ARTICLE IN PRESS
MPB-07597; No of Pages 4
Marine Pollution Bulletin xxx (2016) xxx–xxx
Contents lists available at ScienceDirect
Marine Pollution Bulletin
journal homepage: www.elsevier.com/locate/marpolbul

Baseline

Baseline concentration of Polonium-210 (^{210}Po) in tuna fish

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ARTICLE INFO

Article history:
Received 22 October 2015
Received in revised form 3 March 2016
Accepted 23 March 2016
Available online xxxx

Keywords:
^{210}Po
Baseline assessment
Preoperational
Radiological safety
Tuna

ABSTRACT

Several species of tuna fish were analyzed for ^{210}Po content in their edible muscle tissues. This study was carried out as a part of baseline data generation around a large nuclear power plant situated at Kudankulam, southeast coast of India. The concentration of ^{210}Po in the muscle tissue ranged from 40.9 ± 5.2 to 92.5 ± 7.9 Bq/kg of fresh fish, and the highest activity was recorded for the tuna *Euthynnus affinis* and the lowest for *Auxis thazard*. The committed effective dose to the local residents was calculated to be 62.7–141.8 μSv year^{-1}.

Baseline assessment of radionuclide movement, distribution, and transfer in the marine environment has been considered important in recent years (Skwarzec et al., 2003; Fowler, 2011). Seawater and sediment are the most important sources of radionuclides to marine organisms. The process of bioaccumulation in various tissues of marine organisms (marine biota) leads to an increased concentration and availability of radionuclides in the species involved in the marine food chain. Marine fish are considered as potential bioindicators, as they uptake the target radionuclide from surrounding waters (IAEA, 2004). Monitoring radionuclide levels in fish is significant, because they are the cheap source of protein, as well as their significant contribution to natural radiation dose delivered to human beings consuming them; and further, to gain a deeper insight into the radiological sensitivity of the fish (Connan et al., 2007).

After Fukushima accident, baseline data are considered a parameter of prime importance to address radiological dose assessment around nuclear power plants. Studies revealed that the main dietary contribution to the internal radiation dose is the naturally occurring ^{210}Po alone (>90%), compared with anthropogenic radionuclides (Aarkrog et al., 1997; Connan et al., 2007). Establishment of preoperational data and radiation dose around nuclear power plants, particularly from ^{210}Po, can be used to compare with the dose received from the routine low-level discharge containing anthropogenic radionuclides. This helps in the eco-friendly operation and functioning of the nuclear installations. Globally, the average individual effective dose through the consumption of marine food was estimated to be 0.3 and 9 μSv from ^{137}Cs and ^{210}Po, respectively (Aarkrog et al., 1997). However, there had been a deviation in the dietary habits and the type of marine food items.

Tunas are among the largest fish species with most specialized behavior and economic importance (Collette and Nauen, 1983). They belong to the genus *Thunnus* of the family Scombridae. They live in the temperate and tropical oceans of the world and contribute a major proportion to the world fishery products because of their excellent meat quality (FAO, 1997). They are migratory and have few predators. Scientific reports reveal that tuna fish accumulate toxicants, trace metals, and radionuclides. Interestingly, the bluefin tuna *Thunnus orientalis* attracted the attention of nuclear scientists worldwide, which carried the Fukushima-derived radionuclides from Japan to California (Madigan et al., 2012). On the basis of this scenario, this study was focused on quantifying the level of ^{210}Po in several species of tuna and estimating the level of radiological dose exposed to humans.

Tuna samples were collected from the local fishermen from major fish-landing centers, such as Chinnamuttom, Idinthakarai, and Arockiapuram, situated along the southern tip of India (Fig. 1). The prime fishing season for tuna extends from June to September. Pelagic and demersal fish, including tuna of this coast, are largely consumed by the rural fishermen population and urban residents of the study area. In the laboratory, the collected tuna samples were washed thoroughly with tap water and deionized water. The samples were morphologically identified, and their ecology and distribution were obtained from FishBase (Froese and Pauly, 2000) as well as the Internet. Muscle tissues were separated from bones, and the pooled tissues were oven-dried at 105 °C. The samples were then powdered and analyzed for ^{210}Po content. Seawater (~50-l) samples were collected from the inshore (depth 5–6 m) and offshore (depth 25–33 m) areas of the coastal regions. The seawater was filtered using a 0.45-μm-pore-sized filter

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http://dx.doi.org/10.1016/j.marpolbul.2016.03.056
0025-326X/© 2016 Published by Elsevier Ltd.

