Journal of Environmental Radioactivity 149 (2015) 1–7

Contents lists available at ScienceDirect

Journal of Environmental Radioactivity

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

Radioactivity in three species of eastern Mediterranean jellyfish

S. Mamish [a,*], M.S. Al-Masri [a], H. Durgham [b]

[a] Atomic Energy Commission of Syria, Department of Protection and Safety, P.O. Box 6091, Damascus, Syria
[b] Tishreen University, High Institute of Marine Biology, Lattakia, Syria

ARTICLE INFO

Article history:
Received 24 September 2014
Received in revised form
1 July 2015
Accepted 1 July 2015
Available online 15 July 2015

Keywords:
Jellyfish
Eastern Mediterranean Sea
Concentration ratio (CR)
Rhopilema nomadica
Aurelia aurita
Aequorea forskalea

ABSTRACT

Activity concentrations of ^{137}Cs, ^{40}K, ^{210}Po, ^{210}Pb, ^{234}U and ^{238}U were determined in umbrella and oral arms of three widely distributed jellyfish species; namely *Rhopilema nomadica* Galil, 1990, *Aurelia aurita* Linne, 1758 and *Aequorea forskalea Péron & Lesueur, 1810* collected from February 2011 to January 2012 in four sampling locations along the Syrian coast (Eastern Mediterranean Sea). The results have shown significant variations in radionuclides activity concentrations amongst the species. The average activity concentrations of ^{40}K, ^{210}Po, ^{210}Pb, ^{234}U and ^{238}U in the umbrella of *R. nomadica* species were higher than the average activity concentrations in the umbrella of *A. aurita* species by about 3.2, 1.4, 1.8, 3.2 and 3.2 folds, and *A. forskalea* species by about 45.5, 15.4, 19, 7.4 and 7.6 folds, respectively. The average activity concentrations of ^{40}K, ^{210}Po, ^{210}Pb, ^{234}U and ^{238}U in oral arms of *R. nomadica* species were higher than the average activity concentrations in oral arms of *A. aurita* species by about 3.8, 1.7, 1.9, 2.8 and 2.9 folds, respectively. ^{137}Cs activity concentrations were below the detection limit in all measured samples. In addition, activity concentrations of ^{137}Cs, ^{40}K, ^{210}Po, ^{210}Pb, ^{234}U and ^{238}U were also determined in 44 surface seawater samples and the activity concentrations ranged between 10.6 and 11.9 Bq l^{-1} for ^{40}K, 1.1 and 1.4 mBq l^{-1} for ^{210}Po, 0.5 and 0.7 mBq l^{-1} for ^{210}Pb, 40.8 and 44.5 mBq l^{-1} for ^{234}U, and 36.9 and 38.4 mBq l^{-1} for ^{238}U, while ^{137}Cs activity concentrations were below the detection limit in all measured samples. Moreover, the umbrella and oral arms readily accumulated ^{40}K, ^{210}Po, ^{210}Pb, ^{234}U and ^{238}U above ambient seawater levels in the sequence of ^{210}Po > ^{210}Pb > ^{4} K > ^{234}U and ^{238}U. Concentration ratio (CR) values were relatively high for ^{210}Po and ^{210}Pb and reached 10^3 and 10^2, respectively for the jellyfish *R. nomadica* species compared to *A. aurita* and *A. forskalea* species. Therefore, *R. nomadica* can be used as biomonitor for these two radionuclides in the Eastern Mediterranean Sea. However, the obtained data can be considered the first reported baseline values for radioactivity in jellyfish.

