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ECOLOGICAL STUDIES ON THE RIVER COOUM WITH SPECIAL REFERENCE TO POLLUTION

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INTRODUCTION

The indiscriminate loading of the rivers with the large amounts of effluents from wide and varied sources like sewage, industries and agricultural fields lead to the pollution of the rivers. River Cooum plays an important role in the cleanliness of Madras City. It derives its name from village Cooum whose surplus lake water flows into this river. It starts near Sattarai village in Tiruvallur Taluk and flows through 65 kms. before it joins the sea. It enters the city near Aminjikarai, runs for about 18 km. through the city and empties its waters into Bay of Bengal. During November and December the river is mainly tidal. The ebb and flow of the tide flush the river to some extent. When the monsoon is over, water movement is affected due to the formation of a sand-bar at the river mouth region preventing the continuity of the river with the sea. Consequently, the river is not flushed and acute sewage problem is caused. Urban growth on either side of the river, without adequate storm and sanitary sewers, spread over several decades has brought about an adverse impact on the river ecosystem. Sornavel (1978) reported that about 400 million litres per day of sewage was discharged in different zones of Cooum river. This heavy load of sewage prevents the river from self purification and regeneration.

There have been extensive studies on the limnology of River Cooum. (Panikkar and Aiyar, 1937 ; Govindan Potti, 1958 ; Abraham, 1962 ; Narayanan, 1980 ; Joseph et al, 1989). The earlier workers have studied about 18 km. stretch of the River Cooum within the vicinity of Madras. But in the present study the entire stretch of River Cooum was studied for physico-chemical and biological characteristics of polluted and unpolluted regions. In the present study an attempt has been made not only to study the extent of pollution caused by sewage and other pollutants but also to monitor the sewage pollution by indicator species. These indicator species can be used for further monitoring of the freshwater bodies.

Study area, Materials and Methods :

The following six stations given in Fig. I and Table I and Plate I and II were selected along the River Cooum to study the changes in the physio-chemical and biological features.

