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PRELIMINARY OBSERVATIONS ON SEWAGE NUTRIENT ENRICHMENT AND PHYTOPLANKTON ECOLOGY IN THE THERMAIKOS GULF, THESSALONIKI, GREECE

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SELS NUTRITIFS PHYTOPLANCTON THERMAIKOS GRÈCE RÉSUMÉ. - L'abondance et la diversité taxonomique du phytoplancton ont été étudiées en rapport avec la pollution urbaine (à proximité d'un point de décharge) dans le Golfe Thermaikos en Grèce. Des échantillons d'eau de surface ont été pris sur un réseau de stations en septembre 1977. Des échantillons d'eau près d'un point de décharge d'égoûts montraient des teneurs très élevées en phosphore total, phosphate, ammonium et nitrite, ainsi qu'un nombre total de cellules phytoplanctoniques plus élevé et une plus petite diversité taxonomique que les échantillons plus éloignés des égoûts. Une variation considérable des espèces et de la dominance survenait en même temps que le changement du degré de pollution. Les Dinoflagellés dominaient dans les eaux plus propres, loin de la décharge des égoûts. Certaines espèces (Gymnodinium sp., Prorocentrum micans, Peridinium sp., et Ceratium Pulchellum) par leur dominance et leur distribution relative sur le gradient de pollution, se présentent comme indicatrices de pollution. Ces changements correspondent à une dégradation caractéristique d'une communauté complexe qui devient moins mûre en raison de l'apport d'eaux d'égoûts riches en sels nutritifs (eutrophisation) dans la Baie de Thessalonique.

NUTRIENT PHYTOPLANKTON THERMAIKOS GREECE ABSTRACT. — The abundance and taxonomic diversity of phytoplankton has been studied in relation to sewage pollution (proximity to outfalls) in the Thermaikos Gulf, Greece. Surface water samples were collected from a grid of stations in September 1977. Water samples from the vicinity of sewer outfalls showed very high concentrations of total phosphorus, PO_4^{-3} , NH_4^+ , and NO_2^- , a greater total concentration of phytoplankton, and a lower taxonomic diversity than samples remote from outfalls. A considerable variation in the occurrence of species and dominance occurred along the pollution gradient. Dinoflagellates were dominant in pollution waters, while diatoms dominated in cleaner water away from sewage outflow. From the dominance and relative distribution of the species along the pollution gradient certain species (Gymnodinium sp., Prorocentrum micans, Peridinium sp., and Ceratium pulchellum) emerge as indicator species of pollution. These changes correspond to a typical degradation of a complex community to a less mature state by the inflow of nutrient-rich sewage (eutrophication) in the Thessaloniki Bay.

drop of 1 % figCl, have been added for preservation and kept under deep freezes The filtered samples were processed on a Technicon CSM. Autoanalyset following the memod of Hager et al. (1968) and Slawys and Macksese (1972) Chlorophyll a filtered

INTRODUCTION

It is most often the availability of nutrient such as nitrogen and phosphorus that controls the rate of organic production by marine phytoplankton (Thomas, 1966; Dugdale, 1967; Ignatiades, 1969; Ryther and Dunstan, 1971). In the Eastern Mediterranean Sea, the low influx of nutrients from land drainage and the characteristic circulation pattern normally result in a small phytoplankton crop and low rate of primary production (Becacos-Kontos, 1968). However continued increases in the influx of phytoplankton nutrients into coastal environments especially in enclosed seas such as the Mediterranean, can have harmful effects on marine communities. An increase in nutrients is often accompanied by an increase in phytoplankton standing-crop and a decrease in stability and taxonomic diversity, since species with the highest intrinsic rates of natural increase become dominant (Margalef, 1963, 1967). Species diversity indices, when correlated with physical and chemical parameters, provides one of the best ways to detect and evaluate the impact of pollution on aquatic communities (Williams, 1964; Margalef, 1967; Ignatiades, 1981).

As there was not any available literature on phytoplankton ecology and sewage nutrient enrichment in the Thermaikos Gulf, we studied the effects of untreated coastal sewage outfalls in this Gulf, on the relative abundance, species composition and taxonomic diversity of the marine phytoplankton community.

