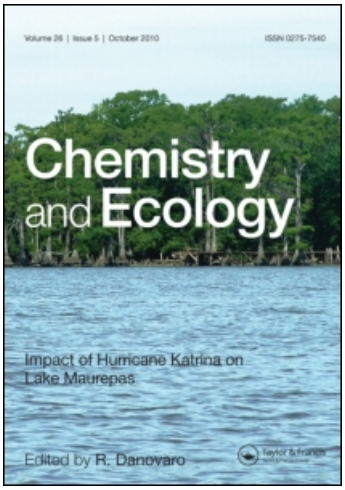

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P. Shahul Hameed[a]; R. Asokan[a]; M. A. R. Iyengar[b]; V. Kannan[b]
[a] Post Graduate Department of Zoology, Jamal Mohamed College, Tiruchirapalli, India [b] Environmental Survey Laboratory, Health Physics Division, Bhabha Atomic Research Centre, Kalpakkam, India

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THE FRESHWATER MUSSEL *Parreysia Favidens* (BENSON) AS A BIOLOGICAL INDICATOR OF POLONIUM – 210 IN A RIVERINE SYSTEM

P. SHAHUL HAMEED*, R. ASOKAN*, M.A.R. IYENGAR** and V. KANNAN**
Post Graduate Department of Zoology, Jamal Mohamed College, Tiruchirapalli 620 020, India,* Environmental Survey Laboratory, Health Physics Division, Bhabha Atomic Research Centre, Kalpakkam – 603 102, India**

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The concentration of ^{210}Po, an alpha emitter from the natural uranium series was measured in the soft tissues (total), shell, and different organs – digestive glands, gills, mantle and foot – of the freshwater mussel, *Parreysia favidens* (Benson), collected from the river Kaveri, at Tiruchirapalli in South India. The analyses were made in three size groups based on shell length (Group 1: 2–4 cm; Group 2: 4–5 cm; Group 3: 5–6 cm). The soft tissues of the mussel accumulated higher concentrations of ^{210}Po (74.0–125.5 Bq kg^{-1} fresh) than the shell (2.9–3.9 Bq kg^{-1} fresh). Further, younger mussels (1 group) showed higher concentrations (125.5±2.0 Bq kg^{-1} fresh) in total soft tissues than older ones (III Group) (74.0±1.6 Bq kg^{-1} fresh); concentration factors were 1.59×10^5 in I group and 9.37×10^4 in III group. The ^{210}Po was observed to be non-uniformly distributed among the internal organs, which maintained the following descending order with reference to ^{210}Po accumulation: digestive glands<gills<mantle<foot, ranging from 286.2±3.5 Bq kg^{-1} fresh to 43±1.3 Bq kg^{-1} fresh. The concentration of ^{210}Po in the mussels was distinctly higher than that in the grass, *Echinochloa colonum* (J. Koenig), and carp, *Cirrhinus cirrhosa* (Bloch), from the same river. These data indicate that younger mussels could be used as an excellent biological indicator of ^{210}Po and among soft tissues, digestive glands are preferable to other tissues to monitor the distribution of ^{210}Po in the riverine system.

INTRODUCTION

Among marine benthic organisms, mussels have been identified as good sentinel species for trace elements (Philips, 1980). Goldberg (1975) proposed the mussel watch concept, and advocated the use of *Mytilus edulis* in marine pollution monitoring. It is particularly efficient in accumulating transuranic nuclides and other radionuclides present in the estuarine environment (Goldberg *et al.*, 1978). Similarly, freshwater bivalves of the family Unionidae are also viewed as reliable indicators of contamination by heavy metals (Hameed and Mohanraj, 1990), and radionuclides (Merlini, 1967; Ravera and Vido, 1961). Like their counterparts in the marine ecosystem, freshwater mussels are fixed to the site for easy and repeated observation and remain at the sediment-water interface, besides occupying a pivotal position as primary consumers in the food chain. They are known to exhibit a high accumulation of trace elements (Havlik and Marking, 1987).

