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CONTENTS OF PHOSPHORUS AND PROTEIN IN SEAWEEDS FROM THE AREA OF FAŽANA (NORTH ADRIATIC SEA)

SADRŽAJ PROTEINA I FOSFORA U MORSKIM ALGAMA OKOLICE FAŽANE

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The phosphorus and protein content in relation to growth in seaweeds was investigated in the area of Fažana. Control analyses of sea water were made. It was established that algal communities in the investigated area are not abundant in total biomass.

INTRODUCTION

The coastal area of Fažana is characterised by numerous coves which, until now were seldom subject to floristic and ecological studies (Cammerloher, 1915). For this reason we have done qualitative and quantitative studies of the seaweeds communities at different localities. At the same time, at each location, algal and sea water samples were collected for determinations of the protein and phosphorus in seaweeds, and nitrates and phosphates in sea water. The investigations were carried out in winter-spring period (February — May 1978) on characteristic and most abundant species which at this time reach the maximum of their vegetative cycle.

Collections were made at five locations (Fig. 1). Barbariga cove is generally exposed to southern wind »jugo« and waves. The coast consists of limestone rocks, pebbles and gravels. At partly sheltered niches, *Fucus virsoides* communities are fairly wall developed. This fucoid species, together with *Enteromorpha intestinalis, E. prolifera, Ulva rigida, Scytosiphon lomentaria,* and *Cladophora dalmatica* dominate with regard to their standing crop. Other accompanying species were *Ceramium diaphanum, Callithamnion corymbosum, Gelidiella lubrica,* and *Ectocarpus siliculosus.*

Peroj cove is less exposed to waves, which favorizes the development of very dense settlements of *Fucus virsoides* at this location. While *Ulva rigida* is relatively scarce, *Enteromorpha intestinalis* and *Scytosiphon lomentaria* are common, especially in the vicinity of coastal springs of fresh water.

Other common species collected for further analyses were: *Ceramium diaphanum, Gelidiella lubrica, Laurencia paniculata, Cystoseira barbata, Ectocarpus siliculosus, Cladophora dalmatica* and *Enteromorpha ramulosa.*

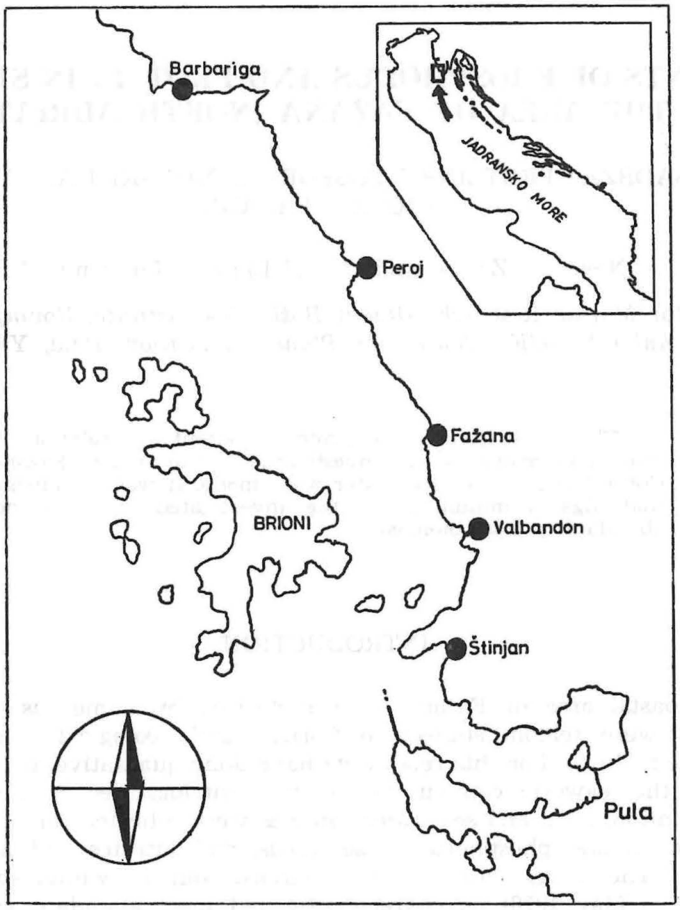

Fig. 1. Investigated area.

