Marine Pollution Bulletin 135 (2018) 1051–1054

Contents lists available at ScienceDirect

Marine Pollution Bulletin

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

Baseline

Baseline radionuclide concentration in selected marine organisms around the coastal areas of Ratnagiri and Sindhudurg districts, west coast of Maharashtra, India

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ARTICLE INFO

Keywords:
Radioactivity
Ratnagiri
Sindhudurg
Maharashtra
Fish
Shellfish

ABSTRACT

The present work deals with assessment of baseline radionuclide concentration in marine organisms around selected coasts of Maharashtra, India. This baseline study highlights concentrations of natural and fallout radionuclides in finfish and shellfish species found in the surrounding seawater. Water and fish samples were collected, processed, and analyzed for ^{238}U, ^{226}Ra, ^{228}Ra, ^{232}Th, ^{40}K, and ^{137}Cs by high-resolution gamma spectrometry. ^{238}U, ^{226}Ra, ^{228}Ra, ^{232}Th, ^{40}K, and ^{137}Cs concentrations were found to be in the range of ≤ 1.5, ≤ 2.0, ≤ 0.4, ≤ 1.5, ≤ 8.0 to 258, and ≤ 0.2 Bq/kg, respectively. The seasonal study revealed the maximum concentration in premonsoon season. Activity concentrations were higher in pelagic fish than those in demersal fish. A higher concentration factor was reported in shellfish than in finfish.

The study of natural and artificial radionuclide concentrations in the marine environment is important because these radionuclides accumulate in marine organisms, which when consumed enter the human body. The radionuclides released from nuclear fuels, nuclear power stations, fuel reprocessing facilities, radioactive waste management facilities, etc. are diluted and dispersed in seawater by ocean currents. The amount of radioactivity released into the marine has been compiled by the International Atomic Energy Agency (IAEA) on the basis of the reports produced by the IAEA member states (IAEA, 1999; Livingston and Povinec, 2000). The uranium and thorium series of radionuclides are of particular importance because they enter the human body mainly through the ingestion of food and smaller quantity through inhalation (UNSCEAR, 1993). These natural environmental radiations mainly depend on geological and geographical conditions also (Florou and Kritidis, 1992). Further, investigations on natural radiation in marine environment have received particular attention worldwide and led to extensive surveys in many countries (UNSCEAR, 2000). Therefore, the present study also determined the baseline data of both natural and artificial radionuclides present in the marine environment and marine organisms. In India, radionuclides are handled, processed, and disposed carefully within the limits, which are specified by the Atomic Energy Regulatory Board (AERB), and these data are monitored by the Department of Atomic Energy (DAE), India. However, there are only limited data on naturally occurring radionuclides in marine fishes from India, especially west coast. Hence, the present study focuses on the concentrations of naturally occurring radionuclides uranium and thorium series and anthropogenic radionuclide ^{137}Cs in finfish and shellfish from Ratnagiri and Sindhudurg districts in Maharashtra, India.

For the present study, the samples were collected from Ratnagiri and Sindhudurg districts (Fig. 1). Sampling was done at offshore areas covering up to 5 km off the coast by considering the distance from the lighthouse in Ratnagiri. From the reference point, two trawlings of 1 h each were conducted, i.e., one to the southwest of Sindhudurg and the other to the northwest of Ratnagiri. The samples were collected on a quarterly basis. Water samples of 60 l were collected from each location and concentrated to 250 ml. Four samplings were conducted because the southwest monsoon wind sampling at offshore was not carried out in monsoon season.

