TRANSFER MECHANISMS AND NUTRIENT ENRICHMENT IN THE NORTHWESTERN AEGEAN SEA : THERMAIKOS GULF

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ABSTRACT

Seasonal water property distributions and a combination of Lagrangian and Eulerian current data are used to investigate water circulation patterns, and associated transfer mechanisms of pollutants, in the northwestern Aegean Sea (Thermaikos Gulf). Nutrient concentrations within the various water masses of the study area are presented and comparisons are made with nutrient concentrations in other coastal waters of the Aegean Sea, to assess the extent of eutrophication in Thermaikos Gulf.

INTRODUCTION

Thermaikos Gulf is a shallow water embayment in the northwestern Aegean Sea (Fig.1); it has been contaminated, within the recent years, by a variety of pollutants, such as sewage and industrial effluents. Several oceanographic investigations, designed to assist the optimal construction of sewage outfalls, were carried out here, during the last ten years (1,2,3,4,5).

METHODS

Water temperature and salinity data from selected depths, were obtained using conventional instrumentation. Current measurements were made using self-recording current meters (Aanderaa RCM4), cruciform drogues and plastic driftcards; the applied methodology and the devices used have been described elsewhere (1). Nutrient analyses were made using a Technicon Autoanalyzer. The methods adopted are those described by Friligos (7). The results were computed according to Satsmadjis (11).

RESULTS

Horizontal water movements are dominated by the wind and the flow of freshwater input from the nearby rivers. Water circulation is counterclockwise, with Aegean Sea

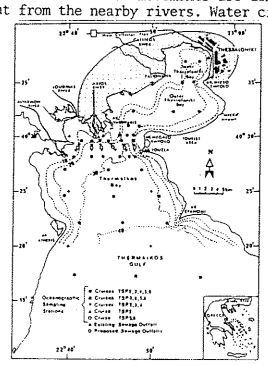

Fig.1

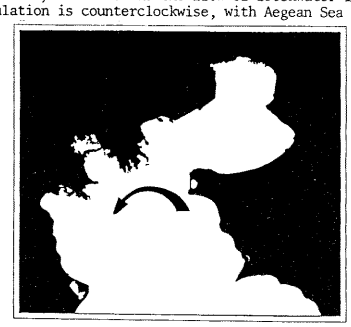

Fig.2

water entering along the eastern coastline; this is mixed with the fresh water discharged by the rivers to form a freshwater mixture, which flows out along the western coast (Fig.2). In winter there is a dominant surface water transport towards the Aegean Sea. In summer frequently appears a surface water flow from the eastern part of Thermaikos Bay towards the innermost region of the embayment. Upper layer currents are generally weak (20 cm s) and in the western part of Thermaikos Bay are dominated by the flow of the river discharge. In the channel between the two embayments upper layer currents are controlled by the wind and the coastline configuration and are quasi-parallel to the coastline. Mid-depth and near bed currents appear to be the

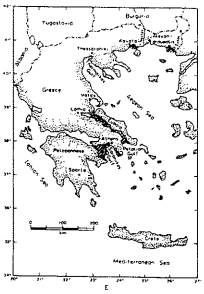

Fig.3

Table 1. Ratio of total nutrient per Area to background nutrients

Area	PO_4-P	SiO_4-Si	NH_4-N	NO_2-N	NO_3-N	N	Reference
Elefsis Bay	5.11	4.15	15.80	3.05	7.00	9.67	Friligos, 1981
Western Saronikos Bay	2.25	2.95	2.50	1.11	6.39	4.00	Friligos, 1983
Inner Saronikos Bay	2.50	1.39	4.10	1.55	2.60	3.97	Friligos, 1982
North Euboikos Gulf	2.87	13.20	1.66	0.49	10.20	5.27	Friligos, 1985c
Kavala Gulf	1.80	1.49	1.00	0.51	1.41	1.10	Friligos, 1985a
Alexandroupolis Gulf	1.32	3.28	1.00	0.65	6.21	3.27	Friligos, 1985a
South Euboikos gulf	1.46	1.41	0.65	0.48	1.17	0.86	Friligos, 1985b
Pagasitikos Gulf	1.02	2.80	2.60	1.25	2.36	2.28	
Thessaloniki Gulf	5.33	3.35	4.58	3.83	3.88	4.14	
Western Thermaikos Bay	2.09	3.81	2.91	2.40	3.80	3.22	
Eastern Thermaikos Bay	1.18	2.21	1.97	1.53	2.20	2.00	

response of the embayment waters to long-term meteorological conditions with cycles of 3 to 10 days.