MATERIALS AND METHODS

The Bay of Thessaloniki is in the northern part of the Thermaikos Gulf. This Bay is a shallow semienclosed coastal basin heavily polluted by domestic and $(120\ 000-140\ 000\ m^3/24\ h),$ industrial waste of the Major Thessaloniki area (Fig. 1). The annual mean discharge of the largest rivers Axios and Aliakmon is of the order of 200 m³/sec. Water samples for the determination of the physico-chemical parameters and phytoplankton were obtained from the surface and sometimes at 20 m for phytoplankton with a Nansen water bottle of capacity 1.5 l/C.O.D. was measured by the SCAN-W (1966) method. The salinity samples were collected in 300 ml glass bottles and measured in the laboratory with an Autolab Mk III 601 inductive salinometer of precision ± 0.003 %. The water samples for nutrient analyses were collected in 100 ml plastic bottles to which one drop of 1 % HgCl₂ have been added for preservation and kept under deep freeze. The filtered samples were processed on a Technicon CSM₆ Autoanalyser following the method of Hager et al., (1968) and Slawyk and MacIsaac (1972). Chlorophyll-a, filtered

through Whatman GF/C filter, was measured by fluorescence after Holm-Hansen *et al.*, (1965). The phytoplankton species diversity D was estimated by the application of Margalef's (1967) formula :

$$D = \frac{1}{N} \cdot \log \frac{N!}{N_a! N_b! \dots N_s!}$$

where Na, Nb,...Ns are numbers of individuals and N is the total number of individuals.



Fig. 1. - Location of the stations.

RESULTS

Physical and Chemical environment

The temperature ranged from 22.9-23.8 °C, while the salinity ranged from 35.4-36.4 ‰ with the lowest values in river estuaries (Table IA). The nutrient concentrations were ranged : $PO_4-P=0.11.0.33$ µg-at/1, total phosphorus = 0.18-1.23 µg-at/1, NH₃-N=0.40-5.00 µg-at/1, NO₃-N=0.06-0.31 µg/1, NO₃-N=0.40-2.92 µg-at/1 and SiO₄-Si= 1.29-3.27 µg-at/1. The distribution of nutrients was not very clear; however total phosphorus, ammonia and silicate decreased with increasing distance from the sewer outfalls.

NUTRIENT AND PHYTOPLANKTON IN THERMAIKOS GULF

	STATIONS		A	C	Q	F	E	I ₁	H	G	G ₃	H ₃	J ₁	J ₄	N	S
	Parameters	in to the second second	111	and the	Calor-			110114	12 (11)	10 (13	PETRIC	a 75. J.	0WOL	01025-1	167323	1014
	T,	°C	23.0	23.2	23.1	22.9	23.0	23.0	22.9	23.8	23.4	23.1	23.0	23.1	23.1	23.0
2	S,	0/00	36.0	36.0	36.2	35.8	35.7	35.8	35.6	35.8	35.6	35.4	36.4	36.2	35.7	36.1
	NH ₄ -N,	µg-at/l	1.19	1.27	1.27	1.03	2.14	0.64	0.71	0.64	0.71	1.03	5.00	1.59	0.40	2 - 18
	NO ₂ -N,	µg-at/l	0.17	0.31	0.15	0.12	0.10	0.07	0.07	0.06	0.13	0.17	0.09	0.24	0.07	22
	NO ₃ -N,	µg-at/l	2.29	1.42	1.56	1.14	2.29	0.57	0.40	0.97	0.64	2.40	2.92	1.34	0.28	<u>191</u> 288
	SiO ₄ -Si,	µg-at/l	3.27	2.91	2.19	1.74	2.01	1.47	1.29	3.27	4.35	2.70	1.59	1.96	1.71	05-36
	PO ₄ -P,	µg-at/l	0.24	0.17	0.20	0.13	0.17	0.33	0.11	0.13	0.13	0.13	0.31	0.24	0.13	11011
	T.P,	µg-at/l	0.65	0.68	0.63	0.25	0.27	0.40	0.18	0.21	1.23	0.18	0.32	0.30	0.18	10 <u>1</u> 00
	COD,	mg/l	0.80	0.32	1.44	1.28	0.80	-	0.48	1.44	0.64	0.48	1.92	1.28	0.13	-
	Chla,	mg/m ³	2.60	li-ja	2.40	0.68	0.63	0.70	0.35	0.65	0.80	0.19	0.33	0.16	0.31	0.10
	Abundance,	cells/l x 10 ³	112	64	27	81	27	41	58	72	66.0	27	50	16	69	7
	Diversity,	bits/individu	3.2	3.4	3.5	3.5	3.3	3.7	3.6	3.9	3.9	3.7	3.9	3.4	3.6	3.4
3	Species	sinti nowae	on no	1 551	avib	SILIS		based	xsbn	-9121	with a	dr. ().	guen	eno)	.8194	0.09
	Diatoms		strib	p entr	0.18-9	0 a a a		01050	0.11	1. 24	ubra	111	0 80	ouen	aib	
	Chaetoceros	affinis	ing m	N.D.F.B	Hom	nioq		minst	and le	3113 30	148	11/1	II CIK	11013	Ande	18
	Chaetoceros	danicus	R 111 769	3 on E	.0.041	11100	7	a fore	ANT N	asqu	25	gn, t	d and	ROD	miqu	pung.
	Leptocylindra	us danicus	50) co1	agelis	lond	29		1000	not (15193	3 5 m	0003	19	32	10.526	as br
	Nitzschia clo	sterium	19494	110000	11	5030 ·		ndi m	OelA	1AL	ald a b	8.80	iste a	DOD N	ali o	berg
	Rhizosolenia	styliformis	5:62.3	eomi2	141615	(Inch		17	22	13	21572	17	shille	20	22	26
	Schroederia	delicatula	16	19	29	48	43	43	42	33	26	26	33	15-189. N	35	BEING.
1	Dinoflagellate	s	-lene	1117 140	2 21/2											
	Exuviaella co	ompressa	21		General	Dim								and all		
	Prorocentrum	micans	24	25		- Torray		- Soft	110005	COLUE-			director.	1		-

