Biol Metals (1990) 2:235-238

BIOLOGY OF METALS

Cd and Zn uptake in macrophyceae from Greek coasts

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Received December 23,1989

Summary. In the frame of a project financed by the General Secretariat of Research and Technology, the Institute of Botany has undertaken to measure the degree of pollution in the marine area by means of physicochemical and biotic parameters. Bioaccumulation of heavy metals in the macrophyceae has also been examined. Since the latter are immobile, they form strong indicators of pollution for the respective biotopes. Comparing the measurements carried out in marine macrophyceae obtained from the Gulf of Kavala and Pylos, we have made the following conclusions. Seasonal variations were detected in the Cd and Zn content of nine marine macrophyceae species which had already been investigated. Cadmium, one of the toxic metals, was, in certain cases, present in a large number of species. Fluctuations in the quantities were seasonally detected, but more obvious differences were those between species from different classes of macrophyceae. In contrast, the amount of Zn was generally lower. When we compared the values of Zn to those of Cd in the same algal species, we detected an antagonism between them (i.e. higher values for Cd were accompanied by lower values for Zn). Finally, on comparing the biotopes, we found there was slightly more Cd in Pylos than in Kavala. In the harbour of Kavala, in particular, where there is strong evidence of domestic sewage, the amount of Cd is very low. It is well known that Cd is derived mostly from industrial waste waters; in the city of Kavala, the domestic waste does not include high quantities of heavy toxic metals.

Key words: Marine pollution - Cd - Zn - Macrophyceae

Introduction

In the frame of a general project, the Institute of Botany in Thessaloniki has untertaken to study the level of pollution in the marine area by means of different parameters (biotic and others). Special interest has been paid to the amount of heavy metals in the macrophyceae because this is a strong indicator of pollution for the actual biotopes.

Until now, very little has been known about the accumulation of heavy metals in macrophyceae from Greek marine biotopes (Haritonidis et al. 1983; Sawidis and Voulgaropoulos 1986; Hartitonidis and Nikolaidis 1988; Sawidis et al. 1988). Certainly the bioaccumulation of heavy metals in marine algae depends on the species, the biotope, the season, parts of the thalli, etc. (Babich and Stotzky 1978).

In this paper, measurement of the accumulation of Cd and Zn in different macrophyceae is described. The problem is compared with pollution indices and has focused on different biotopes (polluted and non-polluted). The sampling stations compared were Kavala harbour and Kavala-Palio (Aegean Sea) and Pylos on the Ionion Sea, Greece.

Slightly more Cd seems to be found in macrophyceae from Pylos than from Kavala. In contrast, the amount of Zn was generally low. There is an antagonism between these two metals (i.e. higher values for Cd were accompanied by lower values for Zn).

Materials and methods

All sample collections were conducted in Kavala and Pylos biotopes, covering a period of two years and at a depth of 1-2 m (Fig. 1). The plant material was washed, dried (80° C) and was finally digested according to Sperling et al. (1988) and Sperling and Bahr (1980).

Thalli of macrophyceae were measured using a Perkin-Elmer atomic absorption spectrometer with a graphite tube atomizer, HGA 72 (Sterrit and Lester 1980).

Results

From the material collected from the coasts of Pylos, the most abundant species were *Cystoseira squarrosa* (Phaeophyta), *Jania rubens, Pterocladia capillacea*

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Fig. 1. Map of Greece. The examined biotopes, Pylos (●) and Kavala (○) are indicated

(Rhodophyta) and the carpet-like *Cladophora albida* (Chlorophyta). The absence of Chlorophyta and some of the other species indicating pollution was obvious in Palio (Kavala) and Pylos (Fig. 1; Haritonidis et al. 1986). From the harbour of Kavala we chose two different sites with very specific marine flora and vegetation. The first was near the harbour of the city with a characteristic flora of about 95% of the well known Chlorophytes, such as for example *Enteromorpha linza*. The second biotope was situated 3-4 km west of Kavala (Palio, Fig. 1). This coast was also very rich in marine plant flora with a composition typical of rocky and exposed waters (Haritonidis et al. 1986). The amount of Phaeophyta and Rhodophyta was very characteristics with *Cytoseira fimbriata* and *Halopteris scoparia* and the calcareous Rhodophyte *Jania rubens*.

