Radium and its Daughters in *Bryopsis plumosa*

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Among the species of marine biota from the Rumanian sector of the Black Sea, the radioactivity of which has been systematically monitored since 1984 (DOVLETE 1984, 1985, 1986 and OSVATH 1987, 1988, 1989), the Bryopsis plumosa green alga stands out due to the great values of its alfa and beta radioactivity. High resolution gamma spectrometrical analysis shows that these are to be attributed to Ra-226, Ra-228 (radionuclides belonging to the uranium-radium, respectively thorium radioactive series) and their daughters (GUSEV and DIMITRIEV, 1978). An average radionuclidic composition of Bryopsis plumosa is presented in Table 1 (natural radionuclides only).

Table 1. Natural gamma emmitting radionuclide concentrations (Bq kg^{-1} fresh weight) at 320 days after sampling

Ra-226	Pb-214	Bi-214	Pb-210	Ac-228	Pb-212	Tl-208	K-40
642±6	437±2	400±2	9±2	250±3	67±1	24±4	75±3

Regarding the members of natural radioactive series identified in Bryopsis plumosa, the following relevant activity ratios were studied: Ra-226/Pb-214, Pb-214/Pb-210 for the U-Ra series and Ac-228/Pb-212 for thorium series. The activity of the i-th radionuclide in a radioactive series at time t is given by:

$$A_i(t) = \lambda_i N_0 \sum_{J=i}^{i} e^{-\lambda_j t} \prod_{K=1}^{i-1} \lambda_K \Big/ \prod_{K=1,K\neq j}^{i} (\lambda_K - \lambda_j) \qquad \text{Eq. (1)}$$

where: λ_i = decay constant coresponding to i-th nuclide
N_o = number of parent nuclei at t=0

Values of the Pb-214/Pb-210 and Ac-228/Pb-212 activity ratios, computed using Eq. (1) and from radionuclide concentration data obtained directly by gamma spectrometrical analysis of the samples are presented in Tables 2 & 3 for various values of time T elapsed after sampling. In computing ratio values by applying Eq. (1) the hypothesis was made that Ra-226 and Ra-228 were the parent radionuclides of the series in the sample, which indicates that Bryopsis plumosa assimilates only the radium isotopes from its environment. The good agreement between calculated and measurement derived values (Table 2, for higher values of T, and Table 3) confirms the hypothesis, leading to the conclusion that the alga does not concentrate uranium or thorium isotopes but only radium isotopes from the environment. This conclusion is validated by the discrepancy between experimental values of the Ac-228/Pb-212 activity ratio and the theoretical ones according to which Th-232 is assimilated by the alga (Table 3). The discrepancy between theoretical and measurement-derived Pb-214/Pb-210 ratio values given in Table 2 is due to the difficulties for measuring Pb-210 by applying gamma spectrometry because its concentration is near the detection limit for lower values of T. The discrepancy obviously decreases with time, as Pb-210 concentration increases through the usual ingrowth process characterising radionuclides in a radioactive series. From this it can also be concluded that the alga does not assimilate Pb-210 from its environment, but all the Pb-210 in the sample are the decay products of Ra-226 assimilated by the living plant.

Table 2. Pb-214/Pb-210 activity ratio

T (days)	240	320	1000
experimental	81	48.7	13.5
theoretical parent Ra-226	45	34.0	11.0

Table 3. Ac-228/Pb-212 activity ratio

T (days)	240	320	1000
experimental	5	3.7	1.3
theoretical parent Ra-226	4.6	3.6	1.4
theoretical parent Th-232	9.4	7.1	2.6

The measurement-derived value of the Ra-226/Ra-228 ratio ranges between 2 and 3 in Bryopsis plumosa and between 1.5 and 3 in marine sediment (OSVATH, 1989), hence in sea water. This confirms that the alga conserves the environmental relative abundance of radium isotopes. It can be concluded that Ra-223 is also assimilated in much lower quantities, according to its relative abundance, but due to their short half-lives, its descendents cannot be identified in samples.

Radioactive equilibrium is achieved between Rn-220 and Po-216, Rn-220 exhalation from the sample being negligible. The situation is different for Rn-222, where a disequilibrium factor of 1.4 exists between Rn-222 and Po-218 (assessed through the Ra-226/Pb-214 ratio). The value of the radium concentration factor (CF) for Bryopsis plumosa calculated using the typical value of Ra-226 concentration in sea water given in (PENTREATH, 1988), is of the order of 10^5, three orders of magnitude above the average value recomended in IAEA, 1985. The computation of CFs for members of radioactive series (e.g Pb-210) is a delicate problem, and often requires supplementary measurements.

REFERENCES

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