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Distribution of ^{210}Po in some marine biota of a Samut-Sakhon region: evaluation of dose to consumers

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Abstract

The determination of ^{210}Po in some marine organisms i.e., krill, mussel, shrimp, thread fin fish and mullet collected during 2013-2014 from Samut-Sakhon region were performed. This study aimed to investigate background information on the ^{210}Po activity and annual dose due to seafood consumption in the region. Concentrations of ^{210}Po ranged from low values of krill < mussel < shrimp < mullet < thread fin fish with a common pattern of exoskeleton of shrimp accumulated higher content than soft tissues of all samples. The feeding habit and transfer factor in the trophic level between species caused the different concentrations of ^{210}Po accumulation. The effective dose levels of marine organisms in the studied area were varied from 1.178 to 177.309 $\mu Sv.y^{-1}$. These values are considered radiological safe for human consumption.

Keywords: ^{210}Po, Marine biota, Activity concentration, Effective dose, Samut-Sakhon

1. Introduction

^{210}Po occurs in the environment as the decay products of ^{238}U radioactive series. ^{210}Po is a pure α-emitting radionuclide with a half-life of 138.377 $\pm$ 0.002 days and with a high specific activity of 1.7 x 10^{14} $Bq.g^{-1}$ [1-2]. It attains great significance in marine biota due to its radiotoxic properties. ^{210}Po is strongly adsorbed onto the surfaces of the living marine organisms and is mostly accumulated in the organic structures or in the edible portions of marine organisms. The ^{210}Po concentration in marine food has received much interest from the marine scientific community because of the high radioactive dose it delivers to marine organisms than anthropogenic radionuclides released into coastal waters. It contributes a higher radiation dose and toxicity (>90%) to humans via seafood consumption. The toxicity of ^{210}Po is connected with a relatively high energy of about 5.3 MeV and that it is concentrated in the soft tissues, such as muscle, liver, kidney, and hemoglobin. ^{210}Po is primarily associated with proteins in living organisms and can also penetrate into the cytoplasm of cells [1-5].

The purposes of this study were (i) to obtain a baseline data on ^{210}Po activity concentrations in marine biota i.e., krill, mussel, shrimp, thread fin fish and mullet collected from Samut-Sakhon province part of the Gulf of Thailand and (ii) to determine the effective dose of ^{210}Po in these organisms.

2. Materials and methods

2.1 The study site

Samples of krill, mussel, shrimp, thread fin fish and mullet were sampling from Moo 8, Fisherman village, PhanTaai Nora Sing district, Samut-Sakhon province. This region is located in the upper Gulf of Thailand where surrounding by many fisherman villages along the coastal region. The place is endowed with a rich diversity of marine organisms and is primed in exporting krill, green mussel, shrimp, anchovy, Siamese glassfish, thread fin fish and mullet.

2.2 Sample preparation

Fishes were dissected into muscle and remainder (bone and viscera), only muscle was used to analysis. Shells of mussel and shrimp were removed and soft tissues were collected. Krill (whole body) and shrimp heads were washed and kept for analysis. All samples were frozen at -20^0C until freeze-dried, wet weight and dry weight of each sample was recorded. Aliquot of the dried, ground and homogenized samples was weighed and analyzed for ^{210}Po.

2.3 Analytical procedure

Briefly, ^{210}Po radionuclide analysis was performed using 10 g of dried homogenized marine biota sample together with 0.12 Bq ^{209}Po as internal isotopic tracer. The sample was digested with concentrated HNO_3. It was slowly heated on a hot-plate until the reaction started. The solution was evaporated to foaming to destroy the organic matter until the incipient dryness was obtained. Due to foaming, the reaction rate was controlled by cooling or lowering the temperature.

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The sample residue was subsequently digested with $HClO_4$ and then HCl. The dry residue was finally dissolved in 6 M HCl and brought up to volume of 100 ml in 0.3 M HCl. The residue was separated from supernatant by centrifugation and the Po contained in the solution plated onto a silver disc and measured by alpha-spectrometer. Measurements of polonium alpha particles emitted by the Ag disc was performed with low background 450 mm^2 ion implant detector from ORTEC EG&G connected to an Octete Plus alpha spectrometer.

Quality assurance of analytical results was ensured by analysis of IAEA certified reference materials (IAEA-414 fish muscle) and participation in inter-comparison exercises with good results.

2.4 The annual committed effective dose (CED)

The estimated CED for individuals as a result of radionuclide intake was derived from measured concentrations in sample using the appropriate ingestion dose conversion factors (DCC) for adults recommended by IAEA [6]. The dose was calculated as follows:

$$C_0 = A_i \times D_F \times E_F \times M_F$$

Where C_0 is the CED in $\mu Sv.y^{-1}$, A_i is the activity intake (Bq. kg^{-1} ww), D_F is the DCC (0.43 $\mu Sv.y^{-1}$), E_F is the exposure frequency (y) and M_F is the modifying factor due to decay of ^{210}Po between catch and consumption (0.6) [3].

