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MOLLUSCS IN RADIOECOLOGY*

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ABSTRACT

Research in this field is concerned mostly with the uptake and loss of radionuclides by molluscs. There is a great deal of information on the concentration and concentration factors for the most dangerous radionuclides. But it is very difficult to draw useful conclusions from these data for reasons discussed in the paper. More information is needed on: 1. the evaluation of the total amount of radionuclides present in molluscan populations; 2. the transfer of radionuclides from the environment to molluscs and "vice versa" and 3. the metabolism of the radionuclides. Only studies of this type will make it possible to evaluate the role played by molluscs in the transfer of radionuclides in an ecosysten. Relevant methods are discussed in the paper.

THE information on radioactive contamination of molluscs is very abundant if compared with that of other taxa.

The main part of the researches concern marine and freshwater molluscs and particularly lamellibranchs and gastropods. The choice of molluscs as the object of so many researches is due to the fact that several species are edibles and they are one of the way through which radioisotopes reach man. Other reasons for this choice are: 1. the easy collection of samples large enough to permit quantitative analysis of radioisotopes; 2. molluscs are able to accumulate large amount of radioisotopes from solutions in which only traces are present.

Since molluscs have a wide tolerance to several limiting factors (*e.g.* quantity and quality of food, light) the breeding of several species is easy.

The great amount of data on molluscs has allowed the determination of the variation range of the concentration and concentration factor for different radioisotopes in several species (Cigna, 1964; Chipman, 1966; Polikarpov, 1966). The knowledge of these ranges and that of the dietary characteristics of human population have allowed a rough evaluation of the amount of radioisotopes ingested by man, due to edible molluscs.

From these researches it has been possible to identify, in some species, indicators of environmental contamination for some radionuclides (Ravera *et al.*, 1961; Gaglione *et al.*, 1964; Cavalloro *et al.*, 1966; Calapaj, 1967; Tassi-Pelati, 1969).

These aims from a point of view of health physics is, at least in part, attained but we cannot draw general conclusions on the radioisotope metabolism in molluscs from the available data for the following reasons: 1. experiments have been carried out under different laboratory conditions; 2. different degree of homogeneity of

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the material. Individuals of different size classes have been used for some experiments and of the same size class for other ones; 3. the radioactivity measured is sometimes higher than that incorporated by the organism. Radioactive material present in the periphyton associated with mollusc, radioactive particles adhering to the gills and present in the intestinal content and radioisotopes adsorbed by the free surfaces (*e g.* shell, operculum) are the causes of the over estimation; 4. in the largest number of experiments the specific activity of the radionuclide is not considered that is the ratio between the radionuclide concentration and that of the corresponding stable element. It is clear that the quantity of radioactivity incorporated, for a unit of time, increases "coeteris paribus" with the specific activity; 5. not enough attention has been paid to the chemical-physical form of the radioisotopes after having been added to the environment; it has been demonstrated that the incorporation of the radioisotopes by the organisms is partly influenced by their chemical-physical form; 6. in some studies the radioisotope concentration in the environment, during the experiment, varies because proportional amounts of radioisotopes have not been added to compensate the activity incorporated by molluscs, or a right ratio has not been established between the volume of the environment and that of molluscs; 7. the largest part of the concentration factors have been calculated when the radioactive concentration in molluscs was not at equilibrium with that of the environment ("observed concentration factor"). There are researches considering all the eventual causes of error (Kečkeš *et al.*, 1968; Chipman *et al.*, 1968) but their number is very scarce and much work must be done to evaluate the role played by molluscs in the cycling radioactive materials in ecosystems.

The evaluation of the amount of radioisotopes from fall-out or radioactive effluents present in a population of molluscs may be obtained with the seasonal sampling of the population, in order to measure its size, and with periodic analysis of radioactivity on the samples. The amount of radionuclides immobilised by the population is given by the product between radionuclide concentration and population biomass, but unfortunately, there are very few papers in which , besides the radionuclide concentration, the biomass of the population is given. In a preceding study I have tried to obtain this information utilizing a fall-out radionuclide (^{54}Mn) and a freshwater lamellibranch: *Unio mancus* var. *elongatulus* Pfeiffer (Ravera, 1962).

