Heavy metal pollution in the Damietta Estuary of the Nile

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At the downstream of the Damietta branch, Faraskour's Dam was constructed separating it from the Damietta Estuary, which receives very small amounts of the Nile water. The average depth of the Damietta Estuary is 7 m and its width at the mouth does not exceed 200 m. The water quality of this Estuary was deteriorated due to pollution, mainly from sewage and industrial wastes. The present study deals with regional and seasonal variations of heavy metals in the Damietta Estuary to illustrate the impact of man on this water body. Water sampling was carried out seasonally during 1979-80 from the surface, middle and bottom waters at five selected stations.

Suspended matter (SM), ranging from 2.3-110.4 mg/l, showed irregular vertical variations. The surface increase in SM content resulted from settling of air-born dust. The bottom increase, however,coincided mainly with stirring up of the sediments by water currents. Such increase was matched with the corresponding increase in the bottom values of particulate heavy metals. The maximum regional average SM value was found at location directly affected by pollution, where dissolved and particulate metals gave maximum or markedly high average concentrations. The maximum seasonal average SM value in winter reflects the effect of strong wind in stirring up the sediments and rainfall in increasing land runoff (ABBAS, 1980). This highest SM content increased obviously the values of particulate metals, giving maxima or markedly high seasonal averages (Table 1).

The concentrations of iron varied widely from 2.16-46. 55 µg/l for dissolved form and from 1.80-406.8 µg/l for particulate form. The increase in the bottom dissolved iron coincided possibly with the increase in the rate of its release from sediments (SANDERS, 1970). Manganese concentrations varied considerably from 0.24-313.3 µg/l for dissolved form and from 1.6-191.1 µg/l for particulate form. Contrary to iron, the seasonal distribution of dissolved manganese reflects the role of phytoplankton uptake (Table 1). However, different pollutants could be considered as main sources for iron.

Copper concentrations varied markedly from 0.25-34.38 µg/l for dissolved form and from 0. 56-52.1 µg/l for particulate form. The minimum seasonal average value of dissolved copper in December was matched with the maximum seasonal average value of particulate copper (Table 1). These extremes in December were correlated with the increase in pH values (ABDEL-MOATI, 1981). The values of zinc varied markedly from 1.68-91. 88 µg/l for dissolved form and from 2.8-102.2 µg/l for particulate form. The increase in the bottom values of dissolved zinc may be attributed to sediment-water exchange of this metal (SONNEN, 1965). The highest regional average value of dissolved zinc matched with the lowest regional average value of particulate zinc was found at location, where reducing conditions prevailed (ABDEL-MOATI, 1981). Cadmium concentrations varied noticeably from 0.03-0.24 µg/l for dissolved form and from 0.04-1.93 µg/l for particulate form. The seasonal distribution of particulate cadmium was correlated with that of SM (Table 1). The increase in the mean values of SM and heavy metals calculated for the Damietta Estuary compared with the corresponding means of the comparatively clean Damietta branch reflects the influence of pollutants dumped in this Estuary.

		March 1	June 9	Sep. 7	Dec. 9	March 1980
SM		11.1	10.5	9.5	25.0	9.5
Fe	D	11.10	11.02	9.27	7.87	6.15
	P	183.2	96.4	106.0	147.2	109.7
Mn	D	16.36	8.64	23.27	55.14	14.6
	P	69.4	22.6	54.6	28.9	16.3
Cu	D	3.64	3.56	3.04	2.23	4.31
	P	8.5	9.2	8.5	11.8	10.3
Zn	D	17.24	6.87	14.99	15.39	13.35
	P	18.2	16.1	21.4	24.4	15.6
Cd	D	0.04	1.14	1.80	1.22	1.08
	P	0.26	0.19	0.16	0.36	0.16

D = Dissolved P = Particulate

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Table 1. Variations of the seasonal averages of SM (mg/l), dissolved and particulate heavy metals (µg/l) in the Damietta Estuary of the Nile

