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^{210}Po in mussels and shrimp from Ilha Grande Bay, Rio de Janeiro, Brazil

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Abstract. *Perna perna* mussels and shrimp, *Xiphopenaeus kroyeri,* collected in August 2010 at Ilha Grande Bay, a tropical estuary in the state of Rio de Janeiro coast, were analyzed for ^{210}Po contents. The method for the determination of ^{210}Po consisted of spontaneous deposition on copper discs, followed by alpha counting. The average values found for the activity concentration of ^{210}Po in *Perna perna* mussels were 105.1 Bq kg^{-1} (8 cm size) and 98.4 Bq kg^{-1} (4 cm size), wet basis. For the shrimp, the values varied from 26.17 Bq kg^{-1} to 29.56 Bq kg^{-1} (wet basis) for the tail muscle, and from 274.49 Bq kg^{-1} to 428.82 Bq kg^{-1} (wet basis) for the head.

1. INTRODUCTION

^{210}Po ($t_{1/2}$ = 138 days) is a natural occurring radionuclide and a high-energy α emitter formed by the β decay of ^{210}Pb via ^{210}Bi in the ^{238}U decay chain. In seawater an appreciable fraction of ^{210}Po is associated with the particulate matter and a part of it, is scavenged from the water column to the sediment.

However ^{210}Po is concentrated by most marine biota and is the major source of the natural radiation dose to these organisms. The accumulation of ^{210}Po varies from one tissue to another, according to the capacity to concentrate polonium [1]. ^{210}Po concentrations in the hepatopancreas are between two and three orders of magnitude higher than in muscle tissue [2].

Assessment of ^{210}Po in natural waters has been one of the most important themes in radioecology in recent times, because it accumulates in aquatic biota and is transferred through the food chain to the human being. Ionizing radiation affects all the organisms, causing cell damage and, sometimes, death. Evidence of diseases caused by low and medium radiation energy may be hidden for months or even years. ^{210}Po is considered to be the most important contributor of radiation dose received by humans via fish and shellfish consumption [3–5].

In coastal areas, like estuaries and coastal lagoons, the activity concentrations of ^{210}Po can vary largely due to the different geology of the watersheds and the weathering conditions [6]. Other factors like industrial and agricultural impact, resulting from the manufacture and use of phosphate fertilizers, can increase the activity concentrations of ^{210}Po [7–10]. As a consequence, the activity concentrations of ^{210}Po in estuarine biota can vary widely worldwide.

Estuaries act as transitional ecosystems between terrestrial and oceanic environments, and present a high accumulation capacity of continental and marine originated materials. They are productive and are home to large numbers of organisms, many of which are of commercial importance. Estuaries also provide vital breeding and feeding grounds for many birds, fish, shrimps and larvae of several animals [11].

These coastal areas, particularly near high population density centers, are of special concern, as they receive the largest exposure to chemical contamination and anthropogenic nutrient inputs due to source proximity.

The objectives of this work were to investigate the activity concentrations of ^{210}Po in *Perna perna* mussels and shrimp, *Xiphopenaeus kroyeri*, from Ilha Grande Bay.

2. METHODS

2.1 Study Area

Ilha Grande Bay is part of a complex estuarine tropical system located in the state of Rio de Janeiro, south eastern Brazilian coast. It is freely connected to the Atlantic Ocean except in its central region where Ilha Grande Island is located. In the eastern side it is connected to Sepetiba Bay, a highly polluted aquatic environment and a potential source of contaminated suspended particulate matter.

The input of freshwater from rivers is not significant. In spite of the accelerated growth process, the main economic activities are fishery, tourism, aquatic sports and commercial shipping. An oil terminal, a nuclear power plant and the Angra dos Reis harbour are located in this area.

Ilha Grande Bay is a typical tropical estuary and the climate involves warm, wet summers and dry, cool winters.