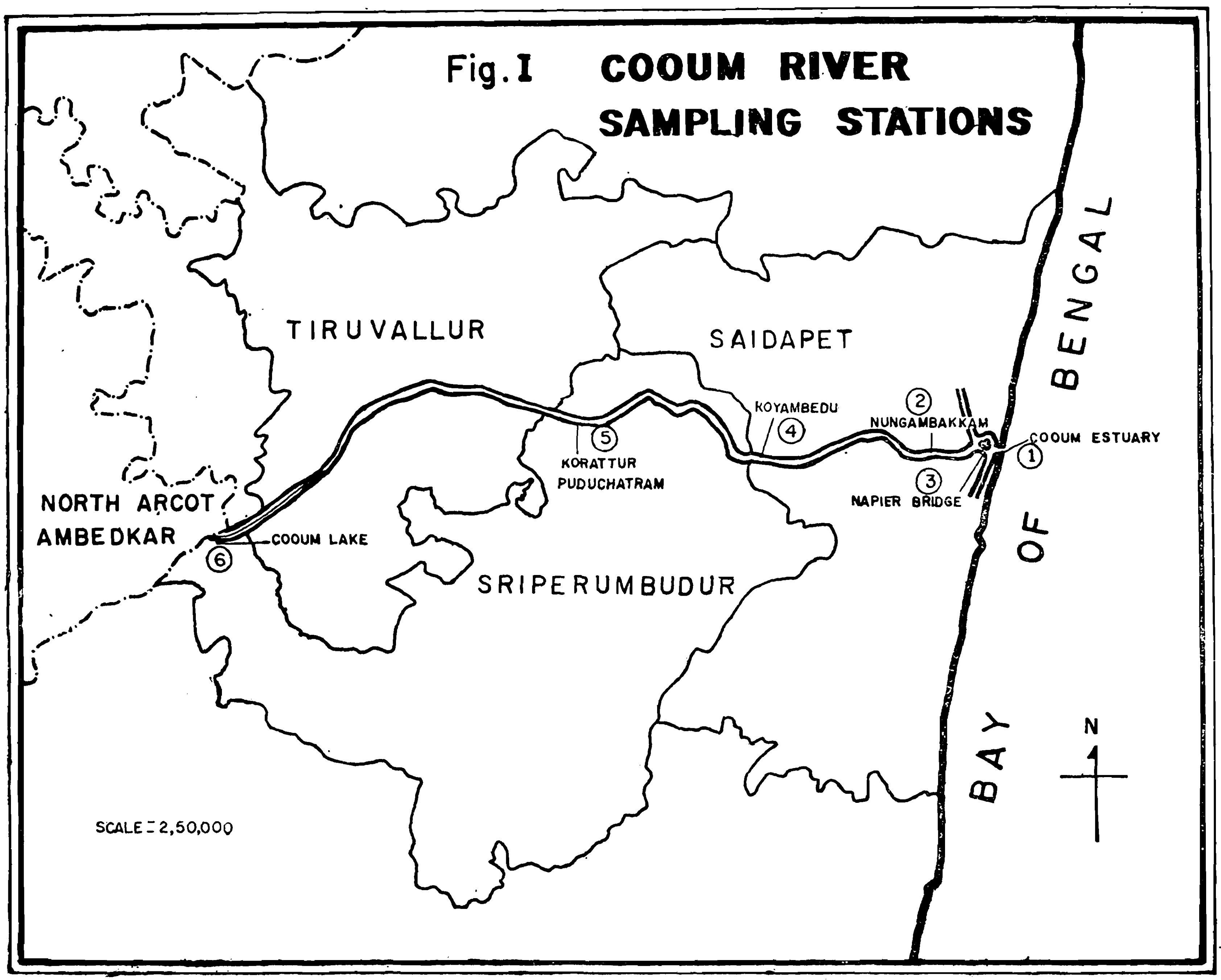


Fig. I COOUM RIVER SAMPLING STATIONS

Table I Sampling Stations

Station	Name	Location	Distance in kms. from sea	Depth Range (in Metres) Maximum	Minimum
1.	Cooum Estuary	Bay of Bengal	0.0	3.00	·6
2.	Napier Bridge	On Kamaraj Salai near University	0.5	3.8	2.0
3.	Nungambakkam	Opposite to Malaria Research Institute	10	3.6	1.3
4.	Koyambedu	Bridge over Cooum	16	3.5	0.8
5.	Korattur Puduchattram	Near Korottur Puduchattram village	45	3.2	1.2
6.	Cooum	Cooum Village	65	6	1.0

Water samples taken at monthly interval from a central area of the estuary and from all the six stations of the river were used for physiochemical and biological analysis. The water samples were collected using a Friedinger type water sampler (Narayanan 1980).

Water sampler was lowered to a specified depth and the sample was collected. The sampler was then lifed up and the air and water temperature were noted immediately. Samples collected at each station were transferred individually to one litre capacity polyethylene bottles and were transported immediately to the laboratory. PH was determined in the field using BDH wide and narrow range PH papers. PH measurements were also made in the laboratory using an electrical PH meter-HACH DREL 5 spectrophotometer. The depth was measured using a line marked in meters. Dissolved oxygen, free carbondioxide, Alkalinity and Acidity were determined using HACH DREL Digital titrator in the field itself. The other parameters like Biological Oxygen Demand (B. O. D.) Chemical Oxygen Demand (C. O. D.), Salinity, Nitrogen Compounds (Nitrite (No_2), Nitrate NO_3), Ammonia (NH_4), Colour, suspended solids, phosphate, sulphate, chloride and silica were determined in the laboratory using HACH DREL Spectrophotometer following the methods in water analysis Handbook (HACH 1983). Months from September to January were taken as the rainy season and February to August as the summer season based on rainfall data.

Plankton samples were collected using a standard plankton net (no. 35 H. D.). At each station standard horizontal hauls were made for a specific period of 3 minutes.

Samples were preserved in 5% formaldehyde solution and the organisms were identified, sorted and counted using Hydrobios plankton microscope. Most of the Micro and Macro fauna were identified to generic level and when possible to species level. (Davis 1955 and Welch 1952).

Results and Discussion

Depth of the river :—Data relating to depth measurements during the period of 1988-1990 were given in Table I. The river is shallow during summer and with the onset of the North-East monsoon during November and December, the depth of the river increases.

Temperature

Water temperature following the atmosphere temperature was maximum in the summer months and minimum in the rainy months (Tables II and III). The water temperature range in the polluted stations (I to III) was higher (23.4°C to 32.6°C) than unpolluted stations (22.0°C-24.0°C). Similarly, the summer months had the highest temperature range (28.8°C-32.6°C) in polluted stations, in contrast to the unpolluted stations (27.8°C-30.8°C). The water temperature during other months in the two sets of stations also behaved the same way. The higher temperature recorded at the polluted stations may be due to the discharge of hot effluents from the factories (Manimegalai *et al* 1986) and longer term of bright sunshine and lack of rainfall. The minimum values recorded in the rainy months may be due to rainfall (Sreenivason 1977).