Tabl. I. -A, Physico-chemical parameters, abundance and diversity of the phytoplankton in the sampling stations; B, cell percentage of the most abundance phytoplankton species in surface samples at the sampling stations.

Abundance, Diversity and Dominance

What are the effects of the sewage nutrient-enrichment described above on phytoplankton abundance, taxonomic diversity and dominance? A dense phytoplankton population was recorded in the water near the sewer outfalls (Table IA) where the density reached 112 cells. ml^{-1} . In contrast, the density was much lower at station S away from the outfalls (7 cells. ml^{-1}). The distribution of chlorophyll-a (Table IA) showed higher values at the point of discharge of the effluents, smaller at small distance and much smaller even further. The distribution of COD was not clear (Table IA).

Taxonomic diversity decreased with decreasing distance from the sewer outfalls (Table IA). The diversity was minimum at stations A(3.2) (Fig. 1). At stations A to N, taxonomic diversity generally increased with decreasing nutrient concentrations. In general diversity was inversely related to abundance. No correlation was found between the chemical parameters and the phytoplankton abundance and diversity, except in the case of total phosphorus and diversity (r-0.45). The greatest degree of dominance (the ratio of the concentration of the two most abundance species to the total cell concentration in

a sample) occurred near the sewer outfalls and decreased as the distance from the sewer increased. Thus stations A and C had the highest dominance values concerning Dinoflagellates (Table IB). Of the four major phytoplankton groups identified, Dinoflagellates dominated polluted waters and their abundance decreased with increasing distance from the sewer. On the other hand, Diatoms were dominant in relatively clean waters (Fig. 2).

DISCUSSION

The annual range of air temperature is 7-27 °C, the lowest, 7 °C, during February and the highest 27 °C, in August. Surface sea water temperature in the Gulf fluctuated between 10 and 23 °C and surface salinity between 34 and 38 $\%_{00}$, with the lowest salinity at the surface in the river estuaries (Friligos, 1977). Tides in this region are not very remarkable and normally the currents are influenced by winds prevailing in the Gulf. Ganoulis *et al.*, (1980) and Balopoulos (1982) reported the prediction of the water movement in Thessaloniki Bay using mathematical models. The nutrients values shown in Table IA do not differ significantly from those found in the same area during August 1975 (Friligos and Satsmadjis, 1977).

Phytoplankton abundance was maximum at the sewer outfalls and lowest at relatively clean stations (Table IA). At the unpolluted reference stations (S), the abundance (7 cells. ml^{-1}) was slighly higher than that of a station in the lower Saronikos Bay (0.1 cells. ml^{-1} ; Ignatiades, 1969). However the maximum abundance (112 cells. ml^{-1}) at station A was lower than that of a station near the sewage outfall in the upper Saronikos Gulf (1 000 cells. ml^{-1} ; Ignatiades, 1981).

Increased nutrient concentrations, brought to the sea by sewage, increase the average level of phytoplankton abundance, and result in a population dominated by a few species. A few "opportunistic" fastgrowing species increase at a much faster rate than others. Consequently the diversity index based on the distribution of individuals, into species decreases. At stations near the sewer the abundance of phytoplankton was high, the number of taxa low, and consequently the taxonomic diversity low compared to the other stations (Table IA). Also in the same study of zooplankton, it was observed that the biomass decreased and the diversity increased gradually from the north to the south (Paradimitriou,



Fig. 2. — The degree of dominance of the two most important groups in surface (1) and water column (2) samples.

1979). Moreover, it was observed from measurements of nutrients and zooplankton in the Thermaikos Gulf during August 1975, that the nutrients decreased from north to south (Friligos and Satsmatjis, 1977), while the distribution of zooplankton had not a clear patter (Yannopoulos, 1979).

Phytoplankton abundance and taxonomic diversity depend upon the supply of nutrients in natural waters. This in Table IA shows that the abundance increases and diversity falls as the nutrient concentrations go-up. Total phosphorus seems to play the most important role in controlling taxonomic diversity.