Studies on natural radioactivity in India are largely made in marine environments (Bangera, 1981; Iyengar *et al.*, 1981; Kannan, 1983; Iyengar, 1983) and only a limited attempt has been made in freshwater systems. Investigations on natural radioactivity in fresh waters offer considerable scope for understanding the mechanism of radioactivity transfer to man through the freshwater food chain. The available data in fresh waters are limited to the work of Ermolach-Makovskaya (1971) and Parfenov (1974).

Studies of ^{210}Po radionuclide in the environment have been considered important either for its toxicological significance or for its special accumulation behaviour in organisms (Parfenov, 1974). The present study is designed to generate baseline data for the hitherto unexplored Kaveri river system on the prevalent distribution pattern of ^{210}Po and to examine the possibility of using the common river mussel, *Parreysia favidens* (Benson), as a biomonitor of ^{210}Po.

MATERIALS AND METHODS

Area of study

The river Kaveri is one of the perennial rivers of South India. It originates in the Coorg district of Karnataka at the elevation of 1355 m in the Western Ghats and traverses a distance of about 850 km through the states of Karnataka and Tamil Nadu. The river is the primary source of water for agricultural activity in Dharmapuri, Salem, Periyar, Tiruchirapalli, Thanjavur and South Arcot districts of Tamil Nadu. At Tiruchirappalli (10°48′ N and 78°42′ E) it bifurcates into two rivers, namely Kaveri and Coleroon, by an impoundment called Upper Anicut where the Nattuvoikal, an irrigation channel, branches off (Figure 1). This study was carried out at Nattuvoikal from June 1989 to February 1990.

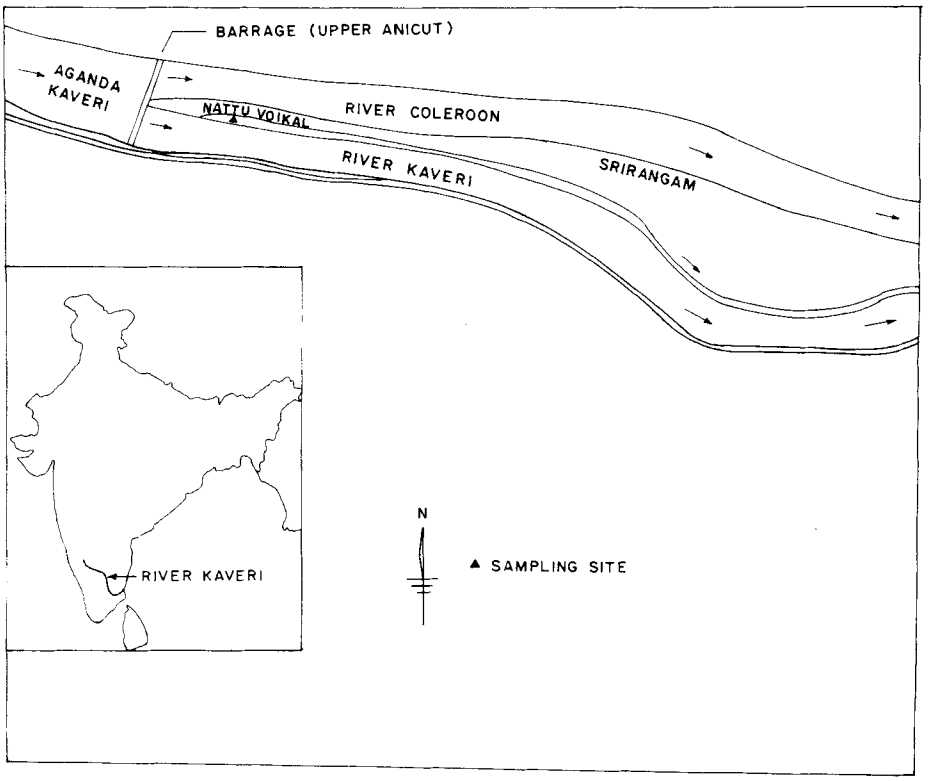

Figure 1 Map showing the location and environs of the River Kaveri and the sampling site.