Fažana cove is protected from winds and waves, but this area is exposed to domestic sewages. On the rocky littoral, the settlements of *Fucus* are somewhat sparse, but the nitrophile *Ulva rigida, Enteromorpha intestinalis* and *Scytosiphon lomentaria* are common. Depending on vegetation season, sequences of *Bangia fuscopurpurea, Ceramium diaphanum, Polysiphonia subulifera, Ectocarpus siliculosus, Cladophora dalmatica,* and *Cladophora pellucida* can be traced.

Valbandon cove is also sheltered and subject to domestic pollution. At this location, the coast is rocky and stony, but at the depth of half meter the sea bottom quickly changes to silty sand. Due to numerous underwater springs of fresh water, the salinity in this area is remarkedly reduced. In the mediolittoral zone, *Ulva rigida* accompanied by *Chaetomorpha linum* and *Scytosiphon lomentaria* dominate. Among other seaweeds, *Enteromorpha prolifera* and *Cladophora dalmatica* are most abundant.

Štinjan cove is moderately exposed. The rocky and stony bottom changes only at 2 meters depth to silty sand. This area is slightly polluted due to the influences of the neighbouring harbour of Pula, sewage from the suburban settlements, and discharges from numerous boats staying in the cove. In some places, the mediolittoral rocks are completely covered by the settlements of *Fucus virsoides*, but the nitrophile *Scytosiphon lomentaria, Ulva rigida, Enteromorpha intestinalis* and *Enteromorpha ramulosa* are also common. Among others, *Gelidiella lubrica, Ceramium diaphanum, Ectocarpus siliculosus,* and *Cladophora dalmatica* were collected for analyses.

METHODS

Seaweeds were collected at all localities described above, using a wire frame of 50×50 centimeters. The algae were drained by filtering paper and their wet weight (g/m^2) was measured. After drying at 105°C for 24 hours, the dry weight of algae was noted and the material was powdered for further chemical analyses.

The protein in algae were determined using micro — Kjeldahl procedure as modified by Parnas — Wagner — Pregl. The phosphorus was analysed according to the method of Harvey (1953).

Simultaneously with collection of seaweeds, also the samples of sea water were taken and analysed in the laboratory for salinity, nitrates and nitrites, reactive phosphorus (Strickland and Parsons, 1968), and the total phoshorus (Menzel and Corwin, 1965).

RESULTS AND DISCUSSION

Surface temperature are presented in Figure 2. One can see that practically there are no differences of this parameter between the sampling sites investigated, except for Valbandon cove where all temperatures measured were 2—5°C higher than at other locations. This cove is remarkable also with regard to salinity of the sea water: it ranged between 5—13‰, while at other stations, at the same time, the salinity varied from 34—37‰ Sal. In May, a lowered salinity was noted also near Peroj (28‰). At both localities, the low salinity is a consequence of subsurface inflows of fresh water.

In Valbandon cove, fluctuations in nitrate content of sea water are very marked: values ranging from 5.21 μg-at/1 to 92.72 μg-at/1 were measured (Fig. 3). Similary, near Peroj, somewhat enhanced concentrations of nitrates in the sea water were also noted (5.21—35.60 μg-at/1), which can be also a consequence of the fresh water inflows. On the other hand, the quantities of phosphates in sea water were nearly the same at all localities investigated (Fig. 4).

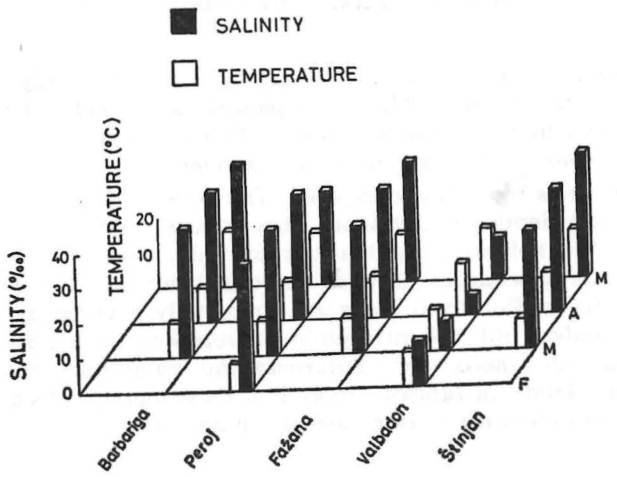

Fig. 2. Variation in surface temperature and salinity.