Colour

By filtering and centrifuging out the suspended materials, the true colour could be determined. The colour of Cooum river is expressed in units of apparent colour following the method in HACH (1983). Observations on the colour variations are recorded in Table II and III. It is seen from the table that the colour of the water varied mostly in accordance with season. During the summer season, the apparent colour of the polluted stations was high (170-680 units) and of the unpolluted stations low (160-420 units). But the apparent colour of the polluted stations during the rainy season was comparatively lower than that of summer. The apparent colour may be due to the presence of algae, rotifers, dissolved substrates or bacteria (Narayanan 1980).

pH

It is seen from the Tables II and III that during the course of study the pH of the polluted stations was alkaline (8-9.5) except for rainy season when it was slightly

Table II. Physico-chemical parameters (mg/l) in the river coom at polluted stations during 1988-1990 (Mean values have been shown along with range in brackets).

	Station I						Station II						Station III					
	1988		1989		1990		1988		1989		1990		1988		1989		1990	
	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy
Air temp°C	28.8 (28.4-31.0)	25.0 (23.4-28.4)	28.8 (23.8-31.6)	25.68 (23.4-28.5)	30.1 (26.8-31.1)	26.5 (23.6-28.5)	29.9 (28.4-31.8)	26.4 (24.6-28.6)	28.8 (24.0-32.0)	25.9 (23.8-29)	28.8 (26.8-31.2)	26.6 (23.8-28.6)	30.6 (28.6-32.6)	28.4 (25.0-29)	28.9 (21.6-32.6)	26.0 (23.6-29.2)	29.0 (27.0-30.3)	26.7 (24.4-28.9)
Water temp°C	29.6 (28.6-31.8)	26.2 (23.6-28.4)	28.6 (24-32)	26.4 (23.6-29.0)	27.5 (25.2-31.2)	22.1 (23.8-23.6)	30.6 (29.0-32.9)	27.1 (24.8-28.8)	28.6 (24.2-29.8)	26.0 (24.0-29.0)	29.0 (25.4-31.4)	22.7 (24.0-28.6)	31.2 (29.4-32.9)	27.5 (25.2-29.3)	29.3 (21.9-32.8)	26.4 (24.0-29.4)	29.0 (27.0-31.4)	26.9) (24.4-28.9)
Colour (in units)	200 (170-240)	180 (160-220)	220 (160-250)	190 (180-240)	230 (190-260)	200 (160-220)	610 (540-680)	300 (215-340)	600 (515-635)	250 (220-270-	630 (600-660)	310 (300-320)	580 (560-590)	290 (285-310)	600 (580-650)	320 (310-335)	650 (610-680)	480 (470-490)
pH	8.3 (7.4-9)	7 (6.6-7.5)	8.6 (8.1-9.1)	7.2 (6-7.5)	8.8 (8.4-9.2)	7.5 (6.5-7.5)	8.7 (8-9.2)	7.2 (7-7.5)	8.9 8.6-9.3	7.3 (7-7.5)	8.9 (8.6-9.4)	6.8 (6.2-7.2)	9.1 (8.8-9.4)	7.1 (6.8-7.5)	9.1 (8.9-9.5)	7.4 7-7.5	9.1 8.8-9.4	7.0 (6.4-7.5)
Salinity	33.4 (23.6-43.5)	13.4 (8.4-20.1)	25 (12.4-44.6)	13.9 8.4-15.8	24.9 (14.6-43.8)	11.2 (8.6-17.4)	29.1 (22.1-38.1)	12.5 (7.4-18.2)	20.7 (9.6-40.1)	9.78 (8.1-14.4)	21.3 (12.4-40.3)	8.2 (5.6-14.2)	17.15 (9.6-18.6)	7.54 (6.4-8.6)	15.6 (8.4-31.2)	7.84 (6.2-10.1)	16.7 (8.6-28.6)	7.38 (5.6-10.2)
Total Suspended Solid	208 (192-212)	83 (72-80)	236 (212-241)	88 (78-96)	245 (192-263)	95 (85-118)	470 (90-490)	62 (56-87)	468 (382-483)	112 (94-126)	475 (321-486)	120 (92-136)	430 (385-468)	106 (94-128)	465 (323-487)	98 (82-108)	525 (386-570)	125 (110-155)
Free Carbondioxide	84.5 (72-101)	69.4 (43-93)	93.8 (79-108)	63.4 (40-90)	94 (68-112)	66 (40-90)	125 (101-138)	77 (58-94)	123 (101-146)	82 (65-98)	121.7 (98-152)	79.8 (50-97)	133 (121-141)	82 (58-94)	117 (84-138)	82.2 (72-91)	121 (88-142)	86.2 (74-97)
Dissolved oxygen	4.1 (3-7)	6.2 (5.2-7.8)	4.3 (3.1-6.8)	6.4 (4.1-8.4)	3.6 (2.5-7.6)	5.6 (2.7-9.8)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
B. O. D.	26 (25-27)	27 (25-29)	28 (25-29)	27 (26-29)	25 (24-26)	20 (25-27)	64 (60-66)	64 (61-69)	65 (62-67)	65 (61-67)	66 (62-68)	65 (63-68)	26 (26-27)	25 (24-26)	26 (26-28)	25 (25-27)	25 (24-26)	26 (26-27)