1. Introduction

Human activities, climatic changes, environmental deterioration, absence of natural predators and competing organisms in the Mediterranean basin, may have contributed to enhancing the population of jellyfish in coastal waters. Despite its simple constitution and small size, carnivorous jellyfish play a crucial role in the marine food chain, they mainly feed on zooplankton, crustaceans, small fish, fish eggs and larvae, and it has been proposed that, dependent on all the above influences, the pelagic food web may switch production away from fish towards jellyfish (Malej, 2001; Mills, 2001; Pagès, 2001; Benovic and Lucic, 2001; Lynam, 2006; Purcell et al., 2007; Boero et al., 2008; Licandro et al., 2010; Sakinan, 2011; Turan et al., 2011; Mamish et al., 2012). Jellyfish is the main pray for sea turtles, sun and tuna fish and is considered a secondary pray for larger crustaceans, lobsters and some seabirds. In addition, jellyfish (especially the umbrella of the large species) is a popular seafood in some Asian countries' cuisine (Harrison, 1984; Hsieh et al., 2001; Nishikawa et al., 2008).

Information on the activity concentration of radionuclides in marine environment becomes important so as to know the accumulation of such radionuclides in the organisms and final transfer to man through sea foods. The baselines and more detailed studies for many marine organisms for biomonitoring purposes in the Mediterranean Sea have been determined (IAEA, 2014). However, similar data for jellyfish are not available. The data available on the activity concentration and accumulation of radionuclides in jellyfish are limited to only one laboratory experiment study, in which, two jellyfish species (*Cassiopea andromeda* and *Aurelia aurita*) were directly exposed to radionuclides (^{134}Cs and ^{241}Am) through water

* Corresponding author.
E-mail address: prscientific13@aec.org.sy (S. Mamish).

http://dx.doi.org/10.1016/j.jenvrad.2015.07.004
0265-931X/

and food and the results showed the ability of jellyfish to effectively uptake and accumulate some radionuclides in their tissues. Therefore, potentially playing an important role in the biological transfer and recycling of such contaminants in the marine environment (Fowler et al., 2004).

The objective of this study was to determine if jellyfish species were capable of accumulating ^{137}Cs, ^{40}K, ^{210}Po, ^{210}Pb, ^{234}U and ^{238}U radionuclides above ambient seawater levels, in order to consider them as a future tool in the radionuclides biomonitoring programs.

2. Materials and methods

2.1. Sampling and preparation of samples

Jellyfish and seawater samples were collected from the Syrian coast at four sampling locations, namely Tartous, Banias, Lattakia (Burg Islam) and Al-Basset, as shown in Fig. 1. Eleven sampling cruises between February 2011 and January 2012 and two sampling cruises in July 2011 were conducted. Random jellyfish samples were collected using long-armed hand net for the large jellyfish species *Rhopilema nomadica* and *Aurelia aurita*, while the small species *Aequorea forskalea* were caught by surface horizontal haul with WP3 plankton net (diameter 113 cm, and mesh size 1000 μm) (UNEP, 1988; Raskoff et al., 2003).

The *Rhopilema nomadica* was the dominant jellyfish species in terms of abundance and distribution in all sampling locations extended from February to April 2011 and then made a second more abundant appearance in July, before completely disappearing for the remainder months of the study. Second in abundance is *Aurelia aurita* species, which was present in two main locations (Banias and Burg Islam) and was seen only during one cruise in December 2011. Only few members of the *Aequorea forskalea* species were collected in April 2011 from Tartous and Burg Islam locations in August 2011.

Diameter of the three jellyfish species, umbrella and length of oral arms of the two scyphozoa species *R. nomadica* and *A. aurita* were directly measured after sampling; the oral arms are absent in the hydrozoa species *A. forskalea*. Jellyfish were placed in a small-pored sieve for a short period to remove any excess water then the wet weight of each individual was recorded. The samples were frozen at temperature −18 °C for preservation. Surface seawater samples were taken at one meter depth by Niskin Bottle, about 50 l, at each site and at each cruise (IAEA, 1970, 1975; 1989).