The Southeast Asia consumption rate used for marine fish, crustaceous (krill and shrimp) and mollusc (green mussel) are 16.4, 1.6 and 4.1 $kg.y^{-1}$, respectively [7].

3. Results

The ^{210}Po activity in marine biota collected at Samut-Sakhon region are given in Table 1.

The annual doses due to ^{210}Po from intake of the studied samples are shown in Table 2.

Table 1 Activity concentrations range ($Bq.kg^{-1}ww$) of ^{210}Po measured in marine biota

Type	^{210}Po level ($Bq.kg^{-1}ww$)
Krill	1.023 – 5.417
Green mussel	1.039 – 6.951
Shrimp	1.044 – 9.436
Shrimp head	28.656 – 83.028
Mullet	1.908 – 13.203
Thread fin fish	2.054 – 15.016

Table 2 Annual committed effective dose range ($\mu Sv.y^{-1}$) of ^{210}Po from intake of seafood

Type	CED ($\mu Sv.y^{-1}$)
Krill	1.178 – 6.240
Green mussel	1.197 – 8.008
Shrimp	1.203 – 10.871
Shrimp head	33.012 – 95.549
Mullet	22.528 – 155.902
Thread fin fish	24.255 – 177.309

4. Discussion

^{210}Po activity in marine organisms revealed that krill < mussel < shrimp < mullet < thread fin fish < shrimp head. Since polonium is absorbed from water and incorporated into the suspended particles, it is suggested that the high concentration in the body tissues might be due to the feeding habits of the marine organisms and its transfer factor to the higher trophic level. The results indicated the relatively low ^{210}Po concentration in krill when compared with others may be due to its primarily feeding on plankton. This is similarly to mussel which is a filter feeder and classified in the secoundary trophic level. While shrimp is a scavenger so it accumulates more ^{210}Po compared to krill and mussel. The ^{210}Po absorption efficiency for shrimp and fish was reported to approximately 0.33 and 0.5, respectively, and roughly corresponded to the assimilation efficiencies of protein from food [8]. Exoskeleton of shrimp or shrimp head contained 4 main components: chitin, protein, minerals, lipid and small amount of carotenoids. In which, protein accounts for the highest amount of 54.4%, minerals of 21.2%, lipid of 11.9% and chitin of 9.3%. ^{210}Po is primarily associated with proteins in living organisms; therefore, shrimp head obtained the highest concentrations of the radionuclide [7]. The observation results in this study are similar to those given in the literatures as shown in Table 3 [2, 9-12].

Annual effective ingestion dose received by an individual was evaluated and found to be in range from 1.178 to 177.309 µSv. The International Commission on Radiological Protection [ICRP] has reported a maximum dose of 1000 $\mu Sv.y^{-1}$ [13].The calculated dose values for ^{210}Po in marine biota collected from Samut-Sakhon province were much less comparable with the ICRP and the global level [10, 13-14]. Therefore, it could be concluded that seafood of Samut-Sakhon do not cause any health hazards to the general public due to ^{210}Po.

5. Conclusions

^{210}Po concentrations (Bq/kg wet weight) and annual effective dose due to ^{210}Po observed in krill, mussel, shrimp, mullet and thread fin fish from Moo 8 fisherman village at Phan-Taai Nora Sing District, Samut-Sakhon province during 2 years studied (2013-2014) is presented. Concentrations of ^{210}Po ranged from low values of krill < mussel < shrimp < mullet < thread fin fish with a common pattern of exoskeleton of shrimp (shrimp head) accumulated higher content than soft tissues of all samples. The estimated consequent annual effective ^{210}Po doses due to seafood consumption were found to be in the range of 1.178 to 177.309 µSv. Based on the international maximum permissible limit, the obtained effective dose levels of seafood in the studied area are considered radiological safe for human intake.

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Table 3 ^{210}Po concentration in marine organisms from different countries

Type	^{210}Po level (Bq.kg^{-1}ww)	Country
Krill	18 ± 2	Portugal [13]
Green mussel	45.69 – 96.44	Malaysia [cited in 10]
	320 ± 18.1	India (Kanyakumari coast)[10]
Pawn	181.3 ± 7.4	India (Palk Strait) [14]
	53.97 ± 3.7	India (Kanyakumari coast)[10]
Crab	148.6 ± 5.1	India (Palk Strait) [13]
	40.10 ± 4.4	India (Kanyakumari coast)[10]
Fish	1.2 – 92.3	India (Wedge bank region) [2]
Grey mullet	6.5	Turkey (Izmir bay)[9]
Red mullet	30	
Mackerel	36.5	India (Wedge bank region) [2]
Herring	29.8	
Sardine	54.5	Turkey (Izmir bay)[9]
	66 ± 2	Portugal [13]

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