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Baseline

^{210}Po concentration in selected diatoms and dinoflagellates in the northern Arabian Gulf

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ABSTRACT

Marine phytoplankton is a primary producer in the ocean that forms the base of the marine food web and supports the pelagic food chain. The two dominant groups of phytoplankton observed in northern Gulf waters are diatoms and dinoflagellates. The diatoms outnumber dinoflagellates in the Gulf waters. This study presents baseline information on the concentration of ^{210}Po among selected phytoplankton in the northern Gulf. The concentration among diatoms varies between 6.99 and 11.4 Bq kg^{-1} wwt, whereas a higher concentration range of 8.51–15.41 Bq kg^{-1} wwt was observed among dinoflagellates. The diatoms analyzed includes *Thalassiosira* spp. – 10.2–11.4 Bq kg^{-1} wwt; *Chaetoceros* spp. – 6.99–7.14 Bq kg^{-1} wwt; *Rhizosolenia* spp. – 9.12–9.95 Bq kg^{-1} wwt. The analyzed dinoflagellate genera include *Gymnodinium* spp. – 8.51–8.78 Bq kg^{-1} wwt; *Noctiluca* spp. – 15.2–15.4 Bq kg^{-1} wwt; and *Karenia* spp. – 14.1–14.9 Bq kg^{-1} wwt. The ^{210}Po concentration in seawater shows a seasonal variation, with a higher concentration range of 0.70 and 0.58 mBq L^{-1} during summer and autumn, whereas a lower range in concentration of 0.38 and 0.30 mBq L^{-1} occurring during winter and spring. The resultant computed concentration factors vary between $2 * 10^4$–$5 * 10^4$ demonstrating a significant ^{210}Po enrichment in the base of the pelagic food chain.

Polonium in marine organisms has been studied for several decades (Beasley et al., 1978; Cherry, 1964; Cherry et al., 1975; Cherry and Shannon, 1974; Heyraud and Cherry, 1979; Heyraud et al., 1976; Shannon and Cherry, 1967; Shannon et al., 1970) A relatively higher concentration of ^{210}Po compared to ^{210}Pb is commonly reported in marine biota. Elevated levels of ^{210}Po in marine biota, suggest that humans could receive an enhanced radiation dose from seafood consumption (Aarkrog et al., 1997; Pentreath and Allington, 1988). As a result, many studies have been carried out to obtain baseline measurements of ^{210}Po concentrations in marine biota and seawater to better understand uptake, bioaccumulation and turnover processes in the marine environment.

Several initial studies have reported elevated uptake of ^{210}Po in phytoplankton and zooplankton (Beasley et al., 1978; Cherry et al., 1975; Folsom and Beasley, 1973; Shannon and Cherry, 1967; Shannon et al., 1970). The first determinations of unsupported ^{210}Po in plankton were attempted back in the 1960s (Cherry, 1964; Shannon and Cherry, 1967) and a concentration of 104 Bq kg^{-1}(dry weight) was reported. Phytoplankton are known to concentrate metals and transuranic elements from surrounding waters (Fisher et al., 1983). However, there are limited data available on ^{210}Po concentration in microalgae. It is vital to determine the ^{210}Po levels in phytoplankton; being primary producers, they can take up large amounts of ^{210}Po, concentrate them and possibly lead to biomagnification. These elevated concentrations are likely to be passed on to the pelagic food chain.