Comparison of nutrient levels in Thermaikos Gulf and in other coastal waters of the Aegean Sea (Fig.3) is shown in Table 1. In Thessaloniki Bay are observed the highest values of phosphate, as well as increased values of ammonium; the latter are similar to those seen in Inner Saronikos Gulf. The northwestern part of Thermaikos Bay, Thessaloniki Bay and Alexandroupolis Gulf contained three times as much silicate as background, owing to the contribution of rivers. Eastern Thermaikos Bay, Pagassitikos Gulf, and South Euboikos Gulf have only greater concentrations of nutrients than those of the Aegean Sea. North Euboikos Gulf presents a great accumulation of nitrate and silicate, due mostly to the great depths and to underwater springs. All nutrients are present, in all areas, at levels well above background. The quality of the receiving waters, with respect to nutrients, is a function of the different sources of nutrients, as well as the morphology of the area and the circulation of waters.

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MECHANISMS OF PRODUCTION AND FATE ON ORGANIC PHOSPHORUS IN THE NORTHERN ADRIATIC SEA

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ABSTRACT

Organic phosphorus, nutrients, primary production rates (^{14}C), chlorophyll a standing crops, and basic oceanographic parameters were measured in the open waters of the northern Adriatic Sea. Relationships between organic phosphorus and other parameters were studied and some mechanisms of organic phosphorus production and consumption within the water column of the region were described.

RESUME

Le phosphorus organique, les sels nutritifs, la production primaire, la chlorophylle a et les paramètres océanographique ont été mesurés dans les eaux internationales de la Mer Adriatique septentrionalle. L'étude des relations parmi le phosphorus organique et les autres paramètres a mis en évidence les principaux procés par lesquels le phosphorus organique était produite et consommé dans la colonne d'eaux de la region.

INTRODUCTION

The northern Adriatic, which receives the discharge of the Po River (1500 m^3/s), is one of the most productive areas in the Mediterranean, even if the concentration of dissolved orthophosphate is very low. It was observed that the organic phosphorus concentration in the region generally exceeded orthophosphate concentrations. So, in order to establish, initially qualitatively, the role of the organic phosphorus fraction in the biological cycle of the northern Adriatic Sea, the seasonal changes of organic phosphorus were studied in correlation with several parameters which characterize phytoplankton activity, organic matter decomposition and freshwater discharge influence.

MATERIAL AND METHODS

From 1980 to 1984 23 cruises were performed at six stations in the central part of the northern Adriatic Sea. Standard oceanographic parameters, nutrients, chlorophyll a and phaeophytin a were determined aboard the research vessel immediately after sampling, using methods recommended by Strickland and Parsons[1]. The samples for primary production determination were incubated with $NaH^{14}CO_3$ at constant light (70 W/m^2) and surface in situ temperature. Organic phosphorus determinations were carried out in unfiltered water after UV irradiation of the samples by the method of Armstrong and Tibbits[2].

RESULTS AND DISCUSSION

The data were analyzed by means of linear regression and three periods, characterized by different ranges and specific relationships between the organic phosphorus concentration and other parameters, were identified:

(a) The late winter-early spring period, when the relatively large variations of organic phosphorus concentration (0.0-0.6 µmol/l) in the surface layer were significantly correlated with primary production, chlorophyll a and oxygen saturation. These results suggest that organic phosphorus was mainly produced during the phytoplankton bloom. In this period a significant inverse correlation with surface salinity was also found. However, it can be expected that mainly orthophosphate is contributed by freshwater discharges to the open waters, from which organic phosphorus can be biologically produced during primary production, leading in this way to an apparent relationship with salinity.

(b) The summer period, when organic phosphorus concentrations were higher than in the precedent period, but were not related to the low and quite constant values of primary production and chlorophyll a. The correlation with oxygen saturation was not significant. In summer the microzooplankton biomass increased significantly in respect to the winter[3]. This probably caused an increase of the organic phosphorus concentration (up to 1.1 µmol/l), which accumulation was also favored by the reduced water exchange rate between the northern Adriatic and other parts of the Adriatic, typical for spring and summer seasons.

(c) The late summer-early winter period, when the organic phosphorus concentrations was the lowest (0.0-0.3 µmol/l) and did not correlate with the other parameters. Then, orthophosphate accumulation was observed, particularly in the bottom layer (up to 1.2 µmol/l). This decrease was most likely due to remineralization processes and to increased flushing rate in the region. Interestingly, no direct relationship between dissolved oxygen and organic phosphorus was found, while the inverse correlation with orthophosphate was highly significant.

In the bottom layer correlations between organic phosphorus and parameters characterizing phytoplankton activity were not significant in all periods. The main process which controls the concentrations of organic phosphorus in this layer was probably sedimentation of organic detritus from the surface layer. In fact, the seasonal changes of organic phosphorus concentrations were similar in both layers.

LITERATURE

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