The occurrence and dominance of species changed along a pollution gradient (Table IB). Compared to reference station S, the greatest degree of dominance in Dinoflagellate species composition occurred at the sewer outfalls and decreased with increasing distance from the sewer. This relative dominance and the distribution of taxa (Fig. 2) along the pollution gradient points to "indicator species" of pollution. The best indicator of sewage pollution are the Dinoflagellates (mainly *Gymnodinium* sp., *Prorocentrum micans, Peridinium* ssp., and *Ceratium pulchellum*). Almost the same species are also recorded along the central coast of Lebanon (Taslakian and Hardy, 1976).

Thus, the natural coastal phytoplankton community appears disturbed by the increased level of nutrients from untreated sewage effluents. Increased total phosphorus and probably some trace metals increase abundance, decrease diversity and radically change the species composition within an extensive coastal area in the Thessaloniki Gulf.

REFERENCES

- BALOPOULOS E., 1982. Circulation and mixing in the water masses of the N.W. Aegean sea. (Noting effects of waste disposal in Thermaikos Gulf). Ph.D. Thesis. University of Wales, U.K. 825 p.
- BECACOS-KONTOS T., 1968. The annual cycle of primary production in the Saronikos Gulf (Aegean Sea) for the period November 1963-October 1964. *Limnol. Oceanogr.*, 13 (3) : 485-489.
- DUGDALE R.G., 1967. Nutrient limitation in the sea: dynamic, identification and significance. *Limnol. Ocea*nogr., 12: 685-695.
- FRILIGOS N., 1977. Seasonal variation of nutrient salts (N, P, Si), dissolved oxygen and chlorophyll-a, in Thermaikos Gulf (1975-76). *Thalassia Yugosl.*, 13 (3/4): 327-342.
- FRILIGOS N. and J. SATSMATJIS, 1977. Nutrient distribution in the Thermaikos Gulf (August, 1975). *Thalassia Yugosl.*, 13 (1/3): 45-51.
- GANOULIS J. and C. KOUTITAS, 1980. Utilisation de données hydrographiques et de modèles mathématiques pour l'étude hydrodynamique du Golfe de Thessaloniki (Grèce). Journ. Etud. Pollut. 5 : 937-944.

- HAGER S.W., L.I. GORDON and P.K. PARK 1968. A practical manual for use of Technikon Autoanalyzer in seawater nutrient analysis. A final report to B.C.F. Contract 14-17-0001-1759. Ref. 68-33. (Unpubl. manuscr.)
- HOLM-HANSEN O., C.J. LORENZEN, R.N. HOLMES and J.D.H. STRICKLAND, 1965. Fluorometric determination of chlorophyll. Cons. Perm. Int. Explor. Mer. 30: 3-15.
- IGNATIADES L. 1969. Annual cycle, species diversity and succession of phytoplankton in lower Saronikos Bay, Aegean Sea. *Mar. Biol.*, **3** (3) : 196-200.
- IGNATIADES L., 1981. On the horizontal distribution of phytoplankton in relation to sewage-derived nutrients. *Rapp. Comm. Int. Mer Medit.*, 27 (7) : 91-93.
- MARGALEF R., 1963. On certain unifying principles in ecology. Am. Nat., 97: 357-374.
- MARGALEF R., 1967. Some concepts relative to the organization of plankton. Oceanogr. Mar. Biol. A. Rev., 5: 257-289.
- PAPADIMITRIOU D., 1979. Zooplankton distribution in Thermaikos Gulf. *Biol. Gallo-Hellen.*, **8**: 37-40 (in Greek).

- RYTHER J.H. and W.M. DUNSTAN, 1971. Nitrogen, phosphorus and eutrophication in the coastal marine environment. *Science* N.Y., 171 : 1008-1013.
- SCAN W., 1966. Determination of permanganate oxygen demand. Scand. Pulp. Pap. and Board Test. Comm., 1: 66.
- SLAWYK G. and J.J. MACISAAC, 1972. Comparison of two automated ammonium methods in a region of coastal upwelling. *Deep Sea Res.*, **19**: 521-524.
- TASLAKIAN M.J. and J.T. HARDY, 1976. Sewage nutrient enrichment and phytoplankton ecology along the central coast of Lebanon. *Mar. Biol.*, **38**: 315-325.
- THOMAS W., 1976. Surface nitrogenous nutrients and phytoplankton in the northeastern tropical Pacific Ocean. *Limnol. Oceanogr.*, 11: 393-400.
- YANNOPOULOS K., 1979. The biologic situation (zooplankton, chlorophyll-a) in Thermaikos Gulf with special emphasis to secondary production. *Prakt. Hellen. Soc. Biol. Sci.*, 1: 11-21 (in Greek).
- WILLIAMS H., 1964. Possible relation between plankton and diatom species and water quality estimates. *Ecol.*, 45: 809-823.