Sample collection, processing, and analysis were carried out according to the IAEA protocol (IAEA TRS 295). Dried fish and

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https://doi.org/10.1016/j.marpolbul.2018.07.064
Received 27 February 2018; Received in revised form 20 July 2018; Accepted 23 July 2018

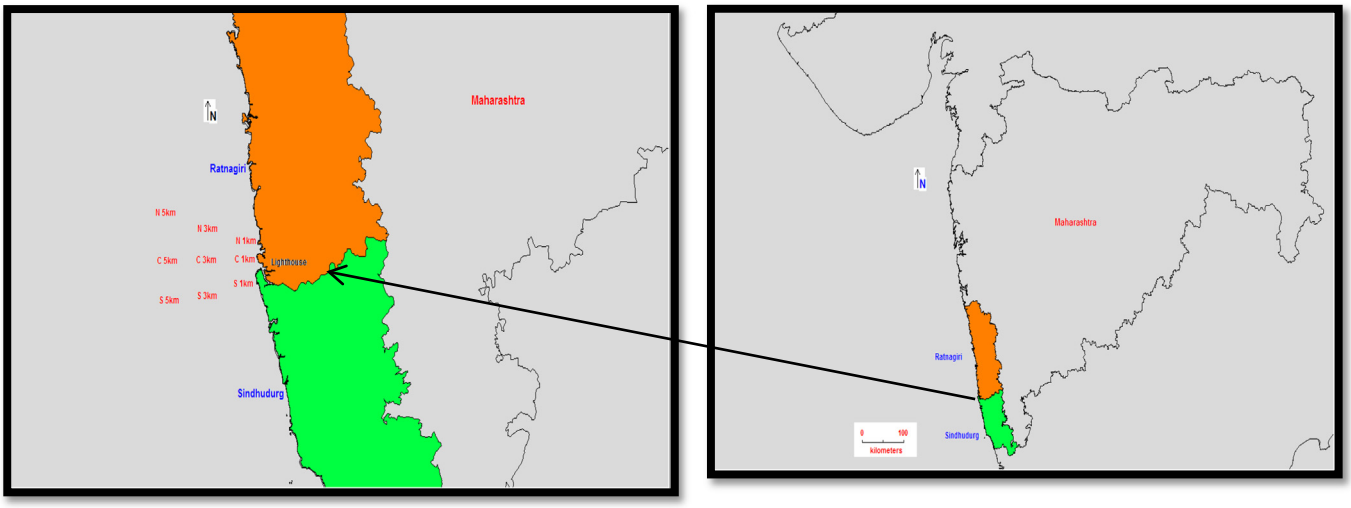

Fig. 1. Study area.

concentrated water samples were filled in plastic containers (Ø7 cm x 6.5 cm) having a similar geometry as that of the standard source. All the samples were sealed properly to ensure radioactive equilibrium between ^{238}U and ^{232}Th with their daughter products. The samples were analyzed using a high-resolution gamma spectrometer, which consists of a coaxial n-type high-purity germanium (HPGe) detector having 50% relative efficiency with respect to a 7.62 cm × 7.62 cm NaI (Tl) detector; its energy resolution measured in terms of full-width at half-maximum is 2.1 keV at 1332.5 keV of ^{60}Co gamma energy at 25 cm from the top of the detector. Spectrum stabilized 8 K MCA (PHAST, Electronics Division, BARC) along with other electronic accessories were coupled with the HPGe detector. The detector was shielded with 7.5 cm of lead to reduce the background contribution of the surrounding. The certified reference materials IAEARGU-I and RGTh-I were used for the energy and efficiency calibration of the system in the energy range of 46.53–2614.53 keV. The spectra were acquired for 1,00,000 s, and the photopeaks were evaluated using the MCA emulation software. The activity of the samples was calculated using the following formula:

$$\text{Activity (Bq/kg)} = \frac{(N - B)}{(T{*}\gamma{*}\varepsilon{*}W)}$$

where B is the background count, N is the gross count, T is the counting time (s), γ is the gamma emission probability, ε is the absolute efficiency of the detector at a particular gamma energy, and w is the sample weight (kg).