Distribution of nutrients in the Acheloos river mouth, Greece

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The study of chemical behaviour and cycling of nutrients in the estuary of Acheloos river is of high environmental importance for the follow reasons :
1. Acheloos is one of the largest Greek rivers (having a drainage area of 5350 Km^2 and a mean average flow of 167 $m^3.s^{-1}$).
2. The geomorphology of the estuary is different from that of other rivers due to the direct discharge of the river waters to the open sea. A very shallow sill exist at the river mouth.
3. Acheloos is among those rivers which are still considered as unpolluted, since it does not pass through heavily industrialized areas and it does not receive sewage and industrial effluents.
4. Some large hydroelectric dams play an important role in the fluctuation of its flow (particularly during the last 10 years) which does not follow a normal annual cycle.
5. A large scale divertion of part of the river water to Thessaly and Pinios river is planned for agricultural purposes. This project raised a series of serious environmental questions since the processes in the river and its mouth and their effects on ecosystems have not been adequately assessed.

A previous study (SCOULLOS *et al.*, 1985) in this area has shown that the river acts as a major source of inorganic nitrogen for the Patraikos Gulf mainly due to washout of fertilizers.

Methods

Eight seasonal samplings were carried out from 1984 to 1989 in an extended grid of stations in all parts of the system (river, estuary, sea). Hydro-bios plastic bottles were used for the collection of the samples and the nitrates, nitrites, ammonia, phosphates and silicates were measured by standard photometrical methods (STRICKLAND and PARSONS, 1972) after filtration of the samples. Dissolved oxygen, salinity, temperature and pH were also measured in situ.

Results and discussion

The observations of the preliminary study of the estuary were confirmed during this more detailed study.

The Acheloos river is a major source of nitrates and silicates in the adjacent sea area due also to the fact that some drainage canals discharge in it. These additions compensate the expected denitrification which could take place in the existing dams. High concentrations are more freequently found during winter when the values of nitrates and silicates in river waters exceed in some cases the level of 60µgat/l. The river contributes also ammonia and phosphates. The concentration of phosphates is usually smaller than 1µgat/l and that of ammonia ranges between 1 and 10 µgat/l. Nitrite concentrations were below 0.3µgat/l. The concentrations of all nutrients decrease in the sea outside the river plume.

Nitrates and silicates have the wider seasonal variations although ammonia and phosphates fluctuate also seasonally in a minor scale. Nitrates are the more abundand nitrogenous nutrient and the NO_3/NH_3 ratio which was practically >1, reaches values as high as >30 during winter.

The N/P ratio also varies and has usually values greater than 15:1, and in winter periods greater than 100:1. This might sugest that the phosphates are the limiting factor for the phytoplankton growth.

The behaviour of the nutrients in the intermixing zone of the estuary, as it concerns their conservativenes, changes seasonally, possibly due to biological activities. The main tendency is addition during winter and removal during summer.

Another interesting phenomenon observed in periods of minimum flow and mainly during summer months is the penetration of saline water inside the river bed and the formation of a thin salt wedge which occupies the near bottom layer of the water column with its thin end pointed up to 1-2 Km upstream. The reduction and control of the river flow by the dams is also responsible for this phenomenon which influences the behaviour and distribution of the nutrients. It is apparent that the position of the salinity front and the width of the intermixing zone fluctuates with time regulated mainly by the flow.

A typical distribution of salinity is shown in figure 1 and the corresponding distribution of nitrates is shown in figure 2. It is obvious that in the surface layer, as the fresh water is mixing with the saline downstream, the concentrations of nutrients decrease. In the near bottom saline layer the concentrations are smaller but an enrichment of nitrates and phosphates is observed inside the river and before the sill. This could partly be attributed to the degradation of the particulate organic matter (flocks etc) which is trapped and/or resuspended in the saline layer. Such profound enrichment at the bottom layer was not observed for silicates.

Figure 1 : Salinity, 6/1990

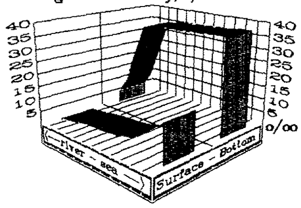
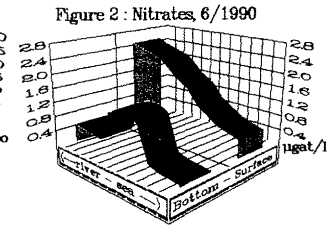


Figure 2 : Nitrates, 6/1990



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