DISSOLVED/DISPERSED PETROLEUM HYDROCARBONS SUSPENDED SEDIMENT, PLASTIC PELAGIC TAR AND OTHER LITTER IN THE NORTH-EASTERN MEDITERRANEAN

by

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Abstract

During the scientific cruise of R/V BILIM in April 1983 visual observations and sampling of litter and the sea surface covering about 50,000 km^2 were carried out. Plastic material, tar, vegetable matter and various artificial materials comprised the litter observed and sampled. The origin of the tar balls collected is not known. Among the plastic material especially, some of the plastic bags used for commercial purposes had the name and address of the companies using them. Some of these addresses belong to companies in Israel, Lebanon, Syria and even Libya. Most probably these materials were disposed of in the above mentioned countries and carried with surface currents to the areas observed. Besides litter the surface waters of the area studied were also analysed for suspended sediment content.

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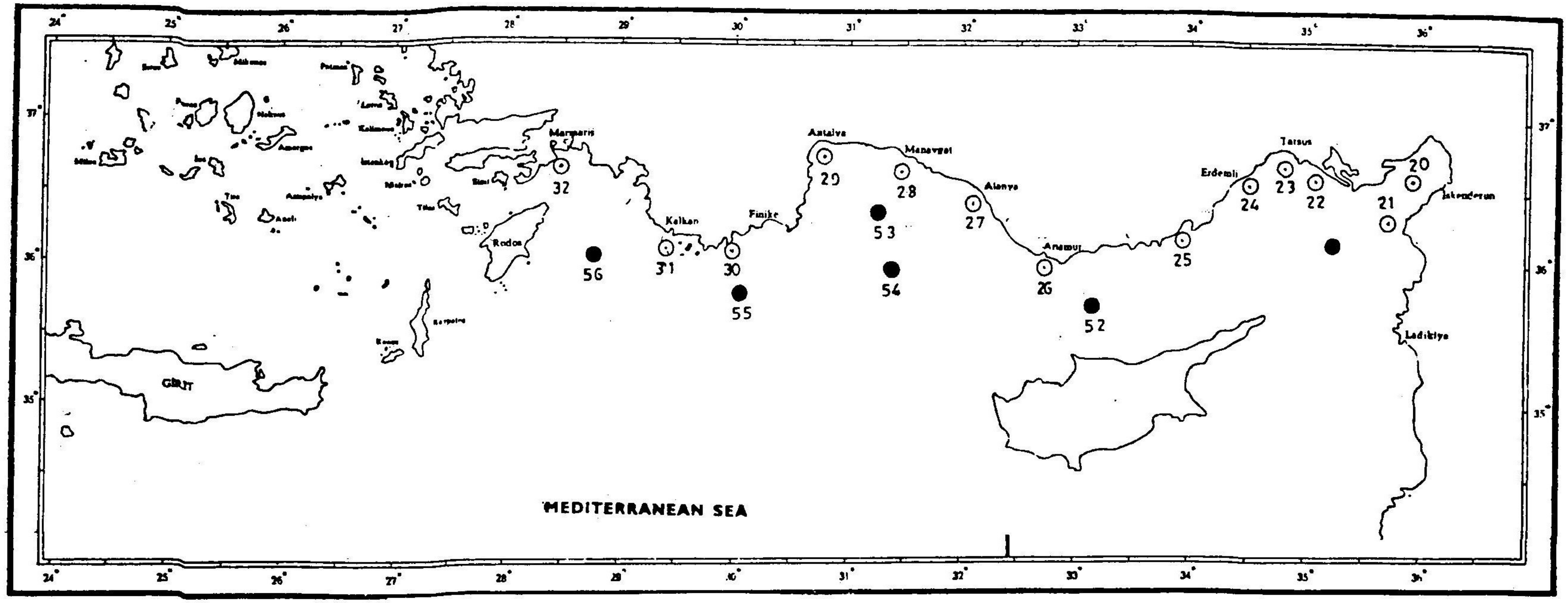
Introduction

