WASTE DISPOSAL AND RIVERS DISCHARGE EFFECTS ON THE EUTROPHICATION CONDITIONS OF THERMAIKOS GULF (N.W. AEGEAN)

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Abstract

Dissolved oxygen and nutrient concentrations, were studied seasonally from May 1995 until March 1996, in order to estimate the impact of the disposal of the urban wastes and the discharge of the rivers on the eutrophication conditions of the Thermaikos Gulf. The results reveal that the waste disposal causes an accumulation of nutrients in the Bay of Thessaloniki (especially in the deeper layer of the upper part), with a decrease of the DO concentrations. In the northwestern part of the Thermaikos Gulf, due to the discharge of fresh water from the rivers, high surface nutrient concentrations were measured mainly during winter and spring.

Key-words: eutrophication, oxygen, river input, Aegean Sea

Introduction

Thermaikos Gulf is a semi- enclosed shallow (maximum depth 42 m) water body located at the northwestern part of the north Aegean Sea. It receives approximately 150.000 m^3/d of urban wastes as well as about 60.000 m^3/d of industrial effluents untreated or partially treated. Moreover fresh waters from three main rivers Axios (20-170 m^3/d depending on the season), Loudias (10-30 m^3/d) and Aliakmon (10-80 m^3/d) are influencing the hydrological regime of the western part of the Gulf (1) Oceanographic studies concerning eutrophication conditions of the Gulf were carried out in the past during the years 1975-76 (2, 3, 4, 5) and 1985-86 (6, 7). Recently Thermaikos was studied during 1992 (8, 9) and 1995-96. The present work deals with the results of the years 1995-96, aiming to access the impact of the above mentioned sources of pollution on the eutrophication conditions of the Gulf.

Materials and methods

Water samples were collected seasonally from standard depths over 19 sampling stations (Figure 1), using 8 L NISKIN bottles attached to a Rosette Multi-Bottle Array System. Determination of DO was carried out on board according to Carritt *et al.* (10). Nutrients were measured according to methods described by Psyllidou *et al.* (11).

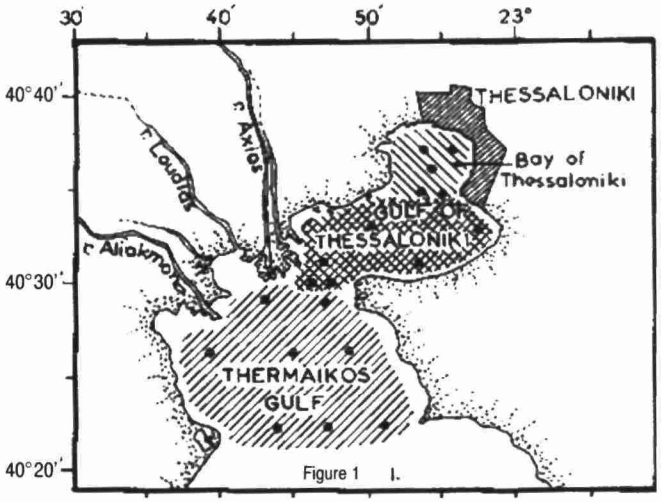

Figure 1

Results and discussion

For better estimation of the results the study area was divided into three water masses (subareas): the Thessaloniki Bay (5 sampling stations), the Thessaloniki Gulf (6 sampling stations) and the Thermaikos Gulf (8 sampling stations)

Dissolved oxygen

During May, high concentrations of DO were measured at the surface layer. The vertical distribution shows decreasing concentrations with increasing depth. Within the bottom layer of the upper part of the Bay the DO concentration reached 0.98 ml/l corresponding to a saturation of 17.16%. These low concentrations were related to high concentrations of nutrients, revealing the impact of the urban wastes on the deep waters of the area. Figure 2 shows the horizontal distribution of DO concentrations at a depth of 20 m (or the maximum depth of stations with depths slightly lower than 20 m) during May 1995.

During August, the vertical distribution of the DO concentrations at the southern part of Thermaikos, shew maximum concentrations at depths between 20 and 40 m, due to better conditions for photosynthesis at these depths, during the summer period. Within the bottom layer of the Bay of Thessaloniki, saturation did not exceed 69.6% (23.15-69.6%).

During winter and early spring (December 1995 and March 1996), due to the vertical mixing of the water masses, the vertical distribution of the DO concentrations was nearly homogeneous and the saturation ranged between 73.7 and 98.9% in December and between 78.7 and 109.3 in March, depending on the station. The discharge of fresh waters at the northwestern part of Thermaikos, near the estuaries, during March, was obvious from the high surface DO concentrations. Figure 3 shows the horizontal surface distribution of DO during March.

Nutrients

In spring (May 1995), nutrient concentrations in the southeastern part of Thermaikos were low and were characteristic of the oligotrophic Aegean Sea waters. In the surface layer (<5 m) of the area near the estuaries of the river Axios, an inflow of fresh waters of higher temperature, lower salinity and high nutrient concentrations was observed (PO_4 0.28, SiO_4 5.97, NH_4 0.68, NO_3 1.64 μg-at/l). This inflow caused a stratification of the upper layer, preventing the vertical mixing of this water with the Aegean waters of the deeper layer. Water masses from the Thermaikos move towards the Gulf of Thessaloniki along the eastern coast, while the water exchange between the Gulf and the Bay of Thessaloniki is not significant. The discharge of urban wastes, mainly from the northeastern coast of the Bay, in combination with the very low water renewal, resulted in an enrichment of nutrients within the deep layer (PO_4 1.27,SiO_4 6.45, NH_4 1.29, NO_3 0.23 μg-at/l). The horizontal distribution of silicates at the surface and of phosphates at the depth of 20 m are shown in Figures 4 and 5.

In summer (August 1995), the influence of fresh water on the concentration of nutrients in the northwestern Thermaikos, was lower than during spring (PO_4 0.14, SiO_4 2.10, NH_4 1.87, NO_3 0.82 μg-at/l), due to the low inflow and the predominant cyclonic surface circulation. The surface water masses from the eastern and central upper Thermaikos, after mixing with the masses of the eastern Thessaloniki Gulf, moved southwest to the Aegean Sea together with the fresh waters of the rivers. The high surface temperatures in the Bay of Thessaloniki, resulted in an intense stratification causing accumulation of nutrients within the deeper layer (PO_4 3.53, SiO_4 19.85, NH_4 13.58, NO_3 0.14 μg-at/l). Figure 7 shows the horizontal distribution of ammonium at a depth of 20 m.

In early winter (December 1995), the vertical distribution showed that the water column was nearly homogeneous in the Bay and the Gulf of Thessaloniki. The vertical mixing of the masses of the Bay resulted in a decrease of the concentration of nutrients (PO_4 0.61, SiO_4 2.36, NH_4 2.31, NO_3 0.89 μg-at/l) in the deeper layer. The water exchange between the masses of the Gulf of Thessaloniki and Thermaikos Gulf was significantly lower as compared to the previous sampling. The increased concentration of nutrients in the northwestern part of Thermaikos, indicated an increase of fresh water discharge (PO_4 0.60, SiO_4 5.42, NH_4 1.72, NO_3 2.55 μg-at/l).

In late winter- early spring (March 1996), the Bay and the Gulf of Thessaloniki were characterized by the lower temperatures and the greater water column homogeneity of the whole sampling period. Nutrient concentrations were low as compared to those measured in December. High surface concentrations near the estuaries of Axios river (PO_4 0.23, SiO_4 25.02, NH_4 1.28, NO_3 13.86 μg-at/l), in combi-