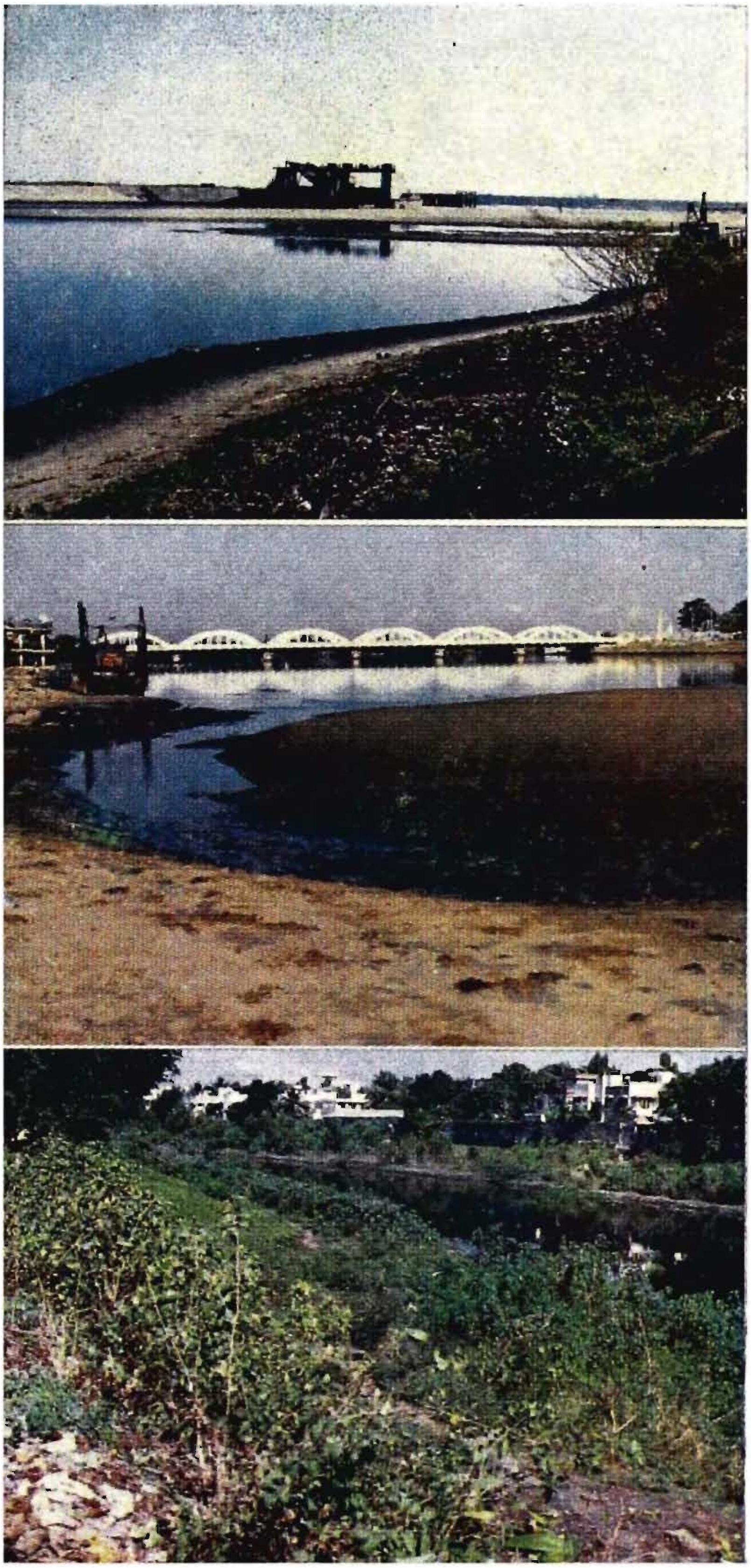
Table II. (*Continued*)

