X-III2

MODE DE COLONISATION DES PARTICULES SÉDIMENTAIRES PAR LES BACTÉRIES

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Il est bien connu que les sédiments naturels sont le siège d'une intense activité bactérienne. Les bactéries y créent des structures d'attachement et de protection qui leur permettent d'exploiter au maximum leurs potentialités métaboliques.

L'observation au microscope électroniques à balayage montre que la surface des grains de sable du littoral marin est, en apparence, peu colonisée, sauf dans les anfractuosités. (Photo 1 et 2). Un examen plus attentif montre qu'en réalité les surfaces lisses sont souvent recouvertes d'un feutrage très dense camouflant les bactéries. (Photo 3). Une coloration spécifique montre que celui-ci est de nature polysaccharidique.

A l'abri de cette protection, qui par ailleurs joue le rôle de capteur d'ions (COSTERTON T.W. and IRWIN R.T. (1981)), les bactéries se développent et éventuellement creusent un réseau de galeries à l'intérieur des grains calcaires ainsi que le montre la photo 4, prise au microscope optique.

Soumis à l'action de l'HCL, les grains de nature calcaire ne se dissolvent, dans la plupart des cas, que si on les brise mécaniquement. Ceci laisse supposer qu'ils sont protégés par le réseau de glycocalyx.

Le feutrage intérieur du grain, qui subsiste après la dissolution, met en évidence des micro-organismes filamenteux, ramifiés ou pseudo-ramifiés, d'un diamètre voisin du micron. D'autres filaments ont un diamètre de 4 à 5 µm et présentent des dilatations apparentées à des fructifications.

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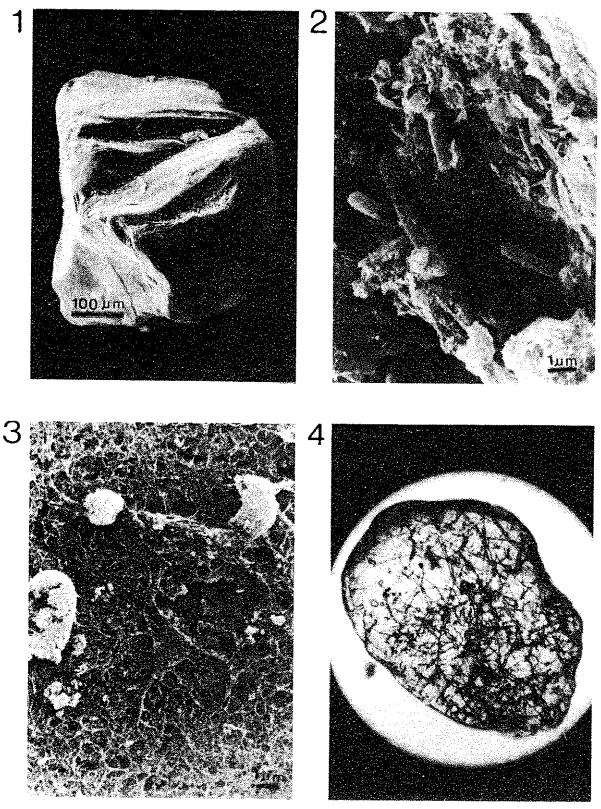
ILLUSTRATIONS

Les photos 1,2 et 3 sont réalisées au S.E.M. La photo 4 est réalisée au microscope optique.

PHOTO 1 : Grain de sable littoral marin, côte belge. PHOTO 2 : Bactéries et glycocalyx dans une anfractuosité du grain de sable. PHOTO 3 : Détail d'une partie lisse du grain de sable. Recouvrement par du glycocalyx.
PHOTO 4 : Réseau de canalicules vu par transparence à l'intérieur d'un grain de sable calcaire.



X-III3

MICROBIAL ACTIVITY IN COASTAL MARINE SEDIMENTS OF ITALIAN COAST

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ABSTRACT - The results are presented concerning the estimation of microbial activity in a few coastal marine sediments of Italian coast. A great variability in microbial activity was observed in the sediments of Apulian coast while a more uniform values were found in the sediments of Gulf of Gaeta and Tuscan coast. No correlation was observed between microbial activity and organic carbon content.
RESUME - Les résultats présentés concernent l'évaluation de l'activité microbienne dans quelques sédiments marins des côtes italiennes. Une variabilité a été observée pour les sédiments de la côte des Pouilles; au contraire, une plus grande uniformité caractérise les sédiments du Golfe de Gaéte et des côtes toscanes. Aucune correlation évidente n'est apparueentre l'activité microbienne et le contenu en substance organique.