Sample collection and processing

The freshwater mussel, *P. favidens*, was collected from the sampling site and brought to the laboratory. Based on shell length, the mussels were divided into three groups, namely Group I (2–4 cm), group II (4–5 cm) and group III (5–6 cm). Mussels of each group were allowed to depurate for 24 hours in the laboratory in order to eliminate the gut contents.

Sixty five mussels of group I, 35 mussels of group II, and 25 mussels of group III were used for analysis of ^{210}Po in total soft tissues. Similarly for analysis of ^{210}Po in the shell, 13 mussels of group I, 7 of group II and 5 of group III were used. However, for the measurements of radioactivity in individual organs, mussels of group III only were used. The depurated mussels were dissected carefully to separate shell and soft tissues. The wet weights of the shell and total soft tissues for each group were recorded and then dried in an oven at 105°–110°C overnight to obtain the dry weight. For analysis of individual organs, the mussels were dissected and individual tissues such as foot, mantle, gills, and digestive glands were segregated, pooled, dried and weighed.

Other samples such as river sediment, freshwater grass, *Echinochloa colonum* (J. Koeniig), and carp *Cirrhinus cirrhosa* (Bloch), were also collected from the same sampling site which is the natural habitat of the mussel, *P. favidens*. Samples were weighed and dried overnight to obtain the dry weight. A river water sample (100 litres) was brought to the laboratory after collection, filtered through Whatman 40 filter paper and acidified with conc. HCl to pH 1.0 in preparation for analysis.

Analysis

The biological materials (mussel, plant, fish etc.) and the sediment sample were wet-ashed using conc. HNO_3 and H_2O_2 mixture (1:1). The mineralised dry residue was dissolved in 0.5 HCl, filtered and ^{210}Po was deposited electrochemically on to a silver planchet following the procedure of Flynn (1968) and Iyengar (1983). The ^{210}Po activity in each sample was measured by alpha counting on both sides of the planchet using an alpha counting system.

In the case of water, Fe^{+++} carrier (5 mg l^{-1} of the sample) was added to the filtered and acidified sample with stirring and left to stand for 3–4 hours. Ferric hydroxide was precipitated in the sample by the slow addition of conc. ammonium hydroxide with rapid stirring until the pH reached 9.0. The precipitate was kept aside overnight, followed by separation of the precipitate by decantation. The supernatant, which was transferred to another container, was once again subjected to reprecipitation of ferric hydroxide as above, followed by separation of the precipitate by decantation. Both the ferric hydroxide precipitates carrying ^{210}Po were combined and dissolved in 6N HCl and finally diluted with distilled water to 0.5 N HCl. ^{210}Po was determined by electrochemical deposition following the method given above.

RESULTS AND DISCUSSION

^{210}Po concentrations in river sediment, river water, total soft tissues and shell of the mussel, *P. favidens*, the fish *C. cirrhosa*, and plant *E. colonum* are given in Table 1. Figure 2 shows ^{210}Po concentration in the total soft tissues and shell of the mussel. It can be observed from the figure that the soft tissues of the mussel concentrated a higher level of ^{210}Po (74.4–125.5 Bq kg^{-1} fresh) than the shell (2.0–3.3 Bq kg^{-1} fresh).

A decreasing trend in the concentration of ^{210}Po in the soft tissues was also observed with the age of the mussel, i.e. the young mussels (group I) accumulated nearly 41% more ^{210}Po than older ones (group III). Similar observations regarding a decrease of ^{210}Po content with age have also been reported by Heyraud and Cherry (1979), Mcdonald *et al.* (1986) and Skwarzec and Falkowski (1988).

The present study has also recorded non-uniformity in the distribution of ^{210}Po in individual organs of *P. favidens* (Figure 3). The concentrations of ^{210}Po in organs in descending order are as follows: – digestive glands>gills>mantle>foot. The digestive glands constitute about 1.8% of total animal weight, but 31% of total ^{210}Po body burden resides in the digestive glands. In contrast the shell represents 80.2% of the total animal weight, but it concentrates only about 13.7% of the total ^{210}Po content, indicating an affinity of ^{210}Po with organic moieties (Figure 4 and 4a).

