CHAPTER 194

STUDY ON THE VARIATIONS OF AN EUTROPHIC ECOSYSTEM FROM THE SPANISH MEDITERRANEAN LITTORAL: DATA TO HAVE IN MIN IN THE NUTRIENT DUMPING TO THE SEA.

by

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ABSTRACT:

Cullera Bay is a neritic ecosystem placed on the Spanish Mediterranean Littoral largely influencied by the Jucar River, that brings about lower salinities than sourrounding waters, and broad variations of its values. An extensive research, with 9 samplings throughout the year, was carried out, measuring both physical and chemical parameters, and the planktonic communities. The trophic status of the ecosystem, the spatial and temporal variations of the nutrients and the planktonic communities were studied, evaluating the influence of the river loads and the littoral dynamics. Some essential basis to allow a suitable emplacement of waste waters disposals along the Valencian littoral are set up in order to minimize the gradual eutrophication of this coast.

INTRODUCTION:

According to the classic literature (until fifties), the incidence of human wastes on the trophic status of the littoral communityes was almost negli-

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geable. It was thus likely because of the lack os a systematic study of the waters from the continental shelf and the peculiar conditions of the ecosystems where these surveys were carried out. Nevertheless, after current studies, coastal ecosystems have appeared as much more complex and diverse than offshore ones.

Numerous processes of eutrophication caused by domestic waste waters have been monitored, and both politicals and scientists have found a lot of objections to standarize their study, monitoring and management, because of their broad variations according to local parameters -coastal shape, littoral dynamics, bulk and kind of loads, etc.

Thus, it is very important to keep in mind the particular characteristics of these areas where waste waters are dumped to the sea, and to conduct specific mionitoring programmes to minimize their ecological consecuences. In other wise, the uncontrolled spills may cause unpredictible and damaging consecuences to the ecosystem. Regrettable examples are well known: the recent "red tides" generated by blooms of toxic phytoplankton species (Baltic Sea, Adriatic Sea, Galician Esuaries, etc.), the gradual degradation of benthic communities, the sanitary problems of beaches, etc.

In an extensive study carried out in Cullera Bay (eastern Spain), the combined effects on the neritic ecosystems caused both by the unpurified disposals of waste waters and the particular hydrodynamics conditions into the bay were evaluated throughout a year.

SAMPLING AREA:

Cullera Bay is placed on the Spanish Mediterranean Littoral (0 13'-0 15', W; 39 8'- 39 12', N), on the middle of the so called Valencian Oval (Figs.: 1A and 1B). A particular environmental problem is raised in this bay because of:

- The Jucar River's presence, which outflows at the southern beaches of the bay.

- The development of the tourism in this area, reaching more than 250.000 inhabitants in summer. The domestic wate waters are directely dumped into the bay through an insufficient marine outfall.

- The importance of the agriculture, involvong a great amount of waste waters with high levels of nutrients, detritus, pesticides, etc.

The particular hydrodynamics within the bay, largely conditioned by some docks built in the mouth of the river and along the northern beaches. This allows the formation of a semi-enclosed area at the norht, where the most serious environmental problems are noticed.

18 sampling stations were spread over the bay: 9 along the beaches and 9 within the bay (Fig.: 1C). 9 samplings were done throughout a year, from April-1983 to March-1984.

