Some aspects of radioecology and chemical ecology of marine macrophytes

by

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To define the concentration factors of calcium, strontium and strontium-90 in natural conditions is of great importance. At present there is only a limited number of works available on this subject [SPOONER, 1949; POLIKARPOV, 1964; PARCHEVSKY *et al.*, 1965; MAUCHLINE & TEMPLETON, 1966].

In this communication the results of the determination of calcium, strontium and strontium-90 in various macrophytes of the Black Sea will be presented.

Samples of hydrobionts and water were taken simultaneously during 1964 and 1965. Strontium was determined in the ash of algae by tributilphosphate [VELTEN & GOLDIN, 1961] and by precipitation of strontium and calcium oxalates in HCl solution of ash with subsequent extraction of yttrium with isotopic or unisotopic (iron) carrier [KULEBAKINA, 1966]. In sea water strontium-90 was determined by precipitation and separation of strontium and calcium carbonates in presence of NH_4Cl [POPOV *et al.*, 1964]. Stable strontium and calcium were determined flamephotometrically by the method of addings [POLUEKTOV, 1959; BACHURIN *et al.*, 1967]. The obtained data were analysed statistically [MITROPOLSKY, 1961].

Table 1 gives the figures for strontium-90 concentration factors (the ratio of the concentrations of a radionuclide or the corresponding element in the organisms and in the aqueous solution) with their standard deviations for some of the investigated macrophytes. As it can be seen from the studied macrophytes the brown algae *(Cystoseira barbata, Padina pavonia)* and the red calcareous algae *(Corallina officinalis)* are the strongest concentrators of strontium-90.

The seasonal comparison of the concentration factors in *Cystoseira* revealed an increase from winter to autumn : from 47.5 in winter to 58.3 in spring, 60.7 in summer and 68.1 in autumn. Statistical comparison based on Wilckockson criterion showed that only winter concentration factors are significantly different from those in other seasons. The lower winter concentration factors are probably linked with the retardation of the growth and metabolism of *Cystoseira* in this season, and in connection with this the content of some elements, particularly calcium, is decreased [ALFIMOV, 1960].

The comparison of strontium-90 and stable strontium concentration factors in the same samples (Table 1) indicated values close enough to each other (in the diapason from two times till the absence of differences). It indicates that in coastal conditions the equilibrium is achieved between the stable and radioactive strontium and that in nature the concentration factors of strontium-90 reached the limit values [POLIKARPOV & ZESENKO, 1965; KULEBAKINA & POLIKARPOV, 1967]. The concentration factors for calcium in red algae and in seagrass exceed the concentration factors for strontium (Table 1) and

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TABLE 1.

Comparison of the concentration factors for strontium-90, strontium and calcium in Black sea macrophytes
(calculations on the basis of the living weight)

Species	Concentration factors			D $\frac{Sr}{Ca}$	Atomic ratio $\frac{Sr}{Ca} \times 10$
	Sr^{90}	Sr	Ca		
Ulva rigida	11.1 ± 6.1*	—	—	—	—
U. rigida	14.8	8.5	—	—	—
Cystoseira barbata	61.0 ± 5.8*	—	—	—	—
C. barbata	48	50	19.1	2.6	17.6
C. barbata	59	45	25.2	1.78	12.1
C. barbata	55.7	56	25.5	2.2	15.8
Padina pavonia	257.0 ± 34.0*	—	—	—	—
P. pavonia	223	148	75	2.0	11.6
P. pavonia	265	258	112	2.3	—
Laurencia obtusa	31.1 ± 11.4*	—	—	—	—
L. obtusa	32.9	15.7	27.5	0.57	—
L. obtusa	29.3	14.8	—	—	—
Ceramium rubrum	12.2	—	—	—	—
Corallina officinalis	264 ± 118*	—	—	—	—
C. officinalis	332	209	657	0.32	2.3
C. officinalis	317	210	—	—	—
Gelidium latifolium	10.0	—	—	—	—
Zostera marina	30.2 ± 23.4*	—	—	—	—
Z. marina	33.9	32.8	55	0.60	4.3
Z. marina	26.6	21.4	68.5	0.31	2.2

* $(C.\bar{F}. \pm t_{10} \frac{S}{\sqrt{u}})$

only in the brown algae the discrimination factors D $\frac{Sr}{Ca}$ amount to 1.5 - 2.6. These data are in agreement with those from literature [MAUCHLINE & TAYLOR, 1964; MAUCHLINE & TEMPLETON, 1966].

An interesting comparison can be made (Table 2) using our concentration factors for stable strontium, strontium-90 and calcium and the corresponding data for the same or related species studies in the Irish sea [MAUCHLINE & TEMPLETON, 1966; BRYAN *et al.*, 1967] where the salinity and the concentrations of calcium and strontium are characteristic for the open waters of the Atlantic and are approximately double of those in the Black sea [SKOPINTSEV *et al.*, 1958; TAMONTIEV & BRUEVICH, 1961; MAUCHLINE & TEMPLETON, 1966]. This comparison shows that the concentration factors for both elements are about 2-6 times higher in species from the Black Sea than in the corresponding species from the Irish Sea.

TABLE 2.

Comparison of the concentration factors for strontium-90, strontium and calcium in related species living weight different seas*

Species	Sampling area (sea)	wet weight dry weight ratio	Concentration factors (C.F.) Sr_{90}	Sr	Ca	D $\frac{Sr}{Ca}$	C.F. in Black sea / C.F. in Iris sea	
*Ulva lactuca***	Irish	11.1	—	2.0	4.0	0,50	—	—
Ulva rigida	Black	25.7	11.1	3.4	7.7	0.44	1.7	1.9
*Fucus serratus***	Irish	15.3	20	12	4	3	—	—
Cystoseira barbata	Black	20.8	59	45	25	1.8	3.8	6.2
*Corralina officinalis***	Irish	2.8	—	83	270	0,31	—	—
C. officinalis	Black	2.6	337	209	657	0.31	2.5	2.4
*Ceramium rubrum***	Irish	15	—	2.0	5	0.4	—	—
C. rubrum	Black	34	12.0	—	—	—	—	—

* Salinity in the Irish sea higher of such than in the Black sea in 1,94, concentration of Sr - in 1,75, concentration of Ca - in 1,45, and atom ratio $\frac{Ca}{Sr} \cdot 10^3$ - in 1,20 times.

** Data by Mauchline and Templeton, 1966; Bryan et al., 1967.

Thus, if we consider the 2-6 times higher concentration factors for these elements and strontium-90 in related species to be essential, then we are stating an inverse dependence between the concentration factors for these elements in hydrobionts and such properties of the sea as salinity and the concentration of strontium and calcium. The $\frac{Sr}{Ca}$ atomic ratio in water and in organisms is practically identical for different seas, i.e. the correlation between the calcium and strontium is maintained.

Summary

1. In the algae studied the highest concentration factors for strontium-90 were found in brown algae and in red algae *Corallina officinalis.*

2. In the brown alga *Cystoseira barbata* seasonal changes for strontium-90 concentration factors were noticed; the lowest in winter, the highest in autumn.

3. Concentration factors for the stable and radioactive strontium were close enough to each other in nature.

4. The increased salinity and concentration of strontium and calcium in water are followed by decrease in concentration factors.

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