DIATOMS FROM THE SALTERN OF STON (CROATIA)

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Abstract

The published information on algal microflora of the Croatian salterns is extremely rare. This paper is a part of phytoplankton investigation at the salterns along the eastern Adriatic coast. The principal aim of this research was to present the list of diatoms in a different salinity gradients in the natural temporary salt ponds in Ston salina. From 106 samples, 96 diatoms were identified in Ston lagoon and 73 in salt ponds at salinity range from 23.2 to 210 ppt. Diatoms prevailed in the phytoplankton community of the lagoon and Ia series of evaporators, where salinity ranged from 23.21 to 50.00 ppt and temperature from 17.0 to 29.0oC. The most euryhaline and eurythermal diatoms were *Amphora coffeaeformis*, *A. cymbifera* and *Nitzschia sigma*.

Key-words: diatoms, lagoons, Adriatic Sea

Introduction

Reports on the presence of diatoms in a salinity gradient of the salt works are relatively few in comparision of diatom investigation in the world coastal waters. This paper reports an extensive analytical and identification study of diatoms in salt ponds due to their importance for integrated mariculture development in the eastern coastal Adriatic area. In the Croatian salterns there is no development of fish farming activities and the *Artemia* population, which is of considerable importance in fish and shellfish larviculture (1) is not present (2). Many parts of the salterns and sea shores around them, along the eastern Adriatic coast, can be transformed for aquaculture activities. For that economic reason, phytoplankton investigation and ecological data collection have been taken in nonmodified saltponds of ancient solar salina in Ston.

Location and the properties of the ponds

The temporary salt ponds in Ston (42°50'N; 17°41'S) are situated at 0.40-0.67 m below the zero sea level at the north-west part of the Ston lagoon. The phenomenon of tides has always been used to flood the saltern with seawater necessary for salt production. The total area of the saltern is 429840 m^2 and it consists of I (245800 m^2), II (47400 m^2+ 50400 m^2) and III series of evaporators (25690 m^2), adjusting ponds (20570 m^2) and crystallizers (39980 m^2). The concentration of salty water, salt precipitation, salt collecting and storing last for around 4-5 months (15 April to 15 September). In spring, the whole saltern is drained dry for a month or two (March, April) and lagoon waters of usuall aboat 35-38 ppt are poured in (April or May), to obtain a sequence of sea water salinities (end of July, August) by distribution of the waters, in accordance with the usual requirements of salt production process. During autumn, winter and a part of spring, the saltern is sometimes flooded by runoff rainwater. There are no brine storage ponds at the saltern and all remaining brine goes back to the sea in the lagoon after the production is finished (November). In winter, during low tides, a part of the lagoon in front of the saltern can be dry that brackish or fresh water flows out of the saltern. Sometimes, during cold winters, ice forms in some parts of the saltern.

Material and methods

Phytoplankton samples were collected in all seasons, in nonregular intervals, always at the same stations in the salt ponds during the period from 1987 to 1991. Intensification of samples collecting, every two week was done from the beginning of June to the end of August, when a sequence of sea water salinities was obtained in evaporators' series. Except to the first salt pond of Ia series of evaporators, where the maximum sea water depth for a short period can reach up to 150 cm, in other ponds water depth vary, depending of the salt processing aproximatelly, from 2.5 up to 20 cm. Phytoplankton samples were collected by bucket and preserved in polyethylene bottles in 2% neutralized formaldehyde solution. Phytoplankton cells were enumerated on an inverted Uterm–hl microscope after sedimentation period of 24 hr and global diversity index after Margalef (3) was used. For qualitative analysis samples were prepared according to Hustedt (4). Benthic samples were collected directly from the bottom mats in the shallow salt ponds and used for qualitative analyses. Parallel with fixed samples, samples with live material have also been taken for identification study, for species isolation and their rearing in limiting volumes as well as for mass production in indoor and outdoor cultures for zooplankton production. Salinity was measured by refractometer or Bauméter and temperature by termometer. Oxygen was determined by the method of Winkler, pH by pH meter and nutrient concentrations (nitrates, nitrites, ammonia, phosphates and silicates) according to the standard methods (5).

Results and discussion

Diatoms dominated in qualitative-quantitative composition of the phytoplankton in seawater of Ston lagoon and their abundance vary in total phytoplankton in salt ponds along the saltern. For example, in IIa series there was a density of 13175 cells ml^{-1} which was 11.1% of the total phytoplankton. The most abundant species (73,62 %) in IIa series was *Dunaliella salina* which dominated also in adjusting ponds with relative abundance 88.1%, where mean cell diatom density was 2100 cells ml^{-1}. From the saltponds where natural mass production of phytoplankton has been observed, the natural food have been taken for mass rearing brine shrimp *Artemia* and ciliate *Fabrea salina* for mariculture purpose.

The highest number of species (96), diversity index (5.61) and relative abundance of diatoms in total phytoplankton were observed in lagoonal waters (23.20-40.60 ppt) with which the saltern is filled for operation. The high fluctuation of nitrates and phosphates were recorded in the lagoon as well as in the saltern. This may be due to the both, land fresh water influence and submarine fresh water springs of the lagoon. These influences are strong especially in the spring, when lagoon water is poured in dry saltern for operation. Some bottom springs of the fresh water were also recorded in the I, II and III series of evaporators. The maximum ratio between nitrates and phosphates indicates a hypernutritification of the lagoon temporary (6). Concentration of the ammonia was about seven times higher in comparison to typical ammonia concentration in temperate coastal zones (7). There is evidence of high nitrates values (> 150 µmol dm^{-3}) also in the Ib and IIa series of evaporators. Organic and inorganic nutrients may cause hypernutrification, possibly phytoplankton blooms, oxygen depletion and formation of anoxic situation (22) which was observed once in one pond of Ib series when phytoplankton bloom was observed.

A total of 115 diatom taxa representing 18 genera were identified in saltponds in salinity range from 23 to 210 ppt and temperature from 5 to 39°C (Table 1). *Cocconeis placentula* var *lineata* was present in salt ponds in a salinity range from 33.67 to 120 ppt and was the most abundant species in the lagoon and Ia series of evaporators in a salinity range from 23.21 to 51.00 ppt and temperature from 17.0 to 29.0°C. This species is abundant in a salinity range from 20.00 to 78.00 ppt in first three section of Tarquinia saltworks. The diatom number and diversity index started to be inversely proportional to salinity (8) in the saltponds of series Ib.

In series of Ib evaporators (51.00-90.00 ppt) *Nitzschia delicatissima* dominated. Maximum diatom density was observed in IIa series of evaporators, in a salinity range from 98.6 to 110.0 ppt, where *Nitzschia seriata* complex together with *Cocconeis placentula* var. *lineata* and *Amphora delicatissima* dominated among diatoms. In IIb series of evaporators *Amphora coffeaeformis* and *A. cymbifera* dominated in the diatom community and in the saltponds of III series of evaporators *Amphora coffeaeformis* was the most abundant species. In adjusting ponds (salinity: 207 to 250 ppt) among the mentioned 3 diatoms which were presented in 210 ppt, Amhora coffeaeformis was the dominant species. In crystallizers (salinity: 255 to 290 ppt), diatoms were not observed. Different temperature and salinity gradients for diatoms have been recorded (9). The most euryhaline and eurythermal diatom in this salina genera were Amphora, and Nitzschia. *Amphora coffeaeformis*, *A. cymbifera* and *Nitzschia sigma* were presented at salinity of 210 ppt, where maximum temperature of 39.0°C was measured.

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