-chamber alpha spectrometry system with a passive ion-implanted silicon detector (active area of 300 mm^2, background count of 2.3 per day, and minimum depletion thickness of 90 μm) was used for the ^{210}Po determination, and the 5.305-MeV energy line was chosen for quantification. These samples were retained for six months and ^{210}Po was determined again. The total amount of ^{210}Po present in the sample was used to determine the ^{210}Pb concentrations. The IAEA 414 – Fish Certified Reference Material was analyzed, together with the seaweed samples for determination of ^{210}Po, and the massic activity of ^{210}Pb (^{210}Po) was found to vary between 1.82 and 2.15 Bq kg^{-1} with a median value of 2.01 Bq kg^{-1} against the ^{210}Pb(^{210}Po) information value of 2.1 Bq kg^{-1} and a 95% confidence interval of 1.8–2.5 Bq kg-1.

The seawater samples were analyzed using method laid down by Bojanowski et al. (1983). 4 l filtered seawater sample was taken in a 5 l beaker and 10 ml of concentrated HCl was added to the sample to prevent the radionuclides from sticking to the beaker wall. 100 μl of ^{209}Po tracer was added to the sample and stirred for 3 h to ensure a tracer equilibration. 5 ml of each 0.2 M $KMnO_4$ and 0.3 M $MnCl_2$ were added and the solution was adjusted to pH 9 with 25% NH_4OH. This solution was stirred for 3 h and kept for a day in order to allow the precipitate to settle down. The supernatant was decanted carefully so as not to disturb the precipitate and the rest was centrifuged. The precipitate was dissolved with 10 ml of 1% H_2O_2 in 5 M HCl. Also, the precipitate was dissolved with 10 ml of 1% H_2O_2 in 2 M HCl. The sample solution was heated-up on a hot plate at 95 °C for 30 min to decompose the peroxide. The sample solution was transferred into a separate funnel and the beaker was washed thrice with 5 ml of 5 M HCl to give a total of 20 m. A small amount of ascorbic acid was added to the solution for quenching Fe. Po was extracted with 10 ml of 0.1% diethylammonium diethyldithiocarbamate (DDTC) in CH_3CCl_3 by 5 min with a shaker (250 rpm). Po was extracted twice with 5 ml of 0.1% DDTC in CH_3CCl_3. If the organic phase was colored, Po was extracted with further aliquots until the color disappeared. The organic phase was combined and evaporated to a dryness on a hot plate at 95 °C. The aqueous phase was reserved for the Pb, Ra, Th and U analyses. The residue was dissolved with 5 ml of 65% HNO_3 to decompose the DDTC and evaporated to a dryness on a hot plate at 95 °C. The residue was dissolved with 2 ml of concentrated HCl and evaporated to a dryness on a hot plate at 95 °C.

Table 1
% Dry weight of the seaweed sampled from Kuwait waters.

Sample	Location[a]	Dry weight (%)
Sargassum boveanum	1	12.2
Sargassum boveanum	2	12.2
Sargassum boveanum	3	12.2
Sargassum oligocystum	1	11.2
Sargassum oligocystum	2	11.2
Sargassum oligocystum	3	11.2

[a] See Fig. 1.

The dry-weight concentration of ^{210}Po in seaweeds varied between 20.2 and 25.6 Bq kg^{-1} and (Table 2) and of ^{210}Pb varied between 15.30 and 22.00 Bq kg^{-1} (Table 3). *Sargassum boveanum* has a higher mean ^{210}Po concentration compared to *Sargassum oligocystum*. The difference in ^{210}Po concentration between these two species is not significant at 95% confidence level (p value = 0.064). While the mean ^{210}Pb concentration in *S. oligocystum* is higher *S. boveanum*, but the difference between the two species is statistically significant ($p > 0.018$). Seawater samples were also collected from each of these locations and ^{210}Po and ^{210}Pb concentrations were also determined. The ^{210}Po and ^{210}Pb concentration in seawater ranged between 0.28–0.38 and 0.58–0.68 mBq l^{-1} respectively (Table 4).

The ^{210}Po concentrations found in these seaweeds from the northern Gulf are comparable to the concentrations obtained from

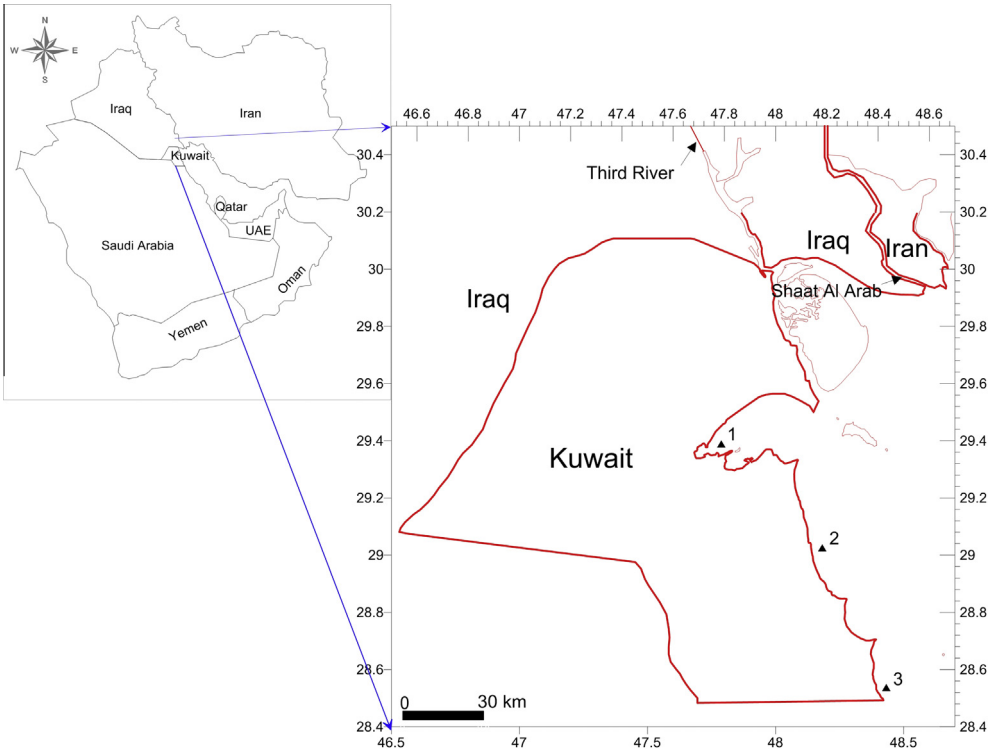

Fig. 1. Location of the three collection sites for *Sargassum* samples along the Kuwait coast.