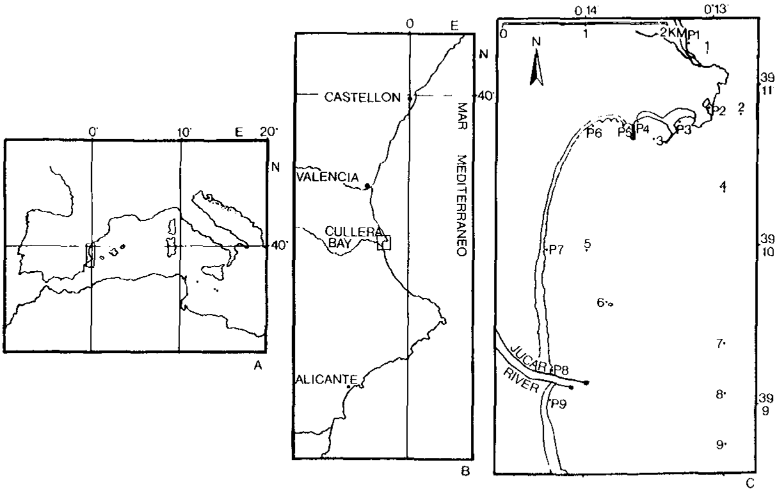

Fig.: 1.- Geographical location of Cullera Bay and sampling stations. A: Western Mediterranean Basin; B: Valencian Littoral (Valencian Oval); C: Cullera Bay with sampling stations (P=Beaches).

MATERIAL AND METHODS:

The parameters measured in ecah sample were:

.- Quantitative and qualitative evaluation of phytoplankton communities.

.- Sea temperature.

.- Salinity.

.- Winds and waves.

.- Nutrients: NO2, NO3, NH4, PSR and SiO4.

Samplings were done with a Van Dorn bottles of 2x4 l, at 0 m depth at beach stations, and at 0 and 5 m depth at bay stations. Phytoplankton samples were fixed with lugol and studied at the laboratory according to Uthermöhl techniques. Salinity was also determined at the laboratory with a salinometer by induction GRUNDY ENVIRONMENTAL SYSTEMS, Inc., 6230 N (The International Oceanographic Tables Vol. I, UNESCO). Because of the broad temporal ans spatial variations of surface salinities, the average values of the salinity at the stations placed at 5 m depth have beenused in the present study, because they show more accurately the mean salinity values.

Nutrients were determined following basicaly the Strickland and Parsons' (1965) and Grashoff's (1975) methods, with some modifications by Solorzano (1969), Mullin and Riley (1955) and Murphy and Riley (1962).

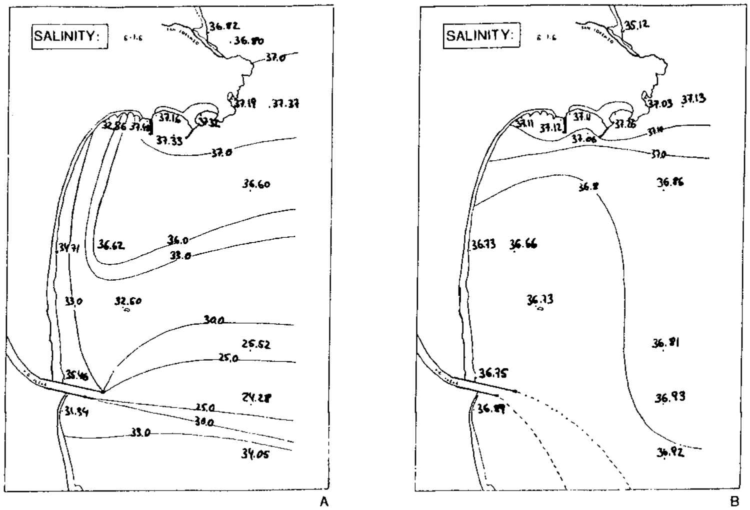

Fig.: 2.- Variations in surface salinities caused by changes in wind direction. A: North winds; B: South winds (G. del Río, 1987).

RESULTS:

The influence of the river gives rise to lower salinities than sourrounding waters, with remarkable spatial and temporal variations. It is possible to differenciate between the variations caused by momentary changes of water direction and those originated by changes of average values in the water body. In the former, the local winds are the determinant factor, being less important the waves and the river flow.

These variations involve esentialy to the upper layer, showing a bigger influence of freshwaters when the south wind prevails, and of offshore waters when it is the north or east wind the prevailing one (Figs.: 2A and 2B).

