

CYANOPHYTA IN HYPERSALINE SOLAR SALTERN PONDS (EBRO DELTA, SPAIN)

CLAVERO E.¹, MERINO V.², GRIMALT J.O.¹ & HERNÁNDEZ-MARINÉ M.²

¹ Department of Environmental Chemistry (CID-CSIC), C/Jordi Girona, 18.

² Lab. of Botany. Fac. of Pharmacy. University of Barcelona. Av. Joan XXIII, s/n. 08028 Barcelona, Spain.

Microbial mats develop in hypersaline environments. One category of these mats are solar saltern ponds used for salt exploitation. This paper describes the cyanophyta assemblages thriving at the Salinas de La Trinitat, located at the Ebro delta (40°35'N, 0°40'E, South Catalonia, Spain). The structure of the sediment of these mats has been reported elsewhere (CLAVERO *et al.*, 1994; DE WIT *et al.*, 1994). Ponds are generally fully flooded in April. Seawater enters and is stored in the "deposits" and then transits through a series of shallow water pools in which the salinity of the water increases due to evaporation. Field observations and sampling were made sporadically from 1991 to 1993 and monthly in 1994. Four zones, distinctly different in salinity, were chosen for sampling and examination. Salinities and the dominant microbiota distribution are given in Fig. 1.

Carbonate domain		Intermediate	Gypsum domain
36-70‰	70-130‰	130-200‰	200-240‰
Diatoms			
Cyanophyta			
Chlorophyta	Purple and green sulfur bacteria		
		Dunaliella sp.	
<53‰	53-100‰	100-140‰	140-240‰
D 0	D 1	D 2	Heaters

Fig. 1. Salinity of the different sampled pools and microbiota distribution

Deposit 0. The low salinity did not allow mat establishment. However, in spring and summer, in the sand floor rooted *Ruppia maritima* L. and green filamentous alga developed. Among them grew *Chroococcus minutus* (Küt.) Näg., *C. turgidus* (Küt.) Näg., *Gomphosphaeria salina* Komárek et Hindák, *Johannesbaptistia pellucida* (Dick.) W.R. Taylor et Drouet, *Phormidium hypersalinum* Campbell et Golubic, *Lyngbya aestuarii* Liebm. and *Merismopedia glauca* (Ehrh.) Näg. The temporarily flooded sides were colonized in spring by a distinct laminated mat of a few mm; the upper layer was orange in colour and was formed either by sand and diatoms or sand and filamentous degraded sheaths, depending on the salinity of the evaporating water cover. The second layer was made up by *L. aestuarii* and *L. marteniana* Menegh., *Oscillatoria limosa* Ag. and *Hydrocoleus lyngbyaceus* Kütz., and the third layer was built mainly by *Microcoleus chthonoplastes* Thuret. When a shield was provided by stones or remains, a bright green layer of *M. chthonoplastes* stood on the surface and the other layers did not develop. As summer went on the flat slime covering dried and was broken into leathery desiccation polygons.

Deposit 1. There were very different populations, depending on the water column depth and the turbulence. In the margins that alternately were flooded and dried a compact layered green, grey and black mats were built, almost exclusively by *M. chthonoplastes*. On the inundated inner ring, a community began to develop in March which was mainly composed by diatoms and detrital particles that were associated with *C. turgidus* and scarce filaments of *L. aestuarii*, *M. chthonoplastes*, *Phormidium valderianum* (Delp.) Gom. and *Spirulina subsalsa* Gom. over a black sulfate-reduced layer. In summer they were substituted by a white and green dirty bed of *L. aestuarii* and *Beggiatoa* spp., whereas the flooded sediment was coated by a thin mat dominated by *L. aestuarii* and *O. limosa*. Additional species were *Oscillatoria lacus-solaris* Campbell et Golubic, *Aphanotece cohenii* Campbell et Golubic, and *A. krumbeinii* Campbell et Golubic. This thin mat trapped oxygen bubbles, was detached and floated although none of the forming species had gas vesicles. Some *Cladophora* bulks were mixed up mainly with *L. aestuarii* and *L. marteniana*. In August, entrance of Deposit 0 water favoured mass development of dinoflagellates and *Tetraselmis* sp. Although at the end of the year (1991-93) *M. chthonoplastes* was dominant, a mat was not established.

