Sources and fluxes of suspended particulate matter in shallow coastal waters (Gulf of Trieste, Northern Adriatic) A. particulate organic matter

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Organic matter in coastal recent sediments is derived from organic matter synthetized by marine organisms (mostly phytoplankton) and that from terrigenous origin, and successively transported to the sea floor as sedimented particulate organic matter (POM), leading to the sedimentary organic matter with different composition to that in the sea surface. A striking characteristic of shallow coastal areas is that the euphotic zone is present down to the sea bottom and hence the production and degradation of POM occurs simultaneously. Macroaggregates or marine snow are frequent phenomenon in the northern Adriatic during summer and may represent the major role in the downward flux. The aim of the present work was to study the origin and temporal variation of chemical composition of sedimented POM in the S part of the Gulf of Trieste in 1991 using traps deployed at depths of 10 and 20 m. Special attention was payed to the sedimentation of macroaggregates in summer of 1991.

The annual variation pattern, depicted in Fig. 1, of particulate carbohydrate sedimentation rates showed the highest values in the mid of August at the depth of 10 m and also at the end of August at the depth of 20 m due to the slower sedimentation rate of macroaggregates in the stratified water column since the macroaggregates are prevalently composed of carbohydrates. A different pattern was observed for particulate protein sedimentation rates, more in phase with sedimented phytoplankton blooms (from chlorophyll a values), showing the highest values during the May, August and October blooms (Fig. 1). The indication of the origin of sedimented POC, estimated by $\delta^{13}C$. POC values (Fig. 1), showed the sedimented POC of purely phytoplanktonic origin ($\delta^{13}C$.POC <20‰) at the depth of 10 m in August in the period of the highest sedimentation rates of macroaggregates of diatomaceous origin. The lowest $\delta^{13}C$ values of sedimented POC observed in June indicated the influence of the terrigenous POC sedimentation originated from enhanced local river (especially Isonzo) discharges. The $\delta^{13}C$. POC variations in deeper trap in the period August-September was, on the other hand, more the consequence of surficial sedimentary organic carbon resuspension, having $\delta^{13}C$ values -22.4‰. Resuspension is an important contributor to the bottom layer sedimentation especially in the period of sea water density stratification (June-October, Fig. 1).

In conclusion, the sedimentation of POM in the central part of the Gulf of Trieste in 1991 was determined by the late spring new phytoplanktonic production and allohtonous riverine input, summer sea water density stratification and bottom sediment resuspension and, in lesser extent, the autumn phytoplanktonic regenerated bloom.

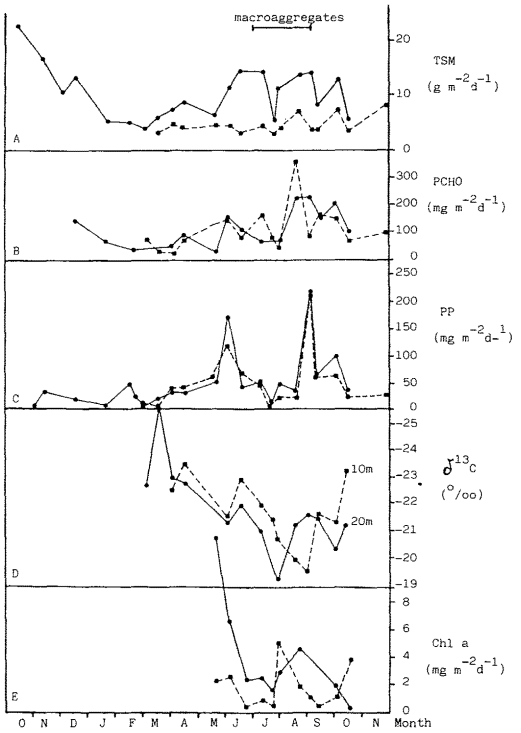

Fig. 1. Sedimentation rate of total suspended matter (TSM, A), particulate carbohydrates (PCHO, B), particulate proteins (PP, C), ^{13}C isotopic composition of sedimented particulate organic carbon (D) and sedimentation rate of chlorophyll a (Chl a, E) at the depth of 10m and 20m at sampling point F in the Gulf of Trieste from October 1990 to November 1991. Horizontal line at top indicates occurence of macroaggregates.