		S g/Kg	P.S.R. µatg/l	NH_4^+ µatg/l	NO_2^- µatg/l	NO_3^- µatg/l	SiO_4^{-3} µatg/l	N.I.D. µatg/l
10-5-83	X̄	37,90	0,36		0,07	11,3	0,7	
	C.V.	0,2	41,7		42,9	61,9	57,1	
4-7-83	X̄	37,25	0,10	0,12	0,06	7,7	3,2	7,81
	C.V.	0,2	20,0	50,0	66,7	24,7	40,6	24,7
19-7-83	X̄	37,43	0,03	1,26	0,08	1,9	2,1	3,18
	C.V.	0,2	66,7	70,6	12,5	52,6	23,8	38,4
25-8-83	X̄	37,43	0,33	1,02	0,05	4,7	1,0	5,77
	C.V.	0,2	21,2	73,5	40,0	34,0	20,0	37,3
10-10-83	X̄	37,61	0,30	15,97	0,34	7,8	5,6	25,75
	C.V.	0,6	16,7	96,3	20,6	73,3	41,1	72,3
29-11-83	X̄	37,54	0,38	2,13	0,53	6,2	4,7	8,31
	C.V.	0,1	10,5	16,4	7,6	32,3	10,6	25,5
17-1-84	X̄	38,03	0,23	1,67	0,12	3,4	0,7	5,07
	C.V.	0,1	26,1	20,4	16,7	88,2	28,6	63,7
31-1-84	X̄							
	C.V.							
21-2-84	X̄	38,09	0,14	1 42	0,37	14,9	3,2	16,32
	C.V.	0,3	35,7	20,8	59,5	59,7	75,0	56,5
28-3-84	X̄	37,88	0,18	1,90	0,45	15,5		17,47
	C.V.	0,8	44,4	57,9	64,4	34,2		34,0

Table: 1.- Mean valalues (X) and coefficient of variation (C.V.) of salinity and nutrients at 5 m depth (P.S.R. = Soluble Reactive Phosphorus; N.I.D. = Dissolved Inorganic Nitrogen) (G. del Río, 1987).

Several factors are involved in the mean salinity of the bay, being the most importants:

- The river discharge.

- The evaporation.

- The littoral dynamics.

Atending to the first and second ones, and assuming a maximum evaporation in summer and a rainfall pattern with summer and winter as dry seasons and rains in spring and, mainly, in autumm, the highest salinity records should be expected in summer and the lowest ones in autumm. Nevertheless, our data do not agree with that pattern (Table: 1), showing that it is the littoral dynamics which is the essential factor to explain this kind of variation.

		FITOPLANCTON nº cél./l.x10^6	CIANOFICEAS nº cél./l.x10^6	COCOLITOFORIDOS nº cél./l.x10^6	DIATOMEAS nº cél./l.x10^6	DINOFLAGELADOS nº cél./l.x10^6	EUGLENALES nº cél./l.x10^5	FLAGELADOS nº cél./l.x10^6
10-5-83	$\bar{X}$	0,80	--	--	0,58	0,06	--	0,15
	C.V.	57,5	--	--	69,0	70,9	--	100,0
4-7-83	$\bar{X}$	0,61	0,16	--	0,22	0,05	0,02	0,16
	C.V.	54,1	106,3	--	18,2	9,3	150,0	243,8
19-7-83	$\bar{X}$	0,79	--	--	0,59	0,20	--	0,15
	C.V.	63,3	--	--	62,7	60,0	--	253,3
25-8-83	$\bar{X}$	2,55	0,03	--	2.38	0,06		0,09
	C.V.	30,6	133,3	--	32,8	50,0	--	77,8
10-10-83	$\bar{X}$	3,76	5,44	--	2,74	0,28	--	0,25
	C.V.	51,1	51,5	--	66,8	46,4	--	84,0
29-11-83	$\bar{X}$							
	C.V.							
17-1-84	$\bar{X}$	3,55	0,12	--	2,15	0,08	--	1,17
	C.V.	36,3	58,3	--	61,9	50,0	--	29,1
31-1-84	$\bar{X}$							
	C.V.							
21-2-84	$\bar{X}$	1,97	--	--	0,72	0,28	--	0,89
	C.V.	39,6	--	--	41,7	28,6	--	39,3
28-3-84	$\bar{X}$				0,95			
	C.V.				41,1			

Table: 2.- Mean values (X) and coefficient of variation (C.V.) of phytoplankton community at 5 m depth (G. del Río, 1987).