The results for uptake of Cd and Zn by these macroalgae are given in Table 1 and Figs. 2 and 3. Mean values for each of the four seasons of the year (W = winter, Sp = spring, S = summer, A = autumn) are given in Table 1 while further details are illustrated in Figs. 2 and 3.

Discussion

The seasonal variation of Cd and Zn uptake by the investigated macrophyceae is represented in Table 1 and Figs. 2 and 3. The variations are accounted for by the favourable or unfavourable season during which each alga is developed (Cook 1977; Zavodnik 1977). Figure 2A shows clearly the differences in the bioaccumulation of Cd by two Phaeophyta which belong to the same genus (*C. squarrosa* and *C. fimbriata*). Both biotopes (Pylos and Kavala-Palio, Fig. 1) are regarded as clean, therefore their values could be indicative of the different capacity each plant has to bioaccumulate. The same algal species was obviously antagonistic to Zn (Fig. 3A) compared with the corresponding values for Cd (Fig. 2A). These results were in accordance with other similar research (see Haritonidis et al. 1983 and the literature cited therein). In Figs. 2B and 3B the Rhodophyta from Pylos (Fig. 1) represented a remarkable differentiation in the accumulation of Cd. The high values in the accumulation of Cd during summer (Fig. 2B) are probably the effect of maximum plant growth. On the other hand, in Fig. 3B the amount of Zn in plants very clearly indicated an antagonistic effect also.

Jania rubens displayed in both biotopes interesting differences in the bioaccumulation of Cd and Zn (Figs. 2C and 3C) by macrophyta. The kind of substrate and other parameters observed among the stations are responsible for these differences. Our results are in agreement with Haritonidis and Tsekos (1975, 1976), Haritonidis et al. (1986) and Tsekos and Haritonidis (1977).

Figures 2D and 3D indicate that uptake of Cd and Zn in two Chlorophyta which are pollution indices and the distinction of biotopes in polluted and non-polluted areas. The amount of Zn and its toxicity were lower in both algal species. The corresponding values for Cd

Table 1. Cd and Zn, uptake from macroalgae

Algae species	Biotope	Cd (nmol/g dry mass) in				Zn (nmol/g dry mass) in			
		W	Sp	S	A	W	Sp	S	A
1. *Cystoseira squarrosa*	Pylos	8.5 ±3	10 ±3	33 ±6	45 ±6	340±40	540±60	130±40	190±45
2. *Cystoseira fimbriata*	Palaio-Kavala	24 ±3	38 ±6	3 ±1	22 ±6	190±40	120±32	130±40	25± 5
3. *Jania rubens*	Pylos	9.25±1	4.25±0.5	38 ±3	10 ±1.2	380±60	520±40	370±35	120±20
4. *Pterocladia capillacea*	Pylos	1.25±0.5	1.30±0.25	36.5 ±1	2.0 ±0.25	30±12	180±45	140±20	110±10
5. *Corallina officinalis*	Pylos	7.25±0.25	7.50±0.1	1.45±0.2	1.45±0.2	75±12	90±15	145±15	120±10
6. *Jania rubens*	Palaio-Kavala	4.25±0.75	1.10±0.25	5.0 ±0.2	4.30±0.50	355±20	260±30	215±15	30± 2
7. *Cladophora albida*	Pylos	1.5 ±0.25	0.60±0.1	9.80±0.2	15 ±0.75	280±45	200±10	120±25	130±30
8. *Enteromorpha linza*	Kavala harbour	1.9 ±0.4	2.0 ±0.4	4.0 ±0.5	8.9 ±0.5	130±25	220±45	250±30	150±30

Every value is the mean value of three measurements.
W = winter, Sp = spring, S = summer, A = autumn

