CONTRIBUTION TO THE STUDY OF RADIOACTIVITY IN MARINE ORGANISMS; DOSAGE OF $^{210}$Po IN Perna perna, LINNAEUS 1758

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ABSTRACT

The bioaccumulation of natural radionuclides in marine organisms along the Rio de Janeiro Coast was studied. Significant levels of $^{210}$Po were found in the edible bivalve Perna perna Linnaeus, 1758. The radionuclide was concentrated predominantly in the viceral mass (52.5%) and gills (43.8%) with minor accumulation also occurring in the bissus (3.8%) and shell (0.1%). The level of $^{210}$Po in the scit tissue of bivalves collected along the Ponta Negra rock there was three times higher than that of similar organisms collected near Boa Viagem.
INTRODUCTION

The dissemination of natural radionuclides in the biosphere results from the rapid diffusion of the Radon isotopes in the atmosphere and contamination from outcrops of. Uranium and Thorium in rocks and soils. One of the more important radionuclides is $^{222}$Rn which belongs to the $^{238}$U series and $^{226}$Ra subseries. It decays rapidly ($t_1/2 = 5.8 \text{ d}$) generating the much stabler isotope $^{210}$Pb ($t_1/2 = 22 \text{ years}$).

$^{210}$Pb fixed in airbones particles is slowly deposited in the soils, vegetation and water, both as dry-fall and in association with rain (Parfenov 1974). The resulting accumulation of $^{210}$Pb and its decendants, $^{210}$Bi ($t_1/2 = 5 \text{ d}$) and $^{210}$Po ($t_1/2 = 138 \text{ d}$) is referred to as the "active deposit" of $^{222}$Rn.

Some components of the radioactive series are leached by rain and carried by rivers to the oceans. Natural concentrations of $^{226}$Ra and $^{238}$U in the ocean can reach $8 \times 10^{-11} \text{ mg/l}$ and $2 \times 10^{-3} \text{ mg/l}$, respectively, (Piccioto "Apud" Chesselet et alii, 1962) while $^{210}$Po can vary between $(0.6 \text{ to } 4.2) \times 10^{-2} \text{ pCi/l}$ or $(0.22 \text{ to } 1.55) \text{ mBq/l}$ (Woodhead 1975) in the chemical form $\text{PoO}_3^-$ (Brewer, 1975).

Systematic estimates of $^{210}$Po and its precursor $^{210}$Pb have been made in marine organisms. Both whole body and organ-specific measurements have been made, the latter providing information on preferential concentration between
tissues. Heyraud and Cherry (1979) studied the distribution of $^{210}\text{Po}$ and $^{210}\text{Pb}$ in food chains; Folsom & Beasley (1973) studied the differential concentration of $^{210}\text{Po}$ in the tissues of marine organisms.

In Brazil, Santos et alii (1972) measured the levels of $^{210}\text{Po}$ originating from fall-out in manufactured products of tobacco. Another important study was that of Stoffel (1979) who examined the behavior of $^{210}\text{Pb}$ in the aquatic environment near a Uranium mine and mill site.

A survey of natural radioactivity in coastal organisms of Rio de Janeiro state (Santos et alii, 1985) and bioassay experiments with radioisotopes have identified several organisms which accumulate radionuclides to a significant degree and thus can be used as biological indicators of radioactive pollution (Gouvea, 1981 and Gouvea, 1982). The pelecipode $Perna perna$ has been shown to be an efficient bioaccumulator of radionuclides (Gouvea, 1982 and Gouvea et alii, 1985). This species is an edible bivalve with a considerable biomass along the coast of Rio de Janeiro the object of the present study is to determine the nature levels of $^{210}\text{Po}$ in these populations.

MATERIAL AND METHODS

The animals were collected at the Boa Viagem and Ponta Negra beaches.
For the $^{210}$Po determination in the shell, samples were cleaned with a nylon brush.

A group of 12 animals (85.0 x 32.2 mm) collected at Ponta Negra beach were dissected to examine the body distribution of $^{210}$Po. Another group of 28 animals in two size classes (71.8 x 33.8 mm and 85.0 x 32.2 mm) collected as both sites had their soft tissues analyzed.