During the scientific cruise of R/V BILIM in April 1983 in the North Levantine Basin an area of about 50,000 km^2 was scanned for particulate pollutants in particular plastics, petroleum residues (oil slicks and tar balls) and suspended sediments. These parameters are often useful indicators of man's input into the marine environment. Plastic materials are a definite indicator of man's pollution of the environment. Some of the plastics have a specific gravity less than sea-water, e.g. polyethylene 0.91-0.96, polystyrene 0.8, so they float on the sea surface and accumulate on sea-shores.

Tar balls have a high resistance to biodegradation and this results in their ubiquitous and persistent distribution in regions where there are human activities. Both pelagic and beach tar can be the result of natural seepage and/or of human activities in the production, transportation and usage of petroleum. In the Mediterranean the oil slicks and tar balls are mostly due to human activities.



⊙ Coastal stations
● Off shore stations

Figure 1. - Sampling stations.

In April 1983 at twelve coastal and six offshore stations (See figure 1) sea-water samples were collected for dissolved/dispersed petroleum hydrocarbons and total suspended sediment analysis. At the above-mentioned locations pelagic tar was collected with the aid of the neuston net. Plastic materials were also collected either by hand or by nets. For comparison some of the stations were visited in June 1983, October 1983 and April 1984 and samples collected and analysed. In order to assess the suspended material input from land based sources and major rivers, samples of streams and sewage were also taken and the total suspended material contents determined.

Experimental

The total suspended sediments (TSS) of the north-eastern Mediterranean Sea between the gulf of Iskenderun and Rhodes (Fig. 1) was sampled during the April , June and October 1983 and April 1984 R/V BILIM cruises.

Sea-water samples collected by bucket were immediately filtered on board, dried and weighed at the laboratory on shore. The Total Suspended Sediment and Dissolved Oxygen concentrations measured for coastal and offshore stations for each cruise are listed in table I. The position of the stations are shown in figure 1.

Sea-water samples were collected 1 m below the surface with the aid of a 2.5 l volume weighted Amberlite bottle and they were treated and analysed for their DDPH content by following the method described by the I.O.C./W.M.O. Manual and Guide n° 7 (I.O.C. 1976). During the spectrofluorimetric measurements chrysene was used as a calibration material. The results are given in table II.

Pelagic tar, plastics and other litter from 0-40 cm depth were collected using a neuston net. To prevent the net from sampling in the ship's wake or bow wave it was mounted on athwartship ahead of the bow wave. Towing was done either in a circle about 1 km in diameter or in a linear tow of about 2 km (30 minutes at a speed of 3 miles per hour).

The results are given in table II and figure 2 for tar balls, pieces of nylon; opaque or clear spherules, and miscellaneous pieces of plastic and wood including cigarette filters.

Discussion

Total Suspended Sediment

From the results given in table I it is rather interesting that for the offshore station (stations 51 to 56) both during the April'83 and April'84 cruises roughly the same overall average TSS load was found. For these stations the settling velocities of particles would suggest that particles would sink rapidly to reach such distances (DRAKE, 1976). Thus the only possibility remains the primary biogenic production. The dissolved oxygen (DO) concentrations measured showed a marked increase which were again very similar both in the April'83 and April'84 cruises. The same picture is also true of the coastal stations. For the April'83 and April'84 cruises the average TSS loads were 2.55 and 2.74 mg/l respectively, whereas for the June'83 and Oct'83 cruises the TSS loads were 1.28 and 1.19 mg/l respectively. The DO concentrations in April were high enough to support the existence of primary biogenic activity.