^{210}Po is particle reactive in seawater, and it is known to become concentrated in the microscopic phytoplankton at the base of the food chain (Fowler, 2011). With a large number of studies conducted on ^{210}Po levels in marine organisms (Boisson et al., 2001; Carvalho and Fowler, 1993; Durand et al., 1999; Farber-Lorda et al., 2013; Farber Lorda et al., 2017; Fisher et al., 1999; Fowler, 2011; Fowler and Fisher, 2004; McDonald et al., 1986; Stewart et al., 2005; Tateda et al., 2003; Uddin et al., 2015a; Uddin and Behbehani, 2014; Uddin et al., 2017), it is known that the ^{210}Po activity concentrations spread over several orders of magnitude, across the trophic levels and geographic locations. Previous work by this group has attempted to provide a comprehensive baseline on ^{210}Po in marine organisms across trophic levels (Uddin et al., 2017). Unlike the information on ^{210}Po concentration in macroalgae, the data for different plankton groups (micro, nano, and picoplankton) are extremely sparse in the literature (Fowler, 2011). This study attempts to fill this data gap by providing such information from the northern Gulf.

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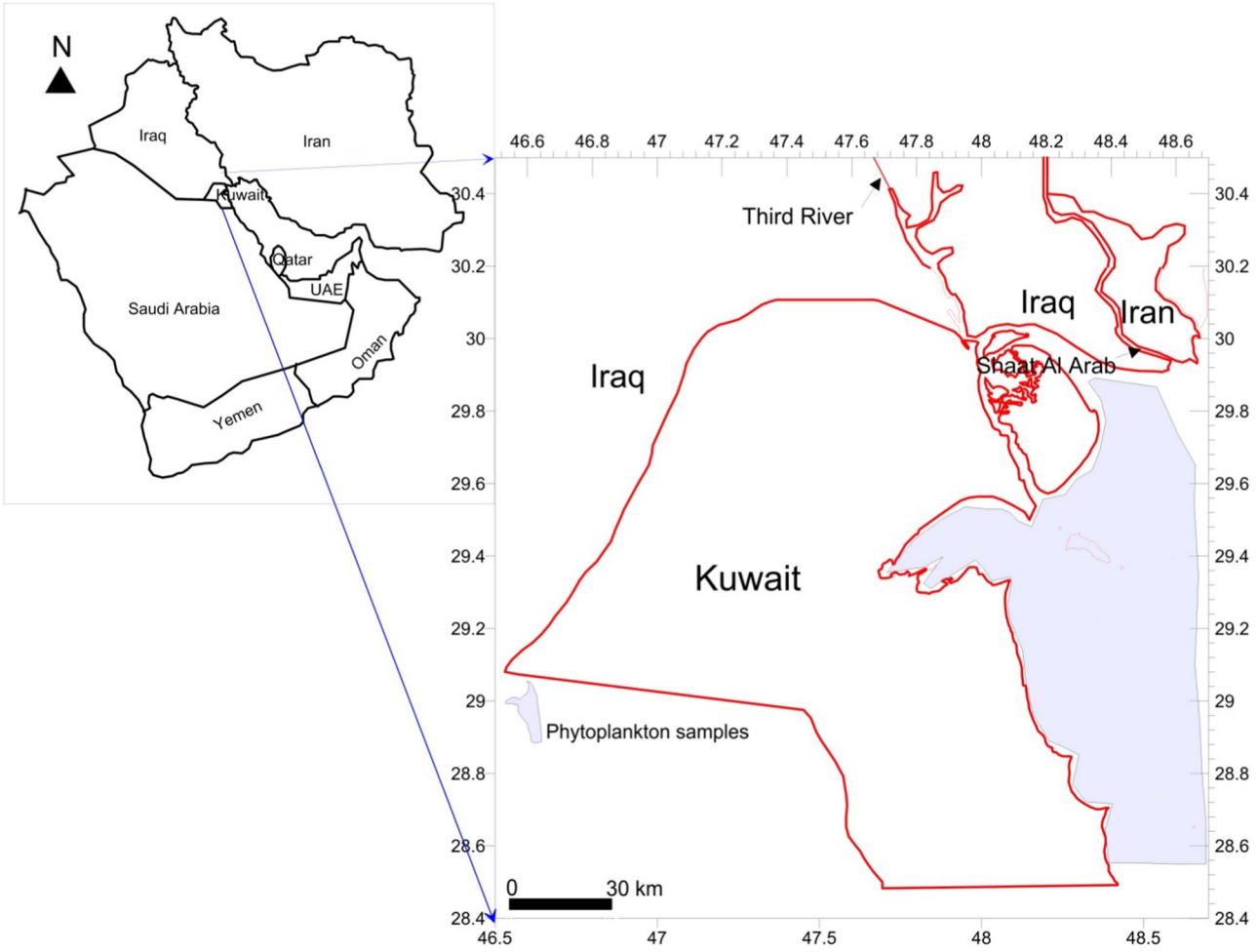