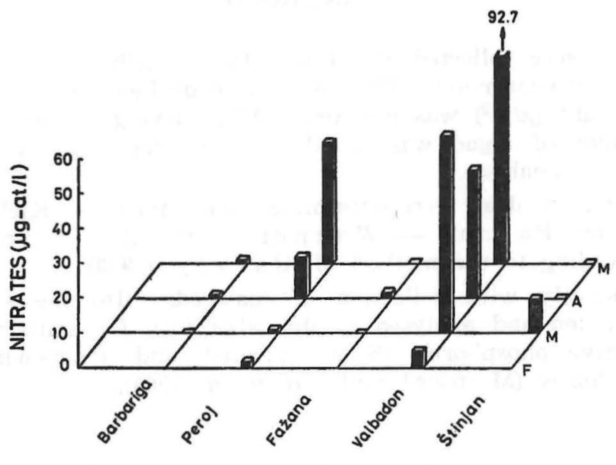

Fig. 3. Variations in nitrates in sea water.

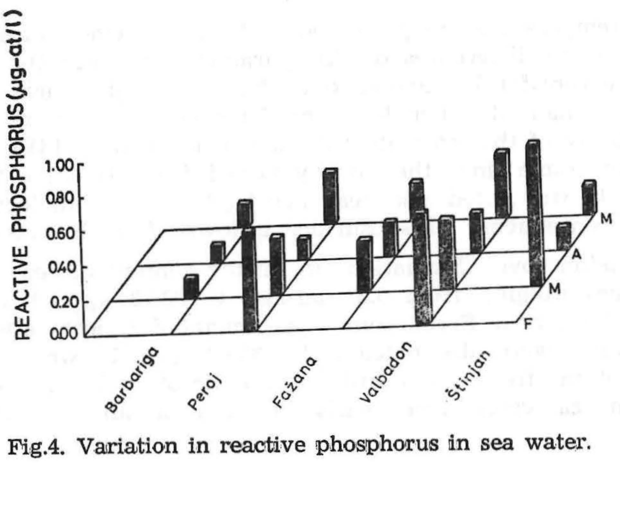

Fig.4. Variation in reactive phosphorus in sea water.

The species composition of collected algae indicates an advanced eutrophication of the environment at all habitats investigated. Generally, the standing crop of most species was insufficient to allow enough dried substance for subsequent chemical analysed. At all locations, most dominant seaweeds belong to the stock of nitrophile species such as *Ulva rigida, Enteromorpha intestinalis* and *Scytosiphon lomentaria. Fucus virsoides* was also common elswhere except in the cove Valbandon, where, obviously, because of advanced pollution, is no more favorable for this alga.

The weight distribution of algal vegetation at localities investigated is presented in Figure 5. Evidently, in February the seaweeds standing crop at

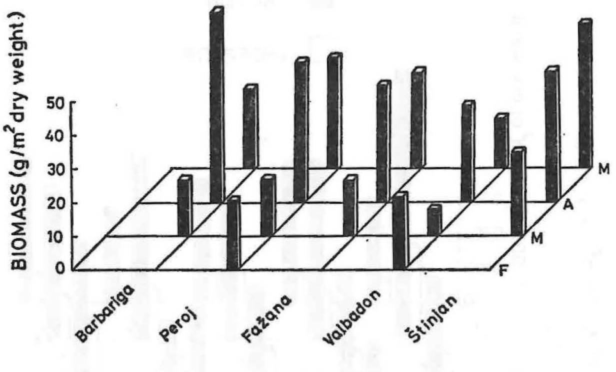

Fig. 5. Variation in algal biomass at investigated coves.