Because ^{238}U ($T_{1/2} = 4.47 \times 10^9$ years) emits weak and low-energy gamma photons (49.56 keV, (0.064%)), it is very difficult to detect uranium concentration using this radio isotope. Hence, the immediate daughter of ^{238}U, i.e., ^{234}Th ($T_{1/2}$ = 24.1 days), which emits gamma photons with energies 63.29 keV and 92.59 keV, was used for the estimation of uranium by using gamma spectrometry. ^{226}Ra content in the samples was estimated through ^{222}Rn progeny after attaining equilibrium with radium. Gamma lines of ^{214}Pb and ^{214}Bi were used for the analysis of ^{226}Ra. ^{228}Ra was estimated using 911-keV gamma energy of ^{228}Ac. For the estimation of ^{232}Th in the samples, gamma lines of ^{228}Ac and ^{208}Tl were used. ^{40}K was estimated using the gamma line 1460.83 keV (10.7%). The combined standard uncertainty was estimated by considering the errors due to counting statistics, gamma emission probability, and absolute efficiency.

The minimum detectable activity (MDA) (95% degree of confidence) was estimated using the following formula:

$$\text{MDA(Bq/kg)} - \frac{4.66\ B^{1/2}}{(T{*}\gamma{*}\varepsilon{*}W)}$$

where B is the background count, T is the counting time (s), γ is the gamma emission probability, ε is the absolute efficiency of the detector at a particular gamma energy, and w is the sample weight (kg).

A total of 52 species of finfish and shellfish were collected and identified. Among them, only 47 species of finfish and shellfish were preprocessed to estimate the natural and global fallout radionuclides by gamma spectrometry. The radioactivity levels of ^{238}U, ^{226}Ra, ^{228}Ra, ^{40}K, and ^{137}Cs were calculated from the biological samples, and the results are reported as Bq/kg of fresh weight (Table 1). The radioactivities of naturally occurring radionuclides such as ^{238}U, ^{226}Ra, ^{228}Ra, and ^{232}Th were in the range of ≤1.5, ≤2.0, ≤0.4, and ≤1.5 Bq/kg of fresh weight, respectively. The ^{40}K activity was found to be in the range of ≤8.0 to 258 Bq/kg of fresh weight. The average activity of ^{40}K was significantly lower than that of the worldwide average of 420 Bq/kg (UNSCEAR, 2000). Furthermore, the activity concentration of ^{40}K in sediment samples from the present study area was much higher than the world average concentration (Data not shown). This result strongly suggests that the high radioactivity level of ^{40}K may have arose from Ratnagiri and Sindhudurg sediment nature as well as agricultural activities, which require potassium-enriched fertilizers and pesticides, and various industrial inputs in this area. In addition, the man-made radioactivity of ^{137}Cs was also analyzed, and the value was found to be less than the below detection level (BDL) in all the samples, except in prawn shell (7.8 ± 0.94 Bq/kg), which is nonedible. The mean activity levels of ^{238}U, ^{226}Ra, ^{228}Ra, and ^{40}K in water samples were found to be 4.4, 1.7, 1.6. and 42 mBq/kg, respectively. The geometric mean activity concentrations of ^{238}U, ^{226}Ra ^{228}Ra, and ^{232}Th were ≤1.5, ≤2.0, ≤0.4, and ≤1.5 respectively. The concentration of ^{238}U radionuclide in all the species was recorded in a different season, and the ^{238}U activity concentrations were found to be very low (≤ 1.5) in both finfish and shellfish. However, the radioactivity in the fishes along the coastal line of Bay of Bengal was found to be between 0.3 and 1.4 Bq/kg (Alam et al., 1995). Further, Wesley and Khan, 2011, also reported that the radioactivity in finfish was 0.2 and 0.7 Bq/kg in the same coastal line. ^{226}Ra concentration in finfish was BDL; this is similar to the findings with Kudankulam coast (Khan et al., 2007) and Kalpakkam coast (Rajan et al., 1980). Yet, the maximum activity was reported in *Sardinella longiceps* (0.2 Bq/kg) by Kannan et al. (2003) at the east coast of India, whereas the same species in the present study was found to be ≤MDL.

The highest geometric mean activity was observed from the ^{40}K radionuclide, and the values were 37.37 and 60.38 Bq/kg in finfish and shellfish, respectively. Moreover, with regard to seasonal variations, higher activity and concentration factor (CF) were found in premonsoon than those in postmonsoon season for ^{40}K in both finfish and