As mentioned before, the locations of offshore stations cancels out the effect of land-originated particulate matter since such material would be lost from the surface waters. Therefore it is not possible to expect such high loads for these stations. The average for April'83 and '84 offshore TSS load would give 2.21 mg/l. The averages of June'83 and Oct'84 TSS load should give the background load since the input of suspended load should be at a minimum during these periods and it is 0.78 mg/l. This value is in good agreement with the rather sparse data existing for the north-eastern Mediterranean Sea. Concentrations between 0.5-1.0 mg/l have been measured by EMALYENOUS and SHIMKUS

Table I. - TSS and DO Concentrations in coastal and off Shore stations.

Stations	Cruise Dates							
	4/83		6/83		10/83		4/84	
Coastal	TSS	DO	TSS	DO	TSS	DO	TSS	DO
20	3.69	7.6	2.14	6.6	1.43	5.3	2.49	7.3
21	1.83	7.9	0.50	6.8	1.18	5.3	4.96	7.4
22	0.78	7.9	0.37	7.8	2.33	5.3	1.26	7.3
23	1.48	7.0	2.31	6.9	1.57	5.4	1.16	7.3
24	1.54	7.3	0.55	-	2.71	5.4	7.44	8.1
25	0.82	7.0	0.37	-	0.55	-	1.86	7.0
26	2.50	7.4	0.44	6.3	1.55	5.6	2.48	6.9
27	1.10	6.5	1.46	5.9	0.52	5.7	1.00	6.6
28	1.80	7.8	1.50	5.7	-	5.7	1.23	8.2
29	1.44	6.7	-	5.9	1.45	5.8	1.63	9.1
30	2.81	8.4	0.11	5.9	0.39	5.6	0.93	7.1
31	0.63	8.0	3.78	6.1	0.50	5.6	5.82	7.5
32	12.75	8.3	1.87	5.9	0.17	6.1	2.38	7.1
Average	2.55	7.54	1.28	6.34	1.19	5.56	3.56	7.12
Off Shore								
51	2.53	7.4	0.43	7.1	4.83	5.9	1.00	7.5
52	1.20	6.7	0.68	5.8	4.43	5.6	2.79	7.4
53	1.21	7.2	0.06	5.9	-	-	1.96	8.1
54	4.07	8.0	0.41	5.9	0.63	5.6	1.87	7.2
55	5.41	7.9	0.41	5.9	0.43	5.5	2.30	7.3
56	2.03	8.4	0.41	6.0	0.81	5.6	1.75	7.5
Average	2.47	7.60	0.40	6.10	1.39	5.64	1.95	7.50

TSS : in mg/l
DO : in mg/l
N.D : Not Detected

Table II. - Tar Balls and Litter Collected from the Surface Waters of Coastal and Off Shore Stations (mg/m2) and DDPH (μg/l).

Coastal Stations

Date: 22-27/4/1983

Station	Tar ball	Nylon Pieces	Spherules	Miscell*	DDPH
20	33.38	4.7	1.27	1.21	5.6
21	0.20	0.2	N.D	0.05	1.3
22	0.06	N.D	N.D	N.D	0.6
26	N.D	12	"	"	1.5
27	1.53	N.D	"	"	2.0
28	0.01.	N.D	"	"	0.1
29	N.D	N.D	"	"	1.5
30	N.D	N.D	"	0.45	0.7
31	N.D	N.D	"	N.D	-
32	N.D	N.D	"	"	0.4