Radioactive tracers could be used in quantitative studies on the assimilation of food and of chemical elements by molluscs; this information is useful from a physiological and ecological point of view. For example, from a study carried out on the freshwater gastropod, *Viviparus ater* , Crist. and Jan, it has been calculated that this mollusc ingestes fall-out ^{106}Ru to an amount of 40% from water and 60% from the sediment, that is its food. It has also been found that ^{106}Ru is eliminated with feces; while radiostrontium, accumulated in the shell, is released to the environment after the death of mollusc. From the same experiment it has been found that the percentage of assimilation of sediment is about 60% (Ravera, 1963).

Simplified models to schematise radioisotope metabolism in lamellibranchs have been proposed by different authors (Kečkeš *et al.*, 1968). Using these models interesting results should be obtained.

To evaluate the quantity of food ingested, the amount of feces excreted and the percentage of assimilation, some simple formulae are proposed that may be used to plan experiments with radioactive tracers. These formulae may be applied for terrestrial as well as aquatic molluscs but for the latter the tracer must be present

only in the food (aquatic plants, sediment, periphyton) and the activity of water must be as low as possible.

I. Molluscs ingest in a certain time a certain amount of food (P_1) labelled with a known activity of tracer (C_1). A part of the food (P_2) and the corresponding activity of the tracer (C_2) will be incorporated by mollusc that will excrete with the feces the non-metabolised fraction (P_3) labelled with a proportional tracer activity (C_3). The incorporated activity (C_2) is the difference between the activity of mollusc at the beginning and the end of the experiment. If at the end of the experiment the quantity of excrements is weighed and the corresponding activity measured we can calculate the amount of radioisotope introduced with food

$$(1)\quad C_1 = C_2 + C_3$$

the amount of food ingested, knowing the concentration of the radioisotope in the food $(\frac{C}{P})$

$$(2)\quad P_1 = C_1 . \frac{P}{C}$$

the amount of food utilized

$$(3)\quad P_2 = P_1 - P_3$$

It is possible to use formulae (2) and (3) only if the amounts of food and radioisotope are incorporated in the same proportion, that is the tracer concentration in the food is equal to that in the excrements:

$$C_1 . P_3 = C_3 . P_1$$

II. If this condition is not realised it is necessary to utilize tracers in a form that may be ingested but cannot be incorporated. For example, we may mix in the food a material labelled with a radioisotope that cannot be digested. Instead of the radioisotopes one may use material with certain stable elements (f.i. Cobalt glass powder) that, at the end of the experiment, can be determined by activation analysis. In these experiments $C_2 = 0$ and $C_1 = C_3$, that is the activity introduced is equal to that eliminated. Consequently, knowing the radioactive concentration of the food, activity and quantity of excrements we may calculate the amount of food ingested

$$(4)\quad P_1 = C_3 . \frac{P}{C}$$

and the amount and percentage of food assimilated

$$(5)\quad P_2 = P_1 - P_3$$

$$(6)\quad P_2\% = \frac{P_1 - P_3}{P_1} . 100$$

III. To evaluate the assimilation of a certain stable element we must know the specific activity of the radioisotope in the food, that is the ratio between the radioisotope concentration $(\frac{C}{P})$ and that of the corresponding stable element $\left(\frac{C^A}{P}\right)$. The amount of stable element assimilated will be:

$$(7)\quad C_2^A = \frac{C^A}{C} . (C_1 - C_3) = C_2 . \frac{C^A}{C}$$

analogously, the amount of feces excreted:

$$(8) \quad C_3^A = C_3 \frac{C^A}{C}$$

and that ingested with the food:

$$(9) \quad C_1^A = C_1 \frac{C^A}{C}$$

IV. If a mollusc, contaminated with a certain radioisotope, is placed in a non-contaminated environment, the radioactivity of the organism will be gradually released to the environment. The loss curve of the radioisotope may be drawn from the data of periodical measurements of the activity of the organism. For example, if R_O is the activity of the organism at the time O and R^t at time t, the percentage of radioisotope (%R) released in a time interval (O-t) willl be:

$$(10) \quad R\%_o = \frac{R_O - R_t}{R_O} 100$$

From the shape of the curve we may know the loss rate for the different biochemical compartments that have incorporated the tracer, and obviously also the corresponding stable element.

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