nearly all locations was extremly low, so that enough material for chemical analyses was collected only at locations in the Peroj cove and Valbandon cove. In subsequent months, species diversity enlarged stepwise at all locations, except in the polluted Valbandon cove. It should be noted, that variations in biomass of algae collected at the same locality, can also be a result of patchiness distribution of seaweeds in habitats investigated. In general, at all localities the maximum standing crop of seaweeds was noted in April when some of the more abundant species reached the top of their vegetative cycle (i. e.*Ulva rigida, Enteromorpha intestinalis* and *Scytosiphon lomentaria).* At the beginning of spring, also the standing crop of *Fucus virsoides* enlarged. The populations of this perennial brown algae, however, at all sites dominate with regard to their biomass: the wet weights noted varied from 20—106 g w. wt. per square meter. The range of standing crops of other littoral common seaweeds in the area investigated, did not reach the values noted for *Fucus: Enteromorpha intestinalis* 34—100 g/m^2, *Scytosiphon lomentaria* 18—90 g/m^2, *Ulva rigida* 6—58 g/m^2. Only exceptionally, relatively high values were measured also in *Enteromorpha prolifera* (86 g/m^2), *Chaetomorpha linum* (48 g/m^2), and *Cladophora dalmatica* (37 g/m^2). The abundancies of other species analysed were negligible yet at their maximum vegetation: *Ceramium diaphanum* 13 g/m^2, *Ectocarpus siliculosus* and *Gelidiella lubrica* 11 g/m^2 each, while the standing crop of *Laurencia paniculata* never exceeded 2 g w. wt. per square meter.

In May, the maximum in the vegetative cycles of most macroalgae already was over, which reflected a decrease of total algal biomass at nearly all locations investigated. For example, in Barbariga and Valbandon coves, the total algal standing crop on littoral rocks dropped to only about a half of quantities noted one month earlier. Curiously, only in the Štinjan cove, due to unknown reasons, the species diversity and the coverage of algae increased which resulted also in higher total algal biomass per surface unit.

The analyses of protein indicate that the total protein content in algal settlements is correlated with the abundances (standing crops) of seaweeds rather than the amounts of nitrates in sea water (Fig. 6). In some species, the

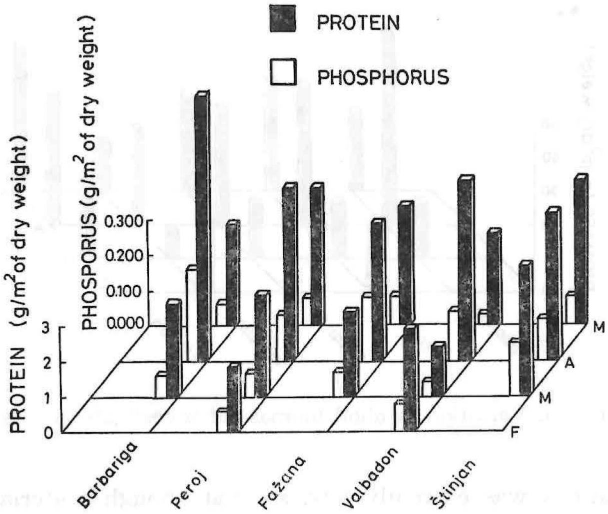

Fig. 6. Variation in protein and phosphorus in algae.

protein contents of algal tissues was the same at all sites investigated, in spite of differences in the nitrate concentrations of the sea water. For example, in *Ceramium diaphanum*, both in the Peroj and Barbariga coves the protein content was 22% of the dry weight. On the contrary, in *Ectocarpus siliculosus* the lower nitrates content in sea water reflected in lower proteins content in algal tissues: only 13% at Barbariga, but even 24% in the Peroj cove. Maximum protein content in seaweeds, in most species, was noted in March, i. e. in the period of the most intensive growth in majority of species. Similar results were reported by Munda (1974). Later, when the vegetative maximum is over and the stepwise decomposition of algal thalli begins (usually at the end of April and in May), a certain diminution of protein in seaweeds occured.

In algae studied by us, the highest amounts of protein were noted in the red algae *Bangia fuscopurpurea*, *Ceramium diaphanum* and *Callithamnion corymbosum* (ranging from 20—24%), in brown algae *Ectocarpus siliculosus* (24%) and *Scytosiphon lomentaria* (18%), and in green algae *Chaetomorpha linum* (20%) and *Ulva rigida* (18%). The brown algae *Fucus virsoides* contained only 8—12% protein, which is in accordance with results noted for

Rovinj area at the time of the beginning of its growth in March-April (Zavodnik, 1973). But, near Rovinj, the protein content in *Ulva rigida* reached cometimes even 29% of dry weight, and in *Scytosiphon lomentaria* 23% (Zavodnik, 1979), althought in this area the concentrations of nitrates in sea water were never as high as it was noted for the area of Fažana (up to 92 μg-at/1).