Sources and fluxes of suspended particulate matter in shallow coastal waters (Gulf of Trieste, Northern Adriatic) B. Particulate heavy metals

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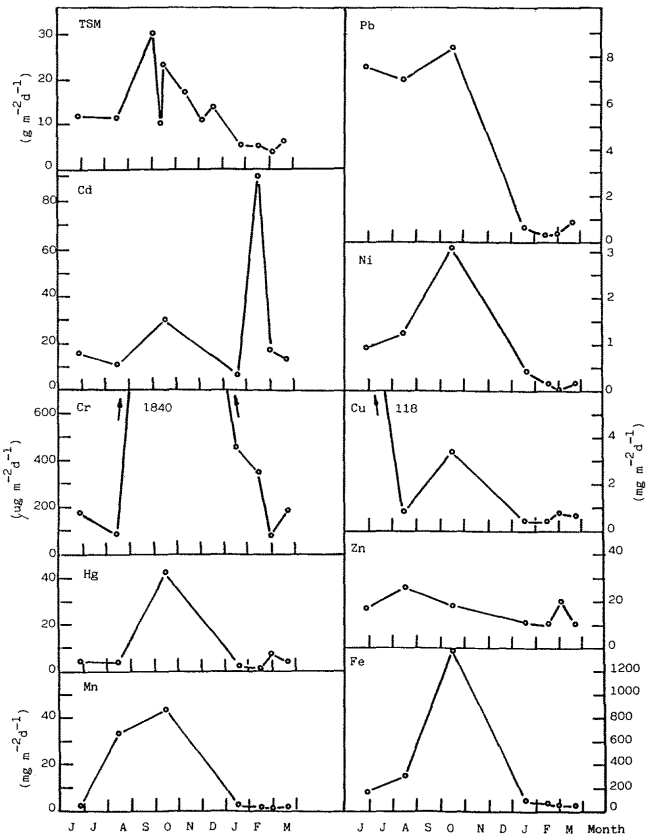
The importance of recent coastal sediments as geochemical sink for heavy metals is now widely recognized. This is also the case for the recent sediments of the Gulf of Trieste, markedly enriched in Hg and Pb contents in S-N direction mostly of riverine (river Isonzo) origin. Despite these findings, only few studies have focused the attention towards the nature of downward transport mechanism and on the nature of solid phases governing the removing of metals from the water column. The metals are bonded in or on particulate phase to be transported to sediments. Important mechanisms responsible for this association to particles, besides precipitation, coagulation and adsorption, is the interaction with the biogenic particles and these may depend strongly on the biological variations in the marine basin. Our objectives were to assess the sedimentation rates of particulate heavy metals Fe, Cu, Ni, Cd, Mn, Zn, Pb, Hg and Cr in shallow coastal marine basin, strongly perturbated by fresh water discharges, wind and sediment resuspension, and to investigate the role of different type of particles (interactions with organisms, organic and inorganic matter) in the downward flux of metals. Sedimentation rates were measured by sediment traps deployed at the depth of 20 m (approx. 1 m above the bottom) at the station in the centre of the Gulf over a year from June 1990 to April 1991 and thus covering the seasonal variations of hydrological and biological properties of the waters of the Gulf of Trieste.

Strong seasonal variations of sedimentation rates of all particulate heavy metals studied, nearly in phase with sedimentation of total suspended matter (TSM), are shown in Fig. 1. All particulate heavy metals showed high sedimentation rates in autumn period (October 1990) in parallel with the highest TSM sedimentation rates in relation to the sedimentation of autumn phytoplanktonic bloom. High particulate Cu, Pb and in lesser extent Zn and Cd sedimentation rates observed in late spring (June 1990) were due to the sedimentation of spring phytoplanktonic bloom. This demonstrated that biological surfaces may interact, besides with Cu and Zn with known physiological roles, also with other particulate metals possibly through adsorption and coagulation. The influence of resuspension, mostly occuring in the summer stratified water column, was pronounced for Pb, Zn and Mn, the latter deriving form the reoxidation of Mn^{2+}, released from sediment pore waters, to MnO_2 which is a very effective scavenger of heavy metals. Resuspension of Fe from sediments, mostly in the form of pyrite, seems to be a minor process. The role of particulate minerals, also composing surficial sediments of the Gulf of Trieste, is at present difficult to assess. The carbonates, comprising up to 67 % of sediment in the central part of the Gulf of Trieste, seem to be less important while silicates (approx. 31 % of sediments) may bond especially Pb which is known to have a high tendency of association with active surfaces.

From the present study it appears that sedimentation of biogenic matter is very important in the transport of metals to surficial sediments in the Gulf of Trieste, especially for Cu, Zn, Pb and Cd, but also for others. Resuspension also contributes to particulate heavy metal sedimentation, especially for Pb, Zn and Mn, the latter as consequence of the oxidation of pore water derived Mn^{2+} to MnO_2, scavenging other metals and transporting them to sediments.

Fig. 1. Sedimentation rate of total suspended matter (TSM) and particulate Cd, Cr, Hg, Mn, Pb, Ni, Cu, Zn and Fe at the depth of 20m at sampling point F in the Gulf of Trieste from June 1990 to April 1991.



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