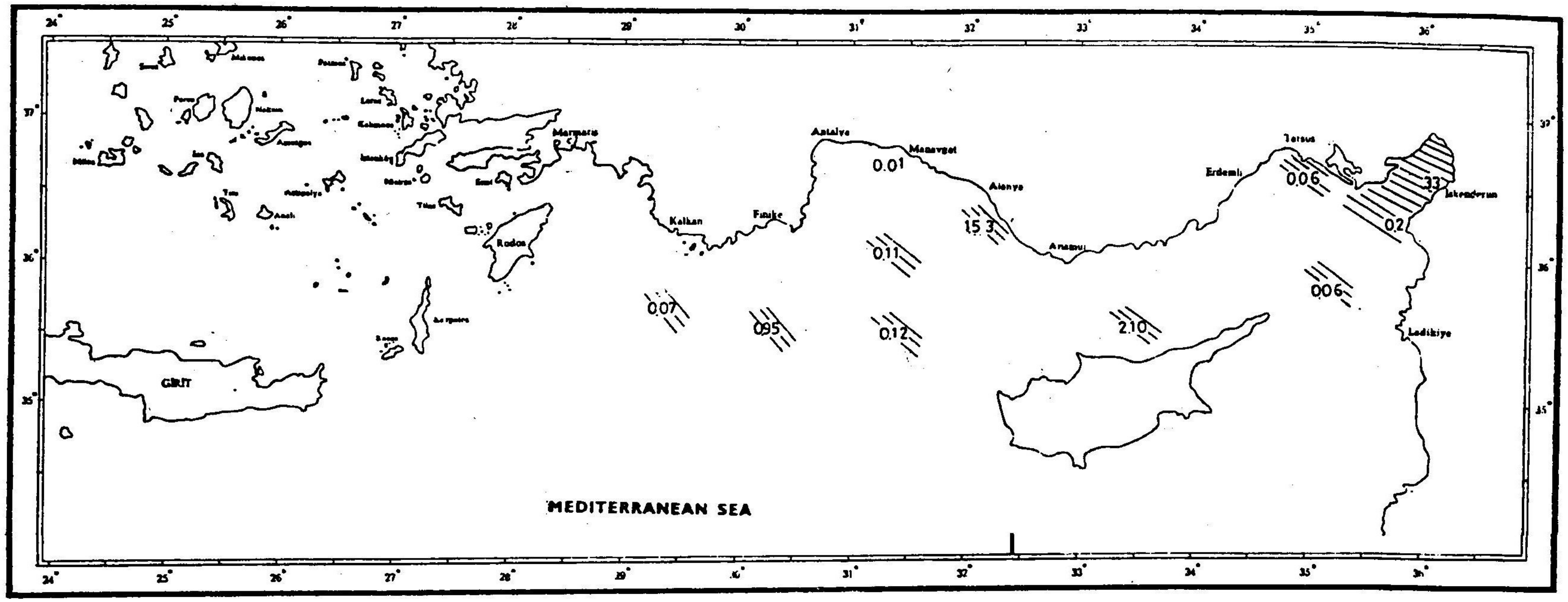
Off-Shore Stations

Date 22-25/83

51	0.06	0.40	N.D	0.06	0.8
52	2.10	N.D	•	0.08	3.8
53	0.11	N.D	0.10	0.72	1.8
54	0.12	3.15	N.D	0.03	2.1
55	0.95	0.20	"	0.03	1.0
56	0.07	N.D	"	N.D	2.2

N.D: Not Detected

* *Miscellenaeus.*



/// Pelagic tar observation areas

Figure 2. - Tar ball sampling areas and quantities (mg/m^2).

(1972). COLLINS and BANNER (1979) have reported inorganic suspended matter concentrations of 0.6-7.0 mg/l. The locations of the present offshore stations fall into the category of 20-30 m Secchi disc depths which should be around 0.5 mg/l suspended matter concentrations.

Therefore if we accept a background TSS load of approximately 0.78 mg/l for the offshore stations and subtract this value from the average April 83/84 values the resultant value should be the TSS load due to primary biological activity.

$$(2.47 + 1.95)/2 = 2.11 \text{ Average 83/84 offshore TSS}$$

$$2.21 - 0.78 = 1.43 \text{ mg/l, TSS to biological activity}$$

If one does the same calculations for the offshore stations average DO concentrations, then

April 83/84 $(7.54 + 7.50)/2 = 7.52$ mg/l DO

June 83/Oct 83 $(6.10 + 5.60)/2 = 5.85$ mg/l DO

$7.52 - 5.85 = 1.67$ mg/l DO

Thus for 1.43 mg/l, TSS increase is accompanied by 1.67 mg/l DO increase for the offshore stations.