Similar to protein, the phosphorus content in algae was the highest at the time of algal maximum growth in March and April. In sea water, maximum amounts of phosphates were noted in February (0.59—0.66 μg-at/1). At this time, the phosphorus in algal thalli ranged between 0.30—0.40% in *Chaetomorpha linum, Cladophora dalmatica, Fucus virsoides* and *Gelidiella luburica*, but only 0.15% in *Ulva rigida*. Later, in March, most phosphorus was found in newly appeared species such as *Ectocarpus siliculosus* (0.93%), *Ceramium diaphanum* (0.42%) and *Scytosiphon lomentaria* (0.35%). In *Chaetomorpha linum, Cladophora dalmatica*, and *Enteromorpha intestinalis* the level of phosphorus contents remained the same as in preceeding month, although they were collected also at several other sites. It is obvious, that at various concentrations of nutrients in the environment, the algae are capable of maintaining a steady level of nutrients in their tissues, or even to regulate it to higher or lower concentrations (Provasoli, 1969). This explains phosphorus contents rations observed in algae in April, when the decrease of phosphates in sea water took place while in several seaweeds the contents of phosphorus increased (*Cladophora dalmatica* 0.58%, *Scytosiphon lomentaria* 0.76—0.80%, *Enteromorpha intestinalis* 0.64%, and *Ectocarpus siliculosus* 1.06%). The capability of seaweeds to concentrate phosphorus is of prime ecological importance, because the phosphorus stored can be used in photosynthetic processes at times when the environmental concentrations of this element are below the minimum required (Lewin, 1962). For this reason, usually it is not possible to establish any correlation between the phosphorus contents in algae, and its concentrations in the environmental sea water.

During our research, in *Fucus virsoides* the content of phosphorus fluctuated between 0.14—0.70% of dry weight, in accordance with the location and the time of collection. A two-years continuous research of *Fucus* near Rovinj resulted in somewhat lower values (Zavodnik, 1973); it should be noted that at the time of research, the nutrients concentrations in sea water near Rovinj were always lower than those in the area of Fažana.

Generally, the biomass values of algal settlements were low in the investigated areas. This was also reflected in low total amounts of proteins and phosphorus in these communities. Abrupt changes of salinity, and related fluctuations of nutrients (especially nitrates), in the Valbandon cove limited the diversity of marine macroflora, which consists mainly of Cyanophyta and several nitrophile species, of which the population were usually well developed. If we compare the algal biomass (mean 2.700 g per square meter) in Fažana area in the period investigated (February-May 1978) with data from Rovinj obtained in 1967—1969, when the *Fucus virsoides* made nearly 5 kg/m^2, or *Cystoseira spicata* in 1962—1963 nearly 10 kg/m^2 (Zavodnik, 1967), it becames evident that the constant influence of urban sewages can inhibit the development of algal species, or can even lead to their total disappearance.

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SADRŽAJ PROTEINA I FOSFORA U MORSKIM ALGAMA OKOLICE FAŽANE

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KRATAK SADRŽAJ

Litoralna naselja viših fotofilnih alga pouzdan su pokazatelj kvalitete vodene sredine: u eutrofiziranim područjima dolazi do kvalitativnih i kvantitativnih promjena unutar zajednice, koje se odrazuju tako u promijenjenoj produktivnosti zajednice kao i veličini organske tvari.

Istraživanjima u Fažanskom kanalu je utvrđeno, da je to područje relativno siromašno obzirom na kvantitet viših alga, što se odrazuje i u ukupnoj količini proteina i fosfora u njihovim naseljima. Istraživane vrste se razlikuju međusobno u sadržaju tih tvari, a postoje i varijacije unutar iste vrste sa različitih staništa. Najviše vrijednosti sadržaja protina i fosfora u algama zabilježene su u doba njihovog najintenzivnijeg rasta.