Fig. 1. Map of the Kuwait coast showing the location of the sampling area.

^{210}Po concentration in diatoms and dinoflagellates has been determined by analyzing samples collected from the Kuwait territorial waters (Fig. 1).

The microalgae samples were collected during a series of cruises using a 20-μm mesh size plankton net with 0.6 m mouth diameter and 2.0 m length. The samples were collected during February and November 2017 by obliquely towing the plankton net at a speed of 2 knots h^{-1}. All the net samples were packed on ice and immediately transported to the special radionuclide- and trace metal-clean laboratory at KISR. The collected samples were preserved with 4% acidified Lugol's solution. The preservation was done because separating phytoplankton was easier when stained. Prior to identification, the collected samples were passed through a four-stage cascade filter with a mesh size of 110, 75, 45 and 20 μm for size segregation. Most of the adult copepods and debris including micro-plastics were retained on 110 μm mesh, whereas the copepodites were mostly retained on 75 and 45 μm. The samples from each mesh were washed with filtered seawater into a beaker, for identification and further segregation of the phytoplankton groups. Subsamples were taken using a stempel pipette and transferred to a combined plate chamber and observed under a stereomicroscope. The identified cells were transferred to specific sample containers using capillary tubes. The near pure samples of phytoplankton were then filtered through a pre-weighed 0.2 μm nylon filter, which was dried to obtain the dry weight. Composite samples were prepared by bulking phytoplankton of a single genus. The seawater with Lugol's solution was also analyzed for ^{210}Po; the levels were between 0.08 and 0.12 mBq L^{-1}, i.e., significantly lower than the ^{210}Po in filtered seawater.

The diatoms and dinoflagellates samples, collected on a single cruise day from different areas within the territorial water were segregated at the genus level, following the taxonomic names given in AlgaeBase (Guiry and Guiry, 2018). The diatoms include: *Thalassiosira* spp. were short cylindrical shaped algae that varied in size between 4 and 32 μm in size. They are larger in winter season compared to summers. *Chaetoceros* spp. have radial symmetry and are coin shaped with a diameter range of 5–80 μm and length of 2–45 μm. *Rhizosolenia* spp. were 10–140 μm in diameter and are cylindrical (rod-like) with a silica shell. The dinoflagellates included were *Gymnodinium* spp., *Noctiluca* spp. and *Karenia* spp. The *Gymnodinium* are dinoflagellates without cellulosic plates; they were broadly oval having 25–40 μm width and 30–65 μm length. They are often associated with red tides, and many species produce toxins that are responsible for fish kills and shellfish poisoning. *Noctiluca* are typically 200–2000 μm in size, subspherical and feed on phytoplankton and other dinoflagellates and protozoans. *Karenia* are circular with a diameter between 20 and 40 μm and thickness between 10 and 15 μm. Several species of *Karenia* have been associated with fish kills and red tides. They are also photosynthetic and possess two flagella that allow them to move in a spinning motion.

Standard protocols for radionuclide determination were followed (IAEA, 1989). Each sample was digested in concentrated nitric acid for at least 24 h with addition of hydrogen peroxide to aid in oxidizing the organic matter, after which 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 this solution was then spontaneously plated onto a 0.64 mm-thick silver disc (1.2 cm dia) after iron reduction with