For the coastal stations the average TSS of April'83 and April'84 is 2.64 mg/l. The average June'83 and Oct'83 TSS is 1.23 mg/l. If we assume the average June and Oct. as a baseline coastal TSS load, then in April there exists an excess load of 2.64 - 1.23 = 1.41 mg/l.

The corresponding DO increase can be calculed as

Average April 83/84 DO $(7.54 + 7.12)/2 = 7.33$ mg/l

Average June 83/Oct. 83 DO $(6.35 + 5.56)/2 = 6.00$ mg/l

$7.33 - 6.00 = 1.33$ mg/l

Thus for coastal stations a 1.41 mg/l particulate matter increase is accompanied by a 1.33 mg/l DO increase, whereas for offshore stations a 1.43 mg/l particulate matter increase accompanied by a 1.67 mg/l DO increase. Within experimental errors there exists a 1:1 correlation between the DO increase and TSS load increase due to primary biogenic activity. Needless to say, this needs further investigations in the north-eastern Mediterranean Sea with some incidences to support the correlation such as chlorophyll-a and nutrient measurements. It is again worth mentioning that there exist relatively high DO increases at the offshore stations which could be to relatively high biological oxygen demand of the coastal stations. Therefore BOD_5 measurements should be made as well.

Plastic, pelagic tar and other litter

a) North-eastern Corner of Levantine Basin

A cyclonic circulation in the Eastern Mediterranean has been proposed as a dominant mean current system. The steady surface current follows the coasts of Israel, Lebanon and Syria and turns west to flow along the southern Turkish coast. COLLINS and BANNER (1979) have utilized ERTS imagery and Secchi disc depth measurements to provide the details of the flow in the north-eastern corner of the Levantine basin in (figure 3). The existence of 33 mg/m2 tar balls in the gulf of Iskenderun is made possible by the presence of two eddy systems (AKYUZ, 1975) which act as a trap for the water masses and consequently for the pelagic material. Hence the increases in the quantity of pelagic material. The gulf of Iskenderun is influenced not only by indigenous materials but by foreign ones as well. Nylon bags collected from the gulf have adresses of neighbouring countries like Syria, Lebanon, Israel and even Egypt, and in calm weather conditions literally cover large areas of the sea surface.

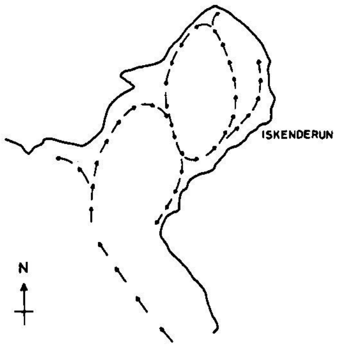


Figure 3. - Iskenderun Bay Surface Currents.

The area of the Iskenderun gulf is about 2,000 km^2 and with a 33 mg/m^2 tar ball load it acts as a trap for about 66 tonnes of the tar balls, 10 tonnes of nylon bags, 2.5 tonnes of spherules and 2.5 tonnes of other pelagic materials.

The existence of low tar ball concentrations but relatively high nylon pieces for station 51 is in good agreement with the mean average surface current of this region. The load introduced to this part of the Levantine basin can be accepted as a baseline input of pelagic material to the study area.