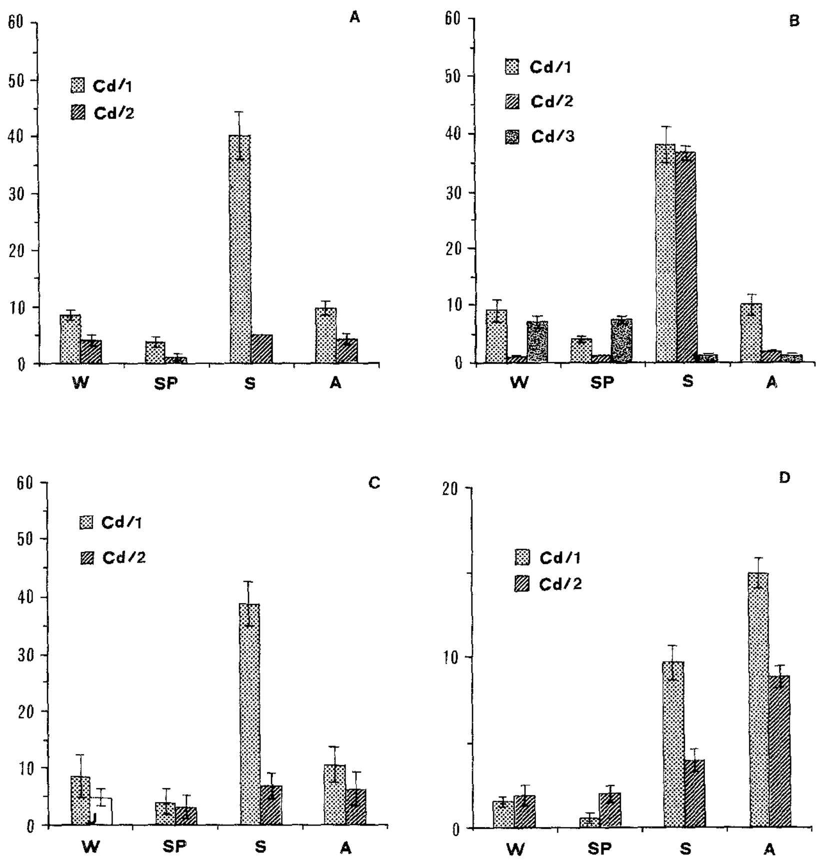

Fig. 2 A–D. Seasonal fluctuations of Cd in different marine macrophyta. **(A)** 1 = *Cystoseira squarrosa*, 2 = *C. fimbriata;* **(B)** 1 = *Jania rubens*, 2 = *Pterocladia capillacea*, 3 = *Corallina officinalis;* **(C)** 1 = *Jania rubens* at Pylos, 2 = *J. rubens* at Kavala; **(D)** 1 = *Cladophora albida*, 2 = *Enteromorpha linza*