Deposit 2. In November of the previous years a thick mat of *M. chthonoplastes* covered the pool. Changes in salinity and the storms of 1994 winter destroyed it, and in the spring small colonies of *A. cohenii* and *A. krumbeinii* were attached to the nude sand floor, along with filaments of *S. subsalsa*. The sizes of *A. cohenii* and *A. krumbeinii* individuals did not overlap. In summer the green-yellow colonies formed a discontinuous thin slime cover with some *M. chthonoplastes* and *O. lacus-solaris* filaments. Orange patches of mineral phases of oxidized iron and green layers of *M. chthonoplastes* were present in the reflooded margins, related to the seasonal changes in water level.

Heaters. In the spring of 1992 and 1993, with salinities between 120-140‰ the mat was mainly built by *P. valderianum* whereas in fall it was substituted by *M. chthonoplastes* and *S. subsalsa* overlaying red dots of Chromatium and a green lamina of sulfur bacteria. As the salinity increases up to 200‰ only soft yellow-brown flocculent mats of *A. krumbeinii* were attached to the saline calcareous substrate. This form is abundant in summer, even at lower salinities.

The entrance of water of low salinity to replace the loss by evaporation, in these man controlled environment, caused alterations on the community structure and composition. The thin established mats, especially those dominated by *L. aestuarii*, became detached from the sediment upon temporal flooding. At the onset of the inundation period some organisms show a rapid colonisation rate upon the establishment of the favourable conditions. They formed blooms that decreased in a few days leaving only a minor signal in the sedimentary record.

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PRELIMINARY STUDY ON OXYGEN AND REDOX PROFILES IN SEDIMENTS FROM THE LAGOON OF VENICE (ITALY)