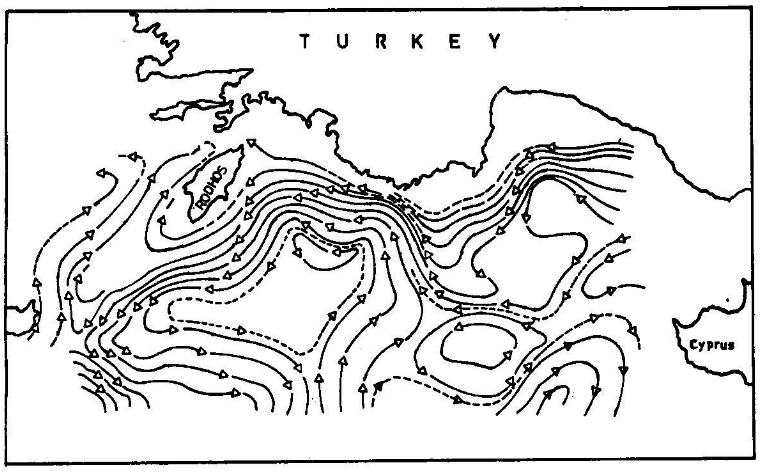


Figure 4. - N.E. Levantine Sea surface currents.

b) North-western Levantine Basin

The mean surface currents of this part of the Levantine Basin are proposed by OZTURGUT (1976) and are given in figure 4. The pelagic materials which exist in the surface waters and are introduced by tanker traffic due to the controlled discharge of ballast water (LE LOURD , 1977) accumulate in these regions where surface currents cause eddies. Thus it becomes possible to explain such high loads of tarball and nylon bag concentrations for stations like 54 and 55. These stations are far away from the mainland masses which cancels out any land-based influences. The patchiness of these stagnant areas makes it impossible to estimate the total amount of tarball and other pelagic materials.

Dissolved/dispersed petroleum hydrocarbons (DDPM)

From table II it clear that DDPH shows the same trend as tar balls and litter, i.e. the highest DDPH concentrations were measured in Iskenderun Bay (station 20) and offshore at station 52. This trend does not in itself connote a correlation between tar ball quantities and DDPH.

Relatively high DDPH concentrations in Iskenderun Bay can be attributed to the existence of two pipeline terminals within the bay and extensive tanker and ship traffic.

Table III. - TSS loads of Industrial Complexes Domestic Sources and Rivers (mg/l).

Rivers	Average	Range
Esen	1777	(81-4398)
Göksu	849	(41-1193)
Ceyhan	777	(57-2157)
Seyhan	73	(30-160)
Manavgat	48	(44-52)

Industrial and Domestic	Average	Range
Gulf of Iskenderun :	7440	(1651-20428)
Mersin Bay :	49	(12-118)
Antalya :	21	(17-25)

Land-based sources

During the course of the study period the major rivers and those industrial and domestic effluents which flow directly into the sea were monitored as well (table III and figure 5).

There exist five major rivers which flow continuously throughout the year. All their suspended loads fluctuate seasonally but the river Esen carries by far the highest TSS load into the Mediterranean. The rivers Ceyhan and Seyhan have been restricted by a barrage which traks their suspension loads. Only during flooding periods do they discharge significant loads in the sea.

Industrial complexes are located mainly around Mersin and around the gulf of Iskenderun. Among others there exist one petroleum refinery, two pipeline stations and two other petroleum storage and filling depots, one iron and steel complex ,three fertilizer plants one soda-ash and one chromnium ore enrichment complex. In addition there are huge textile and agrochemical industries which indirectly discharge their effluents to the Mediterranean Sea.

The immediate consequence of all these complexes is reflected in the variations observed in their TSS loads (table III).