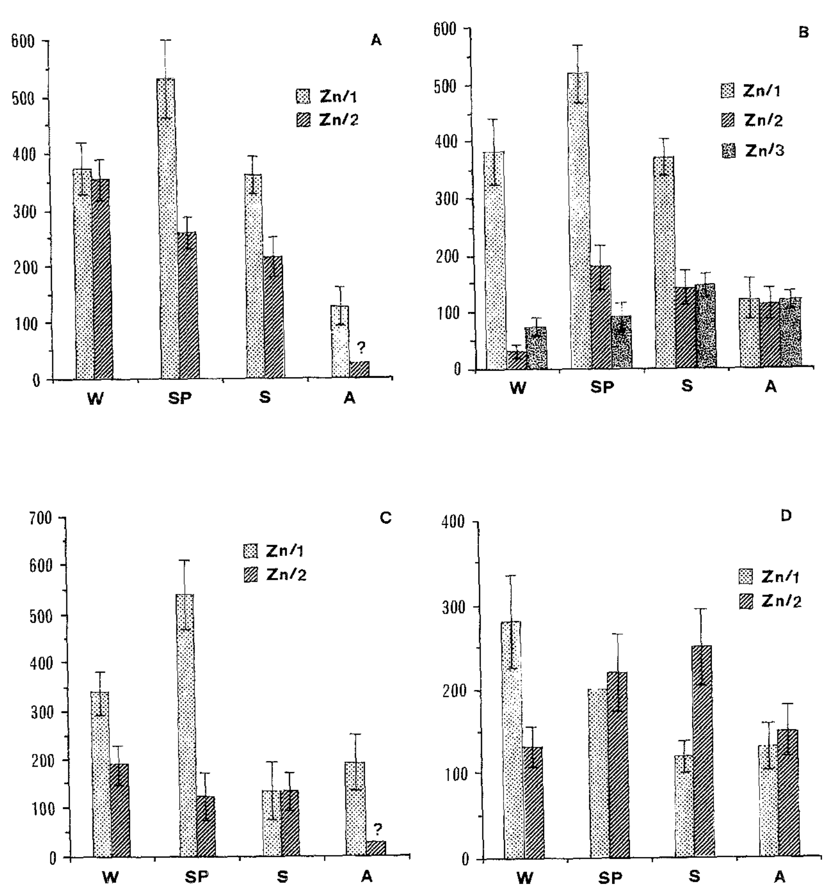

Fig. 3. Zn uptake in some marine macrophyta. **(A)** 1 = *Cystoseira squarrosa*, 2 = *C. fimbriata;* **(B)** 1 = *Jania rubens*, 2 = *Pterocladia capillacea*, 3 = *Corallina officinalis;* **(C)** 1 = *Jania rubens* at Pylos, 2 = *J. rubens* at Kavala; **(D)** 1 = *Cladophora albida*, 2 = *Enteromorpha linza*

were also very low, except in autumn (Fig. 2D). It is thus evident that the above areas suffer more from domestic than from industrial waste waters (Cook 1977; Haritonidis 1978; Sterrit and Lester 1980).

Based on the measurements carried out so far, we conclude that some macrophyta accumulate quite high quantities of heavy metals from sea water (Cook 1977; Zavodnik 1977). Some of them can also be used as pollution indices for both domestic and industrial wastes. There was a seasonal variation in the bioaccumulation of Cd and Zn in algal species which was attributed both to the special growth optimum of each alga and to the changes in the different parameters (Table 1).

Accumulation is similar in macrophyta from both biotopes. The higher Cd compared to that of Zn was indicative of the clear antagonism between these two. Although the values of Cd were quite high, they were far from the point to cause alarm for the above biotopes.

References

Babich H, Stotzky G (1978) Effects of cadmium on the biota: Influence of environmental factors. Adv Appl Microbiol 23:55–117

Cook J (1977) Environmental pollution by heavy metals. Int J Environ Stud 9:253–266

Haritonidis S (1978) Contribution to the research of marine plant macrophyceae (Chloro-, Phaeo- and Rhodo-phyceae) of Thermaikos Gulf. Dissertation. Thessaloniki, Greece, 175 pp (in Greek with English summary)

Haritonidis S, Tsekos I (1975) Marine algae of Northern Greece. Bot Mar 18:203–225

Haritonidis S, Tsekos I (1976) Marine algae of the Greek west coasts. Bot Mar 19:273–286

Haritonidis S, Jäger H-J, Schwantes H-O (1983) Accumulation of cadmium, zinc, copper and lead by marine macrophyceae under culture conditions. Angew Bot 57:311–338

Haritonidis S, Nikolaidis G, Tsekos I (1986) Seasonal variation in the biomass of marine macrophyta from Greek coasts. Mar Ecol 7:359–370

Haritonidis S, Nikolaidis G (1988) Pb accumulation in macrophyceae of the coasts of Kavala (Aegean Sea) and of Pylos (Ionion Sea), Greece. Toxicol Environ Chem 20–21:261–265

Sawidis T, Voulgaropoulos A (1986) Seasonal bioaccumulation of iron, cobalt and copper in marine algae from Thermaikos Gulf of Northern Aegean Sea. Mar Environ Res 19:39–47

Sawidis T, Haritonidis S, Voulgaropoulos A (1988) Seasonal bioaccumulation of Cd, Zn, Ni, and Mn in marine macroalgae from Greek coasts. Proceedings 23rd European Marine Biology Society Meeting, Swansea, UK

Sperling KR, Bahr B (1980) Determination of extremely low concentrations of Cd in blood and urine by flameless AAS. I. Testing of micro method. Z Anal Chem 301:29–31

Sperling KR, Bahr B, Kremling K (1977) Heavy metal determination in sea water and in marine organisms with the aid of flameless AAS. IV. Description of a routine method for the determination of Cd in small samples of biological material. Z Lebensm Untersuch Forsch 163:87–91

Sterrit RM, Lester JN (1980) Atomic absorption spectrophotometric analysis of metal content of waste water analysis. Environ Tech Lett 1:402–417

Tsekos I, Haritonidis S (1977) A survey of the marine algae of the Ionion Islands, Greece. Bot Mar 21:47–65

Zavodnik N (1977) Note on the effects of lead on oxygen production of several littoral seaweeds of the Adriatic Sea. Bot Mar 20:167–170