2.2 Sampling

Mussels and shrimp belong to different trophic levels: mussels are filter-feeder bivalves that live fixed on rocky shores and shrimp are omnivorous and feed on small organisms and detritus.

Both, mussels and shrimp were obtained from the fishermen during de first week of August (dry season) in 2010. Bivalves and shrimp were washed thoroughly to free them from attached particulate matter owing to high radionuclide association with silt/detritus materials. Mussels were selected according to size and separated in two lots (10 individuals each): 4 cm and 8 cm size. The soft tissues were separated from the valves and analyzed. Shrimp (all of similar size, about 6 cm) were divided in three lots (10 individuals each), according to the place where they were collected. They had the tail muscle separated from the head for the ^{210}Po determination.

2.3 Analytical procedure

To determine ^{210}Po in the bivalves and shrimp (tail muscle and head), each sample was weighed and spiked with a known activity of ^{208}Po as an internal isotopic tracer for radiochemical yield, then digested by concentrated HNO_3 and after that by H_2O_2 30%. The solution was boiled for 2 hours, cooled and then filtered. The filtrate was evaporated at 80°C until dryness. The residue was dissolved in 0.5 M HCl and 1 g of hydroxylamine hydrochloride was added, heated at 90°C and polonium was spontaneously deposited on copper disks during 4 hours.

For determination of ^{210}Po activity, an alpha spectrometry system was applied with a silicon surface barrier detector, ORTEC, model 576, coupled to a computer for spectrum analysis [12].

Analytical quality was made by analysis of blank and reference standard (spiked sample) for every 20 analyzed samples, according to EPA recommendations [13].

3. RESULTS AND DISCUSSION

Results of ^{210}Po are displayed in table 1 and table 2.

There is no significant difference between the results for the two different sizes (8 cm and 4 cm) of mussels. When compared with the mussel *Perna perna* from Guanabara Bay, also in Rio de Janeiro state, close to the city of Rio de Janeiro, mussels from Ilha Grande Bay present an activity concentration for ^{210}Po 2 to 10 times higher [12]. However this activity is between the activity found in the bivalve *Mytella falcata* from Mundaú Lagoon, situated on the northeast coast of Brazil, state of Alagoas, close

Table 1. ^{210}Po average activity concentrations in *Perna perna* mussels from Ilha Grande Bay (August 2010).

Lot	^{210}Po (Bq kg^{-1}, wet weight)
1 (8 cm)	**105.1±5.5**
2 (4 cm)	**98.4±12.6**

Table 2. ^{210}Po average activity concentrations in shrimp *Xiphopenaeus kroyeri* from Ilha Grande Bay (August 2010).

Lot	^{210}Po (Bq kg^{-1}, wet weight)
1	28.94±1.86 (muscle tail); 428.82±17.68 (head)
2	29.56±1.63 (muscle tail); 274.49±11.86 (head)
3	26.17±1.66 (muscle tail); 296.30±12.38 (head)

to the city of Maceió [14], and the activity found in *Perna perna* mussels caught in Cabo Frio Island, approximately 100 km northeast of Rio de Janeiro city [15]. If compared with the results obtained for mollusc from the Northeast Atlantic [16], the activity concentrations of ^{210}Po are similar.

The values found for the activity concentrations of ^{210}Po in the head, where is located the hepatopancreas and other organs, are 10 to 15 times higher than the values found for the muscle tail. This is in agreement with other authors who describe relative low ^{210}Po values in the muscle of marine biota, in contrast to the high values in the hepatopancreas [2, 17, 18].

The higher values were found in the shrimp collected in the eastern side of Ilha Grande Bay where it is connected to Sepetiba Bay, a potential source of contaminated suspended particulate matter.

Results of ^{210}Po in shrimp or other crustaceans from Brazilian coast were not found in the literature. Comparing the values of the muscle tail (the edible part of shrimp) with the edible parts of crustaceans from Cienfuegos Bay, Cuba (Atlantic Ocean) the values found in present work are 2 to 4 times lower [19].

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