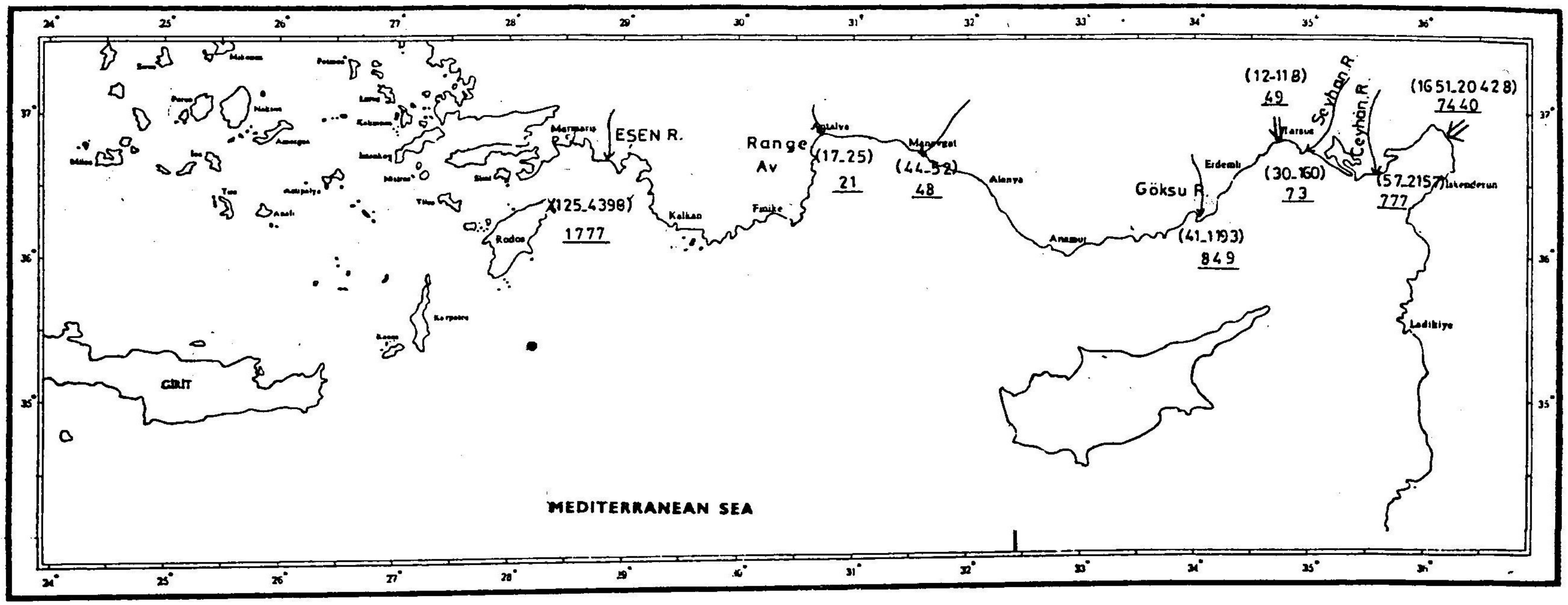
During the monitoring the TSS load introduced from anthropogenic sources was nearly an order of magnitude greater than river input, but the fluxes need to be studied extensively.

Conclusions

From the data and discussions presented in this work it is possible to draw the following conclusions.

1. It seems that there is a close correlation between dissolved oxygen concentrations and total suspended sediment. Within experimental error limits this correlation is 1/1, but this needs further confirmation.

2. Plastic, pelagic tar and other litter accumulates, mostly, in the regions where surface currents form gyres. The best example of this is the gulf of Iskenderun and offshore of Antalya,



--> River Input
==> Industrial and Domesttic Input

Figure 5. - Suspended sediment quantities from land sources (The values in paranthesis are the range, the underlined values are the average quantities in mg/l).

where the two locations represent two extreme cases. The gulf of Iskenderun is a semi-enclosed area which is open to land-based discharges while offshore of Antalya can be considered open sea and it escapes' the direct influence of land-based discharges. Due to the gyre formation the floating material accumulates in the above-mentioned locations.

3. Although DDPH does not have a direct correlation with pelagic tar, they both have similar trends. In the regions with high tar densities the DDPH concentrations are also relatively high.

4. Among land-based sources the highest TSS loads are discharged to the sea by human activities but due to high fluxes natural sources (i.e. rivers) gain importance. However, the fluxes have to be studied in more detail.

Acknowledgement

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