The salinity of the bay results from the mixing of waters with different salt concentration. Firstly, the inshore waters from the bay, seccondly the continental freshwaters from the river, and finally the more salted offshore waters. The ratio of each one of them is largely depending on the littoral dynamics.

Two levels in water mixing have to be distinguished between the effects caused by the waves. On the first hand, a low intensity level, which do not generate a quantitatively significant mixing in the water column within the bay. On the other hand, a level of higher intensity, when the autumm and winter storms produce the mixing not only of the water coumn, but also the dilution of the bay water in the large bulk of open sea waters removed by these storms; thus, an increase in the salinity is observed, reaching its maximum values in this period. The clear deviation from the average value of the sample taken on 29th November was on account of the intense storm and flood suffered some days before of sampling.

The waters taking part in the mixing have distinct salinities at the same time as very distinct trophic status. Those from the Jucar river are very eutrophiced, those from the bay have an intermediate eutrophication levels, and those coming from open sea are clearly less eutrophic and cleaner. According to the ratio of each one of them in the mixing a neat accumulation or a loss of nutrients will be produced, respectively.

Thus, it is possible to suppose that an accumulation of nutrients is taken place during summer and a loss in winter (Table: 1). This can be observed by comparing the samples on 10th October (before the storms) and on 17th January (at the heigh of winter); not only a higher phytoplankton standing stock (Table: 2), but also higher mean values of the nutrient concentrations (G. del Río, 1987). This winter loss is favoured by the bulk of offshore waters displaced by these storms to the bay, which release and redilute the benthic nutrients from the sediments.

Several dense phytoplankton blooms have been observed in Cullera throughout the year. This is a characteristic feature of eutrophic coastal ecosystems, where the shallowness of the waters allows the release of benthic nutrients in the water column with a low intensity mixing of waters, because no strong termocline is formed. Only in calm waters like in the sampling of July, the flow of nutrients from sediment to water column ceases, and the ecological succession beguins in

