

THE DISTRIBUTION AND MOBILITY OF IRON IN COASTAL SEDIMENTS COVERED WITH CYANOBACTERIA MATS

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Abstract

In coastal marine environments with shallow, warm and calm waters, it is sometimes possible to observe the presence of organosedimentary structures (algal mats). The aim of this work was the study of the distribution and mobility of Fe among the main layers of coastal algal mats in a closed bay at Anavissos, on the coast of the Saronikos Gulf. Small sediment cores were collected and separated to three discrete layers. The trace metals of each layer were extracted according to the BCR sequential extraction method. The main results of the study are: a) The labile forms of Fe are mostly associated with organic compounds and sulfides and b) Fe tends to accumulate in the anoxic layer of the sediment.

Keywords : Algae, Anoxia, Metals, Sediments.

In coastal marine environments with shallow, warm and calm waters, it is sometimes possible to observe the presence of organosedimentary structures, which are produced by sediment trapping, binding and /or precipitation as a result of the growth and metabolic activity of microorganisms, principally cyanobacteria [1].

The aim of this work was the study of the distribution and mobility of various forms of Fe, in the main layers of coastal cyanobacteria mats that have been observed in some Greek coastal areas.

The area under research is a closed bay at Anavissos on the coast of the Saronikos Gulf, 50 Km away from Athens, with an area of about 20,000 square meters. This area has ideal conditions for the development of such formations [2]: A line of beachrocks shuts the bay's entrance, obstructing the water's renewal. At the shallow bottom of the cove (max. depth of about 0.6 meters) a layer of green algae with a thickness of 0.2 - 2 mm is observed, which extends throughout the bottom of the bay [3].

Sediment cores about 10 cm long, were collected seasonally from one point inside the bay that is partly covered with seawater for a course of one year. The cores were separated in three layers that were freeze-dried and sieved through 0.25 mm sieves: a) the upper one, 0.2 - 2 mm thick, which includes the cyanobacterial mat; b) the middle one, up to 5 cm thick, of dark colour, which is anoxic and has the characteristic odour of hydrogen sulfide; c) the third one, about 5 cm thick, of brown colour, which represents the background sediment. According to the BCR sequential extraction procedure the trace metals were separated in four fractions: Fraction A: metals connected to small inorganic particles and carbonates; fraction B: metals connected to oxides/hydroxides of Mn and Fe; fraction C: metals connected to organic compounds and sulfides; fraction D: metals strongly bound in the alumino-silicate lattice. A Flame Atomic Absorption apparatus equipped with Sample Introduction Pump System and D₂ lamp for the background signal correction was used for the determination of Fe. The contents of all layers of the sediment in the various fractions of Fe are presented in table 1.

Tab. 1. The content of the sediment in Fe (in mg/Kg)

Fraction	Summer 2000	Autumn 2000	Winter 2001	Spring 2001
Surface layer				
A	0.091	0.049	0.050	0.114
B	0.788	0.721	0.230	0.260
C	0.693	1.54	0.526	0.826
D	13.1	11.9	17.5	18.2
Anoxic layer				
A	0.152	0.185	0.072	0.075
B	0.532	0.577	0.356	0.253
C	1.43	1.55	1.74	0.981
D	12.7	14.3	17.6	11.5
Background layer				
A	0.040		0.055	
B	0.139		0.190	
C	0.353		0.637	
D	12.6		16.4	

According to that table, 90% of Fe in the surface layer, 88% of Fe in the anoxic layer and 95% of Fe in the background layer is strongly bound in the sediment's crystalline grid. The second most abundant form of Fe in all sediment's layers is the one associated with organic compounds and

sulfides and represents 61%, 72% and 70% of all labile forms in the surface, anoxic and background layers respectively. On the other hand, the less abundant form of Fe is the one connected to small inorganic particles and carbonates as it represents 5 -7 % of its labile forms. About half of the labile forms of Fe accumulate in the anoxic layer of the sediment. In order to explain the distribution of Fe among the sediment's layers we tried to extract the ratio $[Fe^{+3}]/[Fe^{+2}]$ in the porewater as the mobility of Fe is dependent on its oxidizing level. After theoretical calculations we found out that this ratio is a function of the oxygen concentration (PO_2), pH, temperature (T), E_o (of the reaction $Fe^{+3} + e^- \rightarrow Fe^{+2}$; here is 0.770) and the number of electrons moved (n; here is 1). Thus, $\log([Fe^{+3}]/[Fe^{+2}]) = f(PO_2, pH, T, E_o, n)$. When applying the physicochemical measurements that we carried out in the anoxic sediment's porewater (pH = 6.8, T = 293 °K, $PO_2 = 0.01$ (anoxia), n = 1 and $E_o = 0.770$) we found out that $\log([Fe^{+3}]/[Fe^{+2}]) = 0.2$, meaning that considerable amounts of Fe^{+2} are present in the porewater. Cyanobacteria that extend through the surface of the sediment uptake inorganic Fe^{+3} and convert it into organic Fe. After their death, organic Fe is gradually buried in the anoxic layer and converted again into inorganic Fe. A part of the Fe^{+3} is reduced to Fe^{+2} due to the anoxic conditions and partly converted into FeS . As Fe^{+2} is more labile than Fe^{+3} , a part of it can reach the surface via porewater, be oxidized into Fe^{+3} and then be recycled. Figure 1 presents the cycle of Fe in this particular ecosystem.

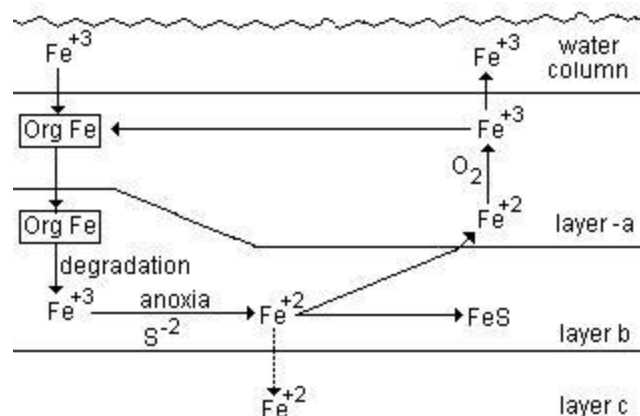


Fig. 1. The behaviour of Fe in the cyanobacteria mat

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