Table 1 also shows that ^{210}Po content in the aquatic plant sample (3.3±0.2 Bq kg^{-1} fresh), in fish muscle (2.5±0.8 Bq kg^{-1} fresh) and in fish bone (1.5±0.2 Bq kg^{-1} fresh) were all significantly less than that observed in the soft tissues of the mussel (125.5±2.0 Bq kg^{-1} fresh). Table 1 also shows the ^{210}Po concentration in the sediment as 8.8±1.17 Bq kg^{-1} dry.

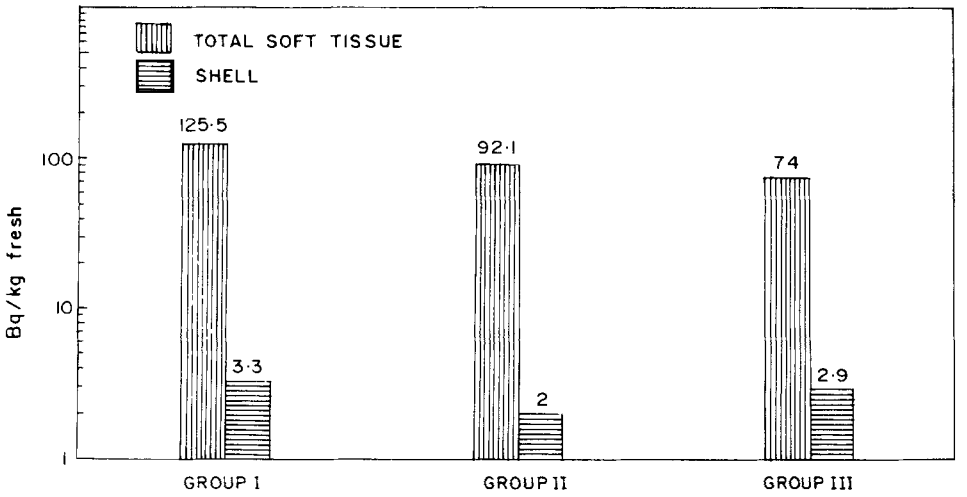

Figure 2 Polonium-210 activity in shell and total soft tissues of freshwater mussel, *Parreysia favidens.*

Iyengar *et al.* (1981) reported that the concentration of ^{210}Po in coastal waters of Kalpakkam (India) was 1.92±0.16 mBq l^{-1} and in soft parts of the marine mussel, *Perna viridis,* was 35.19±0.57 Bq kg^{-1} fresh, the concentration factor being 1.8×10^4. On the other hand, the present study recorded a low level of ^{210}Po (0.76±0.12 mBq l^{-1}) in the Kaveri river water and a high level of ^{210}Po (125.5±2.0 Bq kg^{-1} fresh) in total soft tissues of the mussel, *P. favidens*; the concentration factor being 1.59×10^5 (Table 1). It is thus evident that the freshwater mussel, *P. favidens*, possesses greater ability to concentrate ^{210}Po from ambient waters than the marine *P. viridis*. *P. favidens,* being a burrower, has constant physical contact with the river bottom (^{210}Po concentration in sediment: 8.8±1.17 Bq kg^{-1} dry) and this burrowing mode of life may possibly be associated with a higher level of ^{210}Po, whereas its marine counterpart, *Perna viridis,* belonging to the family Mytilidae, lies attached to wharf pilings, sea walls, and rocks, or among oysters, often in great numbers (Barnes,

Table 1 Polonium 210 activity in water, sediment, the freshwater mussel *P. favidens*, the fish *C. cirrhosa* and the plant *E. colonum*, from Kaveri river system.