J.K. COCHRAN¹, M. FRIGNANI², L. ZAGGIA³ and R. ZONTA⁴

¹ Marine Sciences Research Center, The University at Stony Brook, N.Y., USA

² Istituto Geologia Marina, C.N.R., Bologna, Italy

³ Dipartimento Scienze Ambientali, University of Venezia, Venezia, Italy

⁴ Istituto Studio Dinamica Grandi Masse, C.N.R., Venezia, Italy

The concentration of dissolved oxygen is a sensitive indicator of diagenetic redox reactions occurring in the marine sediments. Microbial oxidation of organic matter in the sediment utilizes dissolved O₂ from interstitial water as the preferential electron acceptor. It can further proceed through a variety of alternate acceptors (as NO₃⁻, Mn⁴⁺, Fe³⁺, SO₄²⁻) until methanogenesis occurs (BERNER, 1980), and this sequence is marked by progressively decreasing redox potential (E_h). Oxygen also can be consumed by the oxidation of sulfide phases present in the sediments. Oxygen dissolved in the overlying water column can diffuse across the sediment-water interface to support this "sediment oxygen demand". When the consumption of O₂ in the sediment is large and its supply from the overlying water is limited, reduced conditions progressively extend toward the sediment-water interface, and hypoxia or anoxia in the overlying water column may even result. Redox potential profiles in surface sediment cores can be considered as an index of the imbalance between oxygen supply and its demand in the sediments (ZOBELL, 1946; CALLAME, 1968) but, due to chemical and thermodynamical limitations, E_h readings by Pt electrodes often do not provide meaningful information on specific redox equilibria. The interpretation of observed trends of E_h readings therefore requires the knowledge of the actual concentration of the chemical species involved. The present study was performed to investigate dissolved oxygen profiles in the near-bottom water and near-interface sediments of the Venice Lagoon, in order to evaluate the pattern of oxygen uptake in the sediments. A comparison was also made between measurements of dissolved oxygen and redox potential profiles, to investigate the relationship between the oxygen uptake and redox conditions in the sediment. Two sub-tidal areas of the Venice Lagoon, which had been previously characterized with respect to hydrodynamics, sediment characteristics and contaminant distribution, were chosen for the study. Sites were selected to be representative of the different sediment conditions. Four sites were in an eutrophic area near the Giudecca Isle, close to the City of Venice. The other 4 sites were in the Cona Marsh, the estuarine area of the Dese River, one of the main tributaries of the basin. The mean depth of the water column is about 0.5 m at all sites. Samples for dissolved oxygen measurement consisted of 7 cm diameter and 20 cm long undisturbed sediment cores, taken with overlying water. Dissolved oxygen was measured with a Clark-type microelectrode with guard cathode (Diamond General Development Corp.) (REVSBECH, 1989), mounted in a micromanipulator capable of vertical adjustment in mm, positioned about 1 cm above the sediment and gradually lowered in 0.5 mm increments. Redox potential profiles were measured in 4 cm-diameter cores at depths corresponding to 2, 5, 10, 20 and 40 cm from the core top, using combined Pt electrodes with a Ag/AgCl reference half-cell (201/L-SM-PT, CLR Milano, Italy) and following a previously tested methodology (ARGESE *et al.*, 1992). The Venice Lagoon represents an ecosystem in which coupling between the sediments and water column may be especially strong because of the organic-rich nature of the sediments and the shallow water column (mean depth of 0.5 m). One feature commonly observed in the oxygen microelectrode profiles is the production of dissolved oxygen by microalgae at the sediment-water interface (Fig. 1, profile 1). Cores incubated in the dark overnight show the disappearance of this feature (Fig. 1, profile 2). Dissolved oxygen penetrates to less than 2.5 mm depth at all sites. Redox values at a depth of about 15-20 cm are similar (≈180 mV) in all the investigated cores, which is a general feature in the sediment of the Venice Lagoon (ARGESE *et al.*, 1992; ZONTA *et al.*, 1994). The gradient between E_h values observed at 2 cm and at 20 cm may be taken as a measure of the extent of reduction of the upper sediment column, with large gradients indicating less reduction in the surface sediments. Oxygen penetration (Fig. 2) is correlated with the redox gradient, with the more reducing sediments of Cona having relatively shallow oxygen penetration depths. The Cona samples appear to have a different trend from those at Giudecca, in part due to differences in grain size and in the type and amount of organic matter for the sediment of the two areas. The data suggest that sediment oxygen demand is greater at Cona than at Giudecca and further studies to determine oxygen fluxes on incubated cores are planned.

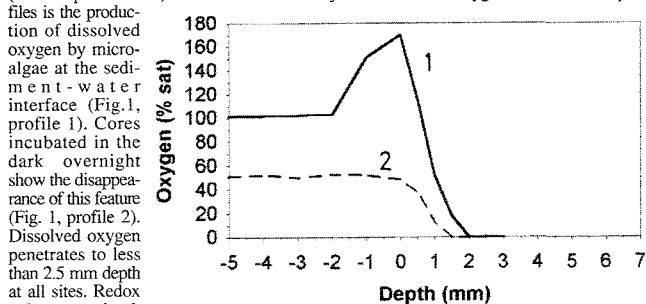


Fig. 1. Effect of oxygen consumption after overnight incubation in the dark.

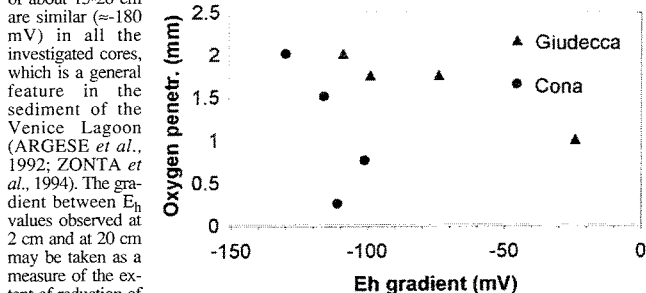


Fig. 2. Plot of the gradient between Eh values at 2 and 20 cm vs. the oxygen

penetration column, with large gradients indicating less reduction in the surface sediments. Oxygen penetration (Fig. 2) is correlated with the redox gradient, with the more reducing sediments of Cona having relatively shallow oxygen penetration depths. The Cona samples appear to have a different trend from those at Giudecca, in part due to differences in grain size and in the type and amount of organic matter for the sediment of the two areas. The data suggest that sediment oxygen demand is greater at Cona than at Giudecca and further studies to determine oxygen fluxes on incubated cores are planned.

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