In the last years ENEA has performed oceanographic cruises along the Italian coasts in order to characterize typical environments and their ecosystems. In this context, sediment microbial activity estimation was taken into consideration due to its importance for nutrient regeneration, organic matter consumption and fate af metal ions following physico-chemical condition changes induced by microbial metabolism.

The environments investigated are: Apulian coast (South Adriatic Sea), the Gulf of Gaeta (central Tyrrhenian Sea) and the central Tuscan coast (North Tyrrhenian Sea). Microbial activity has been determined by measuring resazurin reduction carried out by a sediment sample (0.5-1 g FW) incubated for 1 h at 20° C (Peroni and Rossi, 1986). The results can be expressed as equivalent consumption of oxygen. Organic carbon content has been gas-chromatographically determined by difference between a sample treated at 450° C for 12 h and an untreated sample.

The microbial activity in the surface sediment (0-1 cm) of Apulian coast was determined in 44 sampling stations. It has been possible to divide the sedimentary environment in 5 areas according to the different microbial activities. The sandy stations show very low activities with an average annual oxygen consumption of about 20 g/m^2. The sediments collected in the Gulf of Manfredonia and northward of Brindisi exhibit the highest consumptions (an average, extrapolated on an annual basis, of about 350 g for square meter). The sediments taken southward of Brindisi and off Gargano promontory give average values of oxygen utilization equal to about 100 g/year/m^2. The organic carbon content ranges from 0.40 to 3.51% DW and is higher in the sandy stations (C/N ratio of 25-35). By means of statistical analysis (Pearson correlation coefficient) a significative inverse correlation has been found between microbial activity and particle size and organic matter content. The latter relation stresses that organic matter quality is more important than its absolute amount; in fact, less degradable organic matter can sustain less microbial activity and therefore it persists longer. In the same samples no correlation has been found between microbial activity and bacterial colony numbers on agar plates.

7 stations were sampled in the Gulf of Gaeta. The lowest microbial activities on surface sediments have been found in the stations with abundant shell detritus and in the offshore station (101 m water depth). They are around 70 g of consumed oxygen/year/m^2. Higher values (about 200 g/y/m^2) have been determined in the sediments with scarce shell detritus and in the inshore station, inside the harbour of Gaeta. Organic carbon content is low (0.5-0.7% DW) in the abundant shell detritus stations, while being higher (1.4%) in the other stations reaching a value of 1.9% in the harbour station which is polluted by urban discharges. No apparent correlation, however, was shown between microbial activity and organic carbon content.

Along the Tuscan coast only 5 samples have been examined due to the hard bottom which prevented from sample collection. The equivalent consumption of oxygen was roughly similar averaging 180 g/y/m^2, except in one station where it was about 80 g/y/m^2. In this station the depth of oxidized layer of the sediment was higher. The organic matter concentration was rather uniform and low (0.9-1.2% with C/N ratios ranging from 14 to 17), except in the station near Livorno where organic carbon reached 2.7% due to some organic pollution from the city. Also in this case organic carbon content and microbial activity does not show any apparent correlation. Microbial activity showed no correlation also with bacterial counts as determined by agar plates (0.9-5.3·10^6 CFU/g FW).

In the sediments from the Gulf of Gaeta and Tuscan coast microbial activity was also measured in the subsurface layers, particularly in the transition layer from oxic to anoxic conditions as it can be visually recognized from change from brown to grey-black colour. In most cases subsurface activities were two-four times higher than the surface ones. This implies that resazurin reduction can measure also anaerobic metabolism and this may be true since sulfate reduction requires electron transport chain and many strains of sulfate-reducing bacteria can tolerate oxygen (Hardy and Hamilton, 1981; Cypionka et al., 1985). The transition layer can be thought to be a site of intense bacterial metabolism (Jones, 1979; Novitsky and Kepkay, 1981) and furthermore bioturbation can supply fresh nutrients and organic matter to deeper layers. This can be confirmed by the vertical distribution of organic matter which does not show any decrease with sediment depth, at least for the layer 0-15 cm. However, the subsurface values might be affected by some artifacts. In fact, they might be due to the artificial enhancement of bacterial metabolism following the addition of fresh organic matter contained in seawater used as sediment dispersion medium. Experiments are being carried on in order to test this possibility and, if necessary, modify the method accordingly by using aged and/or oligotrophic seawater.

The data reported here show the usefulness of the method for investigating:
- the degree of organic matter utilization since easily degradable organic matter sustains higher activities;
- the amount of consumed organic carbon by converting oxygen consumption to carbon mineralization;
- the metabolism in the subsurface layers which is important, e.g., for nutrient regeneration.

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X