S.No.	*Sample*	*Size group*	*Polonium 210 activity (Bq kg^{-1} fresh)*	*Concentration factor**
1	RIVER			
	Sediment		8.8±1.17 (Bq kg^{-1} dry)	–
	Water		0.76±0.12 (m Bq l^{-1})	–
2	MUSSEL			
	Shell	I	3.3±0.9	4.2×10^3
		II	2.0±1.0	2.5×10^3
		III	2.9±0.8	3.7×10^3
	Total soft	I	125.5±2.0	1.59×10^5
	Tissues	II	92.1±1.6	1.17×10^5
		III	74.0±1.6	9.37×10^4
	Foot	III	43.0±1.3	5.44×10^4
	Mantle	III	49.7±1.1	6.29×10^4
	Gills	III	65.8±1.6	8.32×10^4
	Digestive glands	III	286.2±3.5	3.62×10^5
3	FISH			
	Muscle		2.5±0.8	3.2×10^3
	Bone		1.5±0.2	1.9×10^3
4	PLANT			
	Whole		3.3±0.2	–

* Concentration factor = $\frac{\text{Concentration in biota (Bq kg}^{-1})}{\text{Concentration in medium (Bq kg}^{-1})}$

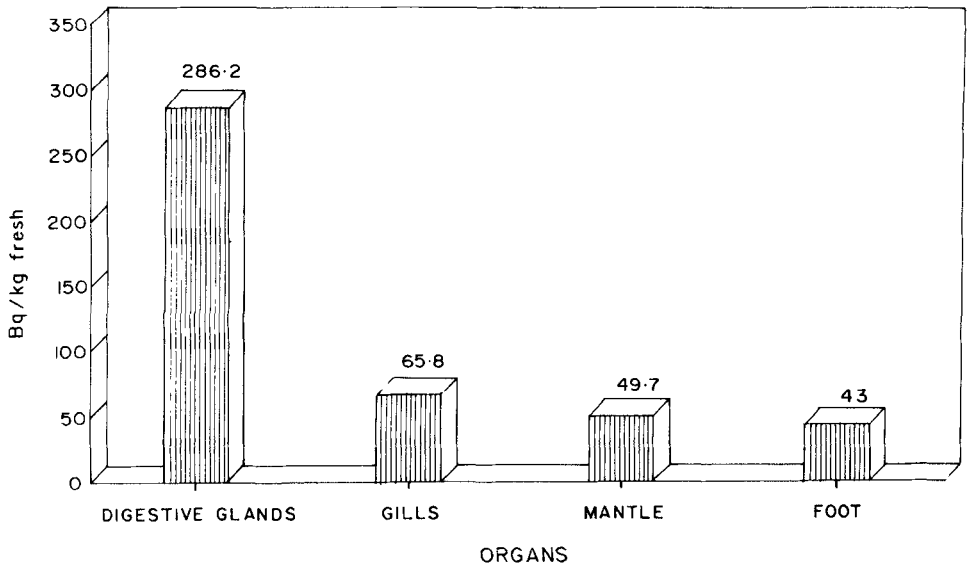

Figure 3 Polonium-210 activity in digestive gland, gill, mantle and foot of freshwater mussel, *Parreysia favidens*.

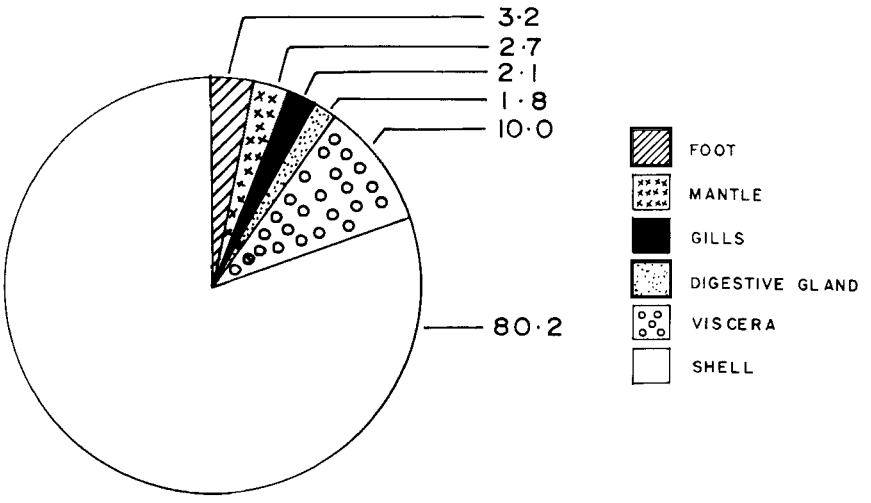

Figure 4a Percentage of individual tissue weight as a fraction of whole mussel weight of *Parreysia favidens*.