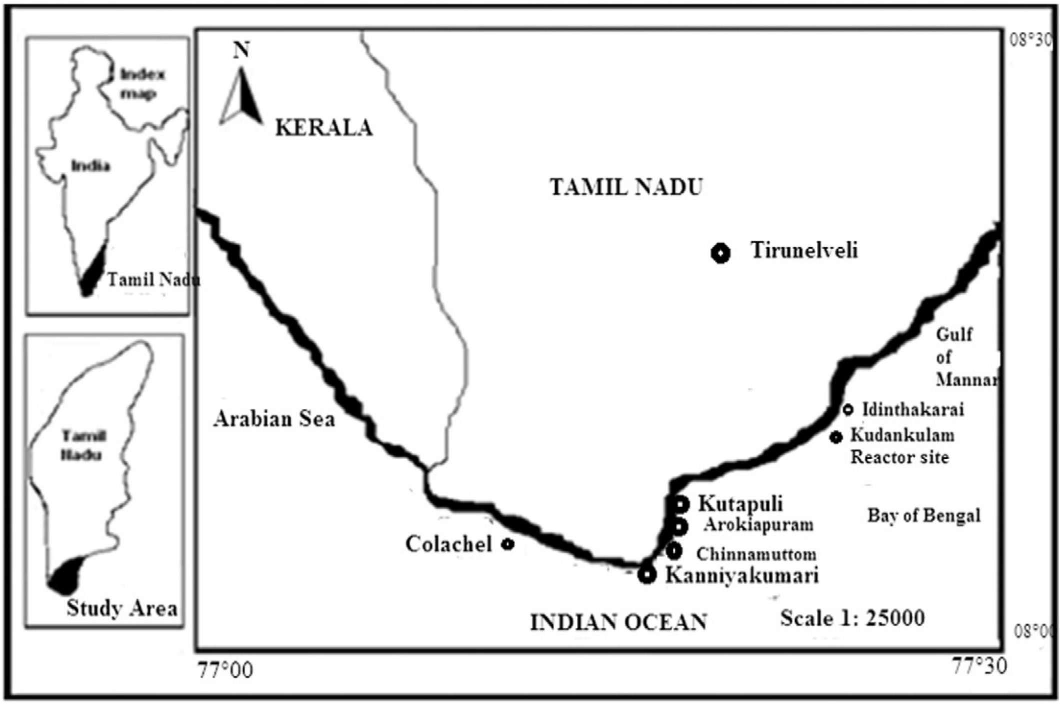

Fig. 1. Map showing the study area.

immediately after sampling, and the filtrate was acidified to pH 1 by adding HNO_3. The ^{210}Po activity of seawater and fish was determined according to the method proposed by Jia et al. (2001). Polonium in a 50-l aliquot of seawater was coprecipitated with $Fe(OH)_3$ (500 mg of Fe^{3+} ml^{-1}) containing 1 Bq of 208Po tracer. The precipitate was centrifuged at 3000 rpm and the brown residue was dissolved in a small amount of concentrated HNO_3 and HCl, and the solution was evaporated to near-dryness. The final white residue was dissolved in and made up to 50 ml with 0.5 N HCl, and then subjected to electrodeposition.

The powdered fish sample (10 g) was wet-digested using a mixed solution of HNO_3, H_2O_2, and HCl together with the addition of a 0.2-Bq ^{208}Po tracer. The resultant solutions were evaporated to near-dryness, and each residue was dissolved in 50 ml of 0.5 N HCl. Polonium was allowed to deposit spontaneously on both sides of a brightly polished silver disk from the solution for approximately 6 h (temperature 80–90 °C). Alpha counting was performed on both sides of the silver disk using an alpha-ray counter (Model RC 605A Nucleonix; efficiency, 35% for ^{241}Am standard; minimum detectable limit, 0.02 Bq). The results were reported after adding the activities of both the sides of the silver disk and applying the tracer recovery (89%). Statistical software ProUCL v 4.1 was used for the normal distribution analysis and potential outlier tests. For normality check, the Lilliefors test ($n \geq 50$) was applied, and for potential outliers, if any, Walsh's test ($n > 60$) was used. Analysis of variance (ANOVA) was used to find the variations (USEPA, 2000).

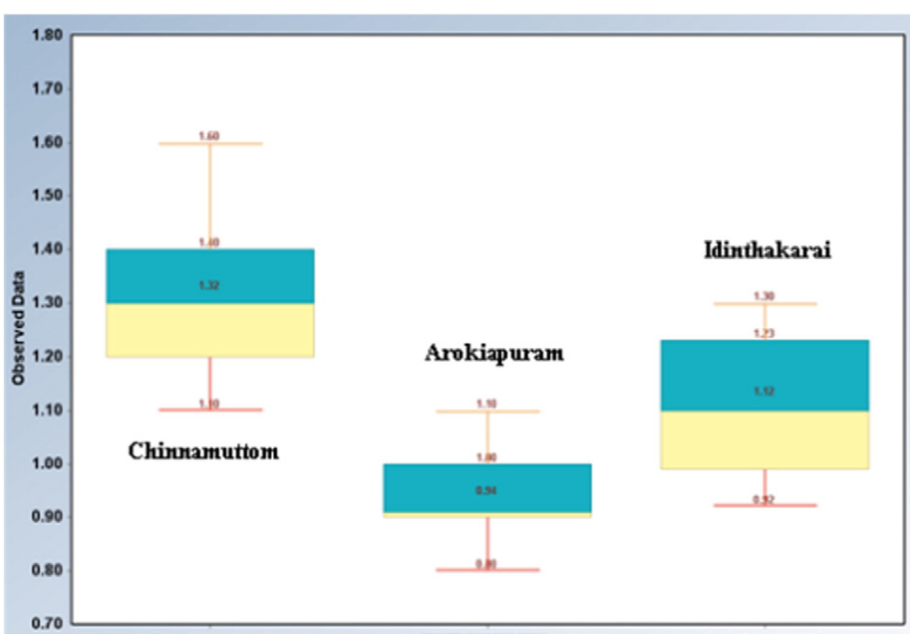

Fig. 2. Box plot showing ^{210}Po in seawater.