Composition and sedimentation of particulate organic matter in shallow coastal waters (Gulf of Trieste, Northern Adriatic)

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Particulate matter in the sea consists of organic and inorganic fractions, arbitrarily defined as matter larger than 1 µm. The quantity and composition of particulate matter varies temporally and spatially in response to physical and biological factors. Among them, the most important in coastal areas are riverine discharge, runoff from rainfall, wind-wave and tidal resuspension, biological production and shore erosion. Studies on the composition of particulate matter in the central and SE part of the Gulf of Trieste (in the period 1979-86) revealed that the majority (approx. 60-70 %) of it is composed of a minerogenic fraction, having identical mineralogical composition as surficial marine sediment: calcite (26 %) > illite (24 %) > quartz > (16 %) > chlorite/kaolinite (15 %) > microcline (8 %) > dolomite (7 %) > plagioclase (6 %) > montmorillonite (5 %) > pyrite, gypsum (4 %). This inorganic particulate material originates principally from sediment resuspension and riverine inflow of fine particles, since larger ones are deposited at the river mouths.

The particulate organic matter fraction is mainly composed of carbohydrates (on the average about 19 %) and proteinaceous matter, of which proteins with molecular weight > 10 000 represent on the average about 6 %, with an additional small lipid fraction (about 1 %). All these components on the average amount to only about 26 % of the total particulate organic matter in the Gulf. The remaining, major, fraction is prorably composed of humic material and lignin of terrigenous origin. The amino acid composition of the proteinaceous fraction in decreasing order is: Gly > Glu > Asp > Ala > Val > Leu > Ser > Thr > Lys > Ile > Pro > Arg > Phe > His. The mean POC, PN and PP concentrations amount to about 410, 85 and 35 µg l^{-1}, respectively. The mean C:N and C:P ratios (atomic) are low, averaging to about 4 and 27, respectively, due to the fact that nitrogen and phosphorus are also bonded in inorganic particles and adsorbed onto particulate material. Amino acid-N and amino acid-C amount to only 16 and 12 % of PN and POC, respectively. POC samples from the Gulf of Trieste showed $\delta^{13}C$ values in the range between -21.1 and -25.3 °/oo, with a mean value of -23.1°/oo. $\delta^{13}C$ seasonal variation in POC shows the inverse relation with phytoplankton biomass and primary particulate production. Mixing models constructed with C:N ratios and $\delta^{13}C$ values of source material forming POC, i.e. allochtonous (riverine and sewage) and autochtonous (phytoplankton) POC, showed that marine POC in the Gulf of Trieste is a mixture of about 1/3 of riverine POM and 2/3 of phytoplanktonic organic matter in the absence of the input of sewage POM which is the most variable. Pelagic food web analysis using $\delta^{13}C$ values of various classes of pelagic organic matterial (phytoplanktonic, POC, net-zooplankton) indicated that the labile fraction of POC is primarily a food for net-zooplankton, while the ^{13}C depleted detritus of riverine and sewage origin is probably deposited on surficial sediment or exported out of the Gulf by horizontal currents.

The sedimenting POC and PN are little affected by the input of allochtonous particulate matter and the contribution of benthic macrophytes. The resuspension of bottom sediments has a great influence on the gross sedimentation rates of particulate organic carbon and nitrogen, averaging about 80 - 90 %. 50 - 70 % of particulate organic carbon and nitrogen produced in the sea water column is decomposed there or transported away by horizontal currents. About 88 % of particulate amino acids are decomposed or transferred to the dissolved amino acid pool during sedimentation. From amino acid analyses in different classes of suspended and sedimentary organic matter the generalized order of amino acid stability during sedimentation was found to be: AA-S > AA-OH > aromatic, neutral-AA with branched C-chain > basic > acidic, neutral-AA with straight C-chain, proline.

Variations des rapports N:P dans le Bassin Occidental de la Méditerranée

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Compared to the Atlantic adjacent waters, the Mediterranean waters are characterized by a lower level in nutrients (PO_4 and NO_3) and by higher N:P ratios. This discrepancy can not be easily explained even if its origin is probably due to the assimilation-regeneration processes inside the Mediterranean basin. In fact, previous works have shown that the difference in the N:P ratios disappears if we take into account the organic forms of nitrogen and phosphorus.

A more accurate study, based on recent data obtained in the Western Mediterranean Sea and in the Atlantic waters near the strait of Gibraltar (Mediprod IV and Mediprod V cruises) give some more insights : 1/ The Atlantic waters keep N:P ratios around 16:1 during their eastward transport in the Mediterranean Sea, while nitrate and phosphate are consumed and become depleted in the north of the basin. 2/ The vertical N:P ratio distribution is characterized by low values (~ 16) in superficial waters (salinity < 38.0), by maximum values (often higher than 30) in subsuperficial waters where salinity reaches 38.20, and by uniform values (20-22) in intermediate and deep waters. These vertical distribution and the subsuperficial maximum can probably be attributed to the biological activity that was found intense along the Algerian coasts. These high values can originate the N:P ratio in the deep water which is formed in winter by the mixing of superficial and intermediate waters.

Les eaux méditerranéennes se distinguent de celles de l'Océan Atlantique par leur pauvreté en éléments nutritifs et, également, par des valeurs différentes des rapports atomiques de ces éléments. Alors que les eaux atlantiques présentent un rapport N:P (NO_3/PO_4) très proche du rapport de Redfield (16:1), les valeurs pour les eaux méditerranéennes sont supérieures à 20:1. Cette différence n'a pu être expliquée d'une manière convainquante même si on peut penser qu'elle tient aux processus de consommation et de minéralisation au sein même du bassin. En effet, on a pu montrer que cette différence ne se retrouve pas si, au lieu de prendre en compte les seules formes minérales, on inclut les formes organiques de l'azote et du phosphore.

Une étude plus détaillée, basée sur les données récentes obtenues dans le bassin occidental de la Méditerranée et le proche atlantique (Campagnes Médiprod IV et V), apporte certaines précisions : 1/ tout au long de leur parcours, les eaux superficielles d'origine atlantique conservent un rapport N:P proche de 16:1 et sont en même temps soumises à une consommation qui a pour effet de les rendre totalement appauvries en nitrate et phosphate dans la partie nord du bassin. 2/ La distribution verticale des rapports N:P est caractérisée par des valeurs proches de 16 dans les eaux superficielles de salinité inférieure à 38, par des valeurs maximales (souvent supérieures à 30) dans les eaux sous-jacentes à salinité d'environ 38,20 et ensuite homogènes jusqu'au fond (20-22). Cette distribution n'apparait que dans le bassin occidental lui-même ; elle est absente dans la mer d'Alboran.

Cette distribution, et plus particulièrement l'existence du maximum subsuperficiel du rapport N:P, a pour origine probable les processus d'assimilation-reminéralisation liés à l'activité biologique intense dans la partie sud du bassin. Au moment de la formation des eaux profondes (composées d'eaux superficielles et d'eaux intermédiaires), ces très fortes valeurs peuvent être à l'origine des valeurs de N:P supérieures à 20 rencontrées dans ces eaux.