Tissues were dried at 105°C, grinded and weighed (1.0 - 5.0 g of dry mass/tissue). These dried samples were then wet mineralized at 120°C with HNO$_3$ and HClO$_4$ (15:1/g of tissue) for 10 to 15 hours in 125 ml erlenmeyer flasks. The wet residues were soaked with 2 ml of HCl - 12 M and allowed to dry. The resulting residue was then dissolved in 100 ml of 0.5 N HCl solution and stored for later expontaneous deposition. Before plating 250 mg of L-ascorbic acid was added to this chloride solution. A stainless steel plate (ref. 304) with a surface area of 12.1 cm$^2$ and one of its faces impermeabilized by a resin glue was then introduced into the mixture. This plating system was then immersed in a water bath at (80 ± 5)°C and agitated continuously for 2.5 h (with the plate in the bottom of the flask and the non impermeabilized face turned up).

After drying, the plated also was placed on top of a 12.6 cm$^2$ ZnS (Ag) disc and put in a "Philips" PW-4111 photomultiplier coupled to a "Philips" PW-4032 electronic counter and a "TECTROL" 3000 TR stabilizer.

The time of the radiometry varied from 5 h for soft
tissue to 15 h for shell and bissus. The background level determined for a reagent blank which passed through all phases of the analysis was \((1.25 \pm 0.22)\text{c.p.h.}\) for a 24 h counting period. The minimum detectable radionuclide concentration for the same counting time was \(1.1\text{mBq/g}\) (95\% C.I.).

The concentration of \(^{210}\text{Po}\) in the samples was calculated by the following equation.

\[
C = \frac{c}{1.108}, \text{ where}
\]

\(C\) = radionuclide concentration in mBq/g (dry mass),
\(c\) = concentration in c.p.h./g (dry mass)
\(1.108 = 0.98 \times 0.314 \times 3.6\)
\(0.98 = \text{radiochemistry recuperation}\)
\(0.314 = \text{radiochemistry efficiency}\)
\(3.6 = \text{d.p.h. equivalent to 1 mBq.}\)

RESULTS AND DISCUSSIONS

The average alpha radiation levels reported by Santos et alii (1983) and Montesinos and De Los Santos (1981) for the soft tissues of marine bivalves were \((1.72 \pm 1.13)\text{mBq/g}\) and \((2.22 \pm 1.46)\text{mBq/g}\) wet, respectively. Santos et alii (1983) found a much higher level of alpha radiation in Perma
perna bissus (35.0 ± 18.3 mBq/g wet). The radiation is due to the presence of isotopes of Uranium and Radium. The Uranium component is the largest due to the high concentration of Uranium in the ocean present in the stable \( \text{UO}_2(\text{CO}_3)_3 \) form. The results reported by Santos et alii (1983) confirm that Uranium is the predominant radio-nuclide alpha-emitter in *Perna perna* bissus (91.95 ± 8.90) \( \mu g/g \) with \(^{238}\text{U}\) and \(^{234}\text{U}\) accounting for 71% of the total \( \alpha \) radiation.

The values presented in Table 1 for \(^{210}\text{Po}\) contrast with those obtained for Uranium in soft tissue and bissus of *Perna perna*. The mean concentration of \(^{210}\text{Po}\) was an order of magnitude higher in the soft tissues especially in the visceral mass where 52.50% of the total \(^{210}\text{Po}\) load was concentrated.

In spite of their capacity to accumulate elements with high atomic numbers (Gouvea, 1982) such as Uranium (Santos et alii, 1983), the bissus and the shell had the lowest concentrations of Polonium-210.

Heyraud and Cherry (1979) studying a crustacea of the genera *Sergestes*, encountered \(^{210}\text{Po}\) levels in the "hepatopancreas" a hundred to a thousand times higher than those in the muscle.

These results and others suggest that the "hepatopancreas" is the organ which most accumulates \(^{210}\text{Po}\) in *Perna perna*.

The organisms collected at Ponta Negra (open sea) had higher levels of \(^{210}\text{Po}\) than those collected at Boa Viagem.
(bay), indicating a greater accumulation of $^{210}\text{Po}$ in the oceans where the Ra-226 concentration is more elevated. Beasley (1975) arrived a similar conclusion in a study of bivalves of the genre *Mytilus*.

Table 1 - Radioactive concentration and body distribution of $^{210}\text{Po}$ in bivalve *Perna perna*, Linnaeus, 1758.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Radioactive Concentration (mEq/g, dry)</th>
<th>Body distribution (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visceral mass</td>
<td>1090.0 - 263.0</td>
<td>52.5</td>
</tr>
<tr>
<td>Muscle, gill and cloak</td>
<td>905.2 - 250.0</td>
<td>43.8</td>
</tr>
<tr>
<td>Bissus</td>
<td>79.3 - 34.0</td>
<td>3.8</td>
</tr>
<tr>
<td>Shell</td>
<td>3.1 - 1.5</td>
<td>0.1</td>
</tr>
</tbody>
</table>

N. animals = 12
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