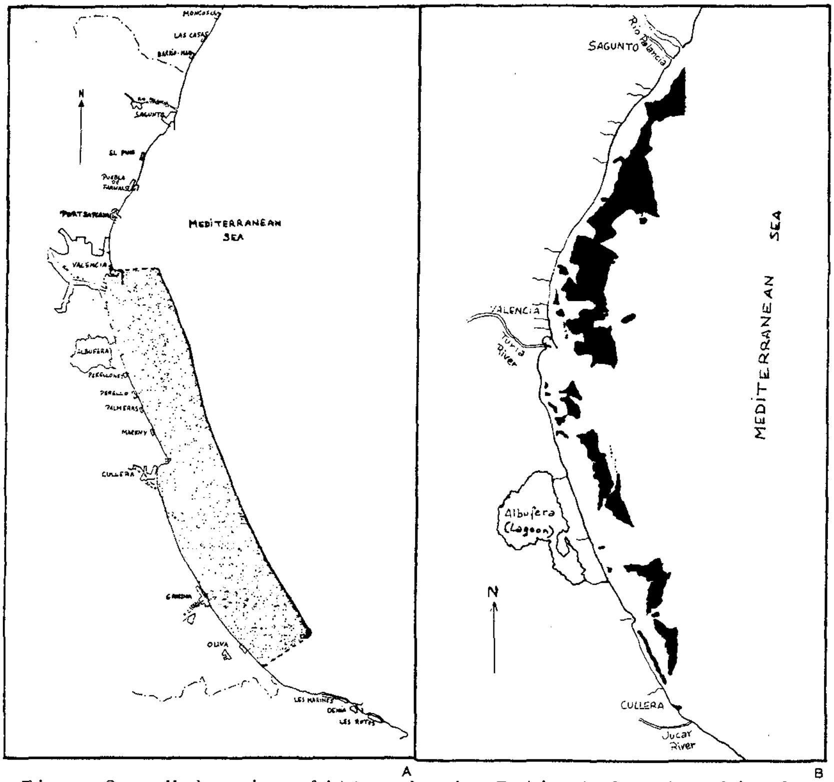

Fig.: 3.- Valencian littoral. A: Estimated eutrophiced area (dotted zone), where the Posidonia oceanica has almost disappeared and the plankton based ecosystem is the dominant one; B: Posidonia oceanica sea grases over forty years ago spread over the Valencian coast (black zone).

plankton populations (G. del Río, 1987). Furthermore, the differences between the phytoplankton communities of the northern beaches are sharper in this period. similar fenomenons have been noticed in Kiel Bight (Smetacek, 1985), Rumanian coasts (Minhea and Cuingioglu), Narragansett Bay (Smayda, 1983), the estuaries of St. Lawrence (Sinclair, 1978) and Puget Sound (Winter, 1975), Anka Bay (Iverson et al., 1979) among others.

This kind of neritic ecosystems with highly eutrophiced waters is not restricted to this place of the Valencian Oval. In a survey carried out that winter (1983-1984) between Valencia Harbour and Cullera Bay, very similar qualitatively and quantitatively phytoplankton communities appeared. But the area with a high eutrophic level is clearly delimited by the dramatic regression of the Posidonia oceanica sea grass. It comprises the coast between Valencia Harbour and the southern limit of the province (Fig.: 3A), where a very intense and fast industrialization and an increase of the resident and non-resident population have happened, and where vast sea grasses of this marine phanerogam spread over the coastal mobile bottoms of this section of littral have disappeared in a few years (Fig.: 3B). Because of that, and an intense overfishing by trawling, an oligotrophic benthic based ecosystem has been transformed into an eutrophic and plankton based one, with limited diversity and very low economic profitability, and a drastic decrease in the number of benthic and demersal species.

This new and unbalanced situation maakes possible the unpredictable and uncontrolable proliferation of opportunistic species, like the massive blooms of the benthic Rodophyta Ceramium fastigiatum during several years along the Valencian Oval, accumulating large amounts of this red algae on the beaches, mainly in summer, owing to local hydrodynamic features (Cullera Bay, Puebla de Farnals, etc.), and causing sanitary and aesthetic problems in these tourist beaches. But in the same way as a non-toxic algae has proliferated, other toxic phytoplankton species can do it too, causing environmental problems as the "red tides".

The high richness of waters and, indirectly, the increase of water turbidity (phytoplankton blooms, suspended particles, detritus, etc.) seems to be the main reason for the regression of the sea grasses and the proliferation of the red algae in this littoral.

CONCLUSIONS:

Marine outfalls obviously can not be considered the definitive solution to the problem of the disposal iof waste waters into the sea but, in any case, they must be contemplated as a suitable choice to mitigate the uncontrolable and impredictable impact caused by the loads in the same shoreline. Nevertheless, not only sanitary aspects must be taken into account in the project and management of sea dumplings, but also the eutrophic conditions of the ecosystem and the problems in regard to them. It seems hence suitable to consider as conclusions of the present work four suggestions in order to keep the Valencian coasts as clean and as healthy as possible.

1.- To preserve the *Posidonia oceanica* sea grasses of the northern part of the littoral, placing the disposal points as far away as possible from them.

2.- To asses the real spreading of the affected area by the eutrophication, and to evaluate the loss of benthic and demersal communities in regard to the volume and pollutant charge of the disposasls, specially on *P. oceanica*.

3.- To favour the correct dilution of the nutrients in the open sea along the coast, removing them from the shoreline.

4.- To keep in mind that some coastal constructions (harbours, docks, etc.) are both sand traps and nutrient-organic matter too, because of the special hydrodynamic conditions generated around and inside of them, favouring hence mass blooms of opportunistic species, some of them of damaging effects for the ecosystem, like the "red tides".

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