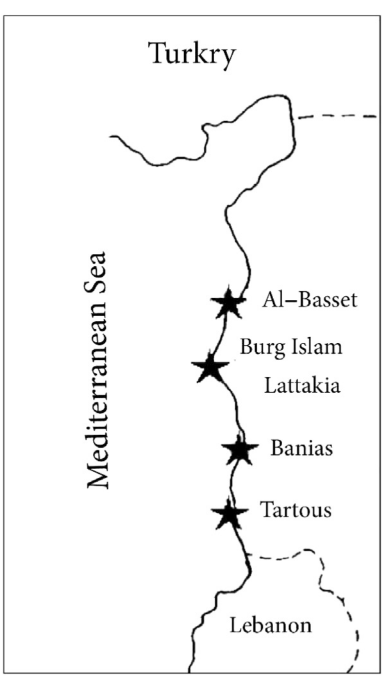

Fig. 1. Sampling sites along the Syrian coast.

Jellyfish samples were dried to acquire a constant dry weight in the oven at 105 °C, the samples were milled and representative homogenized amounts were filled into calibrated geometric plastic containers for gamma measurement. Seawater samples were filtered through filter with a pore size of 45 μm and acidified by adding concentrated hydrochloric acid; pH value was determined to be less than 2 (IAEA, 1989).

Seawater samples were prepared for determination of ^{40}K by evaporation of one liter using hot plate, with reasonable care in order to avoid spattering and loss of sample. The dried salts were milled and representative amounts were filled into calibrated geometric plastic containers for gamma measurement.

Seawater samples were prepared for determination of ^{137}Cs by precipitation of ^{137}Cs with ammonium phosphomolybdate (AMP). The AMP (6 g) was first dissolved in 100 ml of distilled water. This solution was then added to a 20 l seawater sample, and stirred for 2 h to complete the absorption of cesium on AMP. The samples were left 24 h for settling. The AMP-Cs precipitate was collected, dissolved in sodium hydroxide, and transferred to a proper container for gamma measurement (IAEA, 1970; ILMR, 1990; Roos et al., 1994).

2.2. Radioactivity measurements

The γ spectra of the samples (jellyfish and seawater) were counted for 24 h by gamma spectrometry (Eurysis Systems, Lenglshiem, France) using high resolution (full width at half the maximum height was equal to 2 keV at 1.33 MeV), at high relative efficiency (80%), with low background detectors to determine ^{40}K and ^{137}Cs.

An efficiency calibration curve was established for the same geometry used for samples using a spiked sample with standard mixed gamma Certified Reference Material QCY-48 (Amersham, UK), which is traceable to international system, SI. Detection limit values of ^{40}K and ^{137}Cs for laboratory measurements were automatically calculated by the Interwinner-04 software (Itech Instruments Sas, Rognac, France). The lower limit of detection (LLD) for jellyfish samples were 0.4, and 7 Bq Kg^{-1} dry weight for ^{137}Cs and ^{40}K (sample volume 125 g), respectively, while for seawater samples were 3 mBq l^{-1} for ^{137}Cs (sample volume 20 l), and 1.7 Bq l^{-1} for ^{40}K (sample volume 1 l). Only two small samples of *A. forskalea* were counted for 100,000 s by gamma spectrometry (Bruker Baltic, Latvia) using Well-type HPGe Detector (GWD-65 230) to determine ^{40}K and ^{137}Cs. The results were below the lower limit of detection due to small volume of the samples analyzed (around 1.5 g dry w). The LLD is 250 Bq Kg^{-1} dry weight for ^{40}K and 10 Bq Kg^{-1} dry weight for ^{137}Cs; high LLD value is due to small volume of sample.

Activity concentrations of ^{210}Po and ^{210}Pb were measured using the silver disc technique (Flynn, 1968; Clayton and Bradley, 1995; Saito and Cunha, 1997). One gram dry weight of each sample was spiked with known amount of ^{208}Po (0.2 Bq) as a yield tracer. Each sample was digested using a combination of mineral acids (nitric and hydrochloric acid) for at least 24 h. When the solution was clear, the sample was gently evaporated to near dryness. The residue was then dissolved in 100 ml of 0.5 mol l^{-1} hydrochloric acid and the resulting solution was heated to 80 °C and ^{210}Po was spontaneously precipitated onto a rotating silver disc after reduction of iron with ascorbic acid. Alpha counting of ^{208}Po (5.15 MeV)