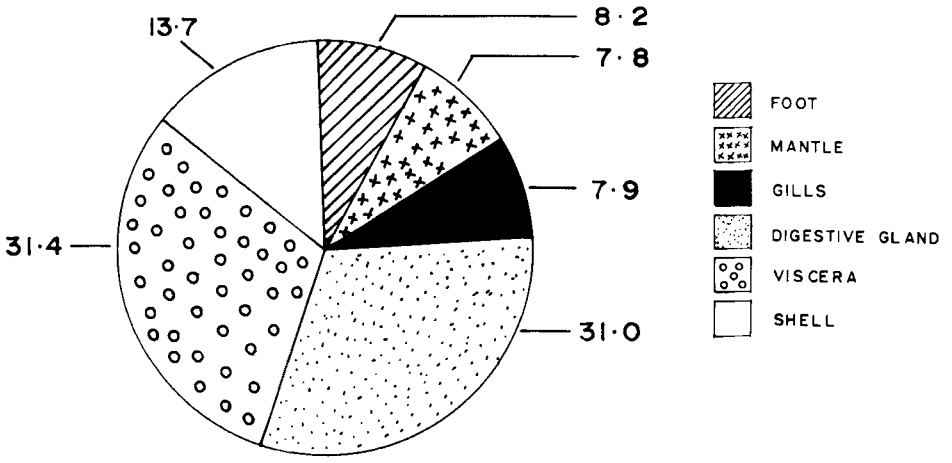

Figure 4b Percentage of individual tissue content of ^{210}Po as fraction of total ^{210}Po in the whole mussel of *Parreysia favidens*.

1974) and hence does not have direct contact with the sea bottom, accounting for a relatively lower level of ^{210}Po accumulation.

Skwarzec and Falkowski (1988) studied the accumulation pattern of ^{210}Po in about 13 species of invertebrates, including bivalves in the Baltic Sea, and concluded that the digestive organs play a dominant role in controlling the absorption and elimination of ^{210}Po. The results of the present study also confirm this conclusion.

Owen (1974), Morton (1983) and Hameed (1984) reported that digestive glands of bivalve molluscs play a dominant role in the process of digestion and absorption of food and the elimination of wastes. The food particles actually enter the digestive glands where they are digested and absorbed. Only undigested wastes are put back into the alimentary canal for condensation and elimination. It may be concluded that the higher accumulation of ^{210}Po in digestive glands is due to their dominant role in the digestive process of food particles which contain appreciable levels of ^{210}Po. The higher accumulative ability of this organ with regard to heavy metals (Mn, Ni, Cu, Zn and Pb) has also been demonstrated by Hameed and Mohanraj (1989). Merlini (1967) reported that the gills and mantle showed a high concentration factor for ^{54}Mn. However, this author did not look into the digestive glands. The results of the present study provide evidence to suggest that the freshwater mussel, *P. favidens*, could be used as a effective biomonitor of ^{210}Po radionuclide in the river system. The total soft tissues of *P. favidens* would provide a more convenient indicator material for analysis than the shell, since the concentration factor in total soft tissues was higher (9.37×10^4 to 1.59×10^5) than in shell (2.5×10^3 to 4.18×10^3). Among the soft tissues, digestive glands are better indicators of ^{210}Po because the highest concentration factor is recorded in this organ (3.62×10^5).

Younger mussels have a higher physiological rate and hence an anticipated greater accumulative ability. Watling and Watling (1976), Rajendran and Kurian (1986) and Havlik and Marking (1987) reported that the young bivalves are often also able to concentrate metals at a higher rate than older ones. It is suggested here that younger mussels could be preferred to older ones for biomonitoring. The possible variation in the levels of radionuclides introduced by the reproductive phase of older mussels (mature) is eliminated when younger mussels (immature) are used.

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