	Station I						Station II						Station III					
	1988		1989		1990		1988		1989		1990		1988		1989		1990	
	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy
C. O. D.	236 (232-241)	236 (230-241)	234 (230-239)	235 (228-242)	234 (229-240)	235 (230-244)	476 (465-485)	474 (460-483)	468 (461-485)	455 (453-487)	473 (461-483)	470 (451-483)	239 (212-253)	249 (243-255)	244 (213-254)	250 (245-258)	251 (245-259)	244 (214-255)
Acidity	227.5 (201-241)	62.8 (54-74)	188.8 (68-246)	61.2 (59-73)	62.6 (54-76)	178.2 (69-249)	305.5 (260-328)	160.2 (128-201)	275.5 (137-331)	163 (130-213)	516 (128-330)	160.4 (131-211)	264.5 (118-328)	172.6 (124-198)	242.4 (114-308)	181.4 (164-208)	227.5 (115-342)	166 (103-201)
Alkalinity	566 (510-612)	101.4 (94-108)	416.7 (139-631)	119.4 (107-129)	512.5 (141-624)	119.2 (112-131)	305.5 (260-328)	160.2 (128-201)	275.5 (137-331)	163 (130-231)	258 (216-330)	160.4 (131-211)	264.5 (118-328)	172.6 (124-198)	710.4 (340-742	465.6 (406-586)	571.2 (342-746)	444.2 (386-541)
Nitrite	0.02 (.01-.03)	0.015 (.01-.03)	0.03 (.01-.04)	0.018 (.01-.02)	0.025 (.01-.03)	0.018 (.01-.02)	0.03 (0.01 .04)	0.025 (.01-.03)	0.035 (.01-.04)	0.028 (.01-.03)	0.04 (.01-.05)	0.026 (.01-.03)	0.04 (.03-.06)	0.025 (.01-.03)	0.042 (.02-.05)	0.03 (.01-.04)	.04 (.015-.06)	.03 (.01-.05)
Nitrate	4.5 (4.3-4.9)	3.6 (2.1-3.8)	4.7 (2.7-4.9)	3.8 (2.0-4.4)	4.8 (3.9-5.9)	3.4 (2.8-3.6)	5.6 (4.2-6.2)	5.1 (4.3-5.4)	5.7 (4.1-5.9)	5.0 (3.8-5.9)	5.8 (4.2-6.4)	5.1 (3.8-5.6)	6.8 (5.2-7.4)	5.2 (4.3-5.8)	6.9 (6.1-7.4)	5.7 (4.3-5.9)	6.8 (5.4-7.6)	5.2 (4.3-5.8)
Ammonia	2.8 (1.4-3.9)	1.9 (1.1-2.3)	2.9 (1.7-3.8)	2.0 (1.2-2.4)	3.1 (2.5-3.8)	2.6 (1.8-3.2)	3.4 (2.4-4.8)	3.2 (2.4-4.6)	3.6 (2.8-4.6)	2.8 (1.6-3.6)	3.8 (3-4.2)	2.7 (2.0-3.3)	4.3 (3.2-5.2)	3.8 (2.1-4.2)	4.4 (2.6-4.6)	3.8 (2.6-4.2)	4.5 (3.2-4.8)	3.7 (2.1-3.9)
Phosphate	2.6 (1.4-3.2)	2.4 (1.8-2.8)	3.2 (1.8-3.3)	2.8 (1.3-2.6)	3.8 (2.0-4.6)	2.9 (2.2-3.8)	5.6 (4.3-5.8)	4.7 (2.9-4.8)	5.85 (3.9-6.1)	3.2 (2.3-4.6)	6.4 (4.3-7.9)	5.3 (4.6-5.4)	6.8 (4.9-7.9)	3.2 (2.8-8.4)	7.3 (5.2-7.6)	5.3 (4.3-5.6)	7.5 (5.6-8.1)	5.8 (4.5-6.4)
Sulphate	85 (76-119)	54 (42-68)	200 (106-218)	65 (52-85)	185 (92-218)	72 (65-110	172 (95-186)	60 (51-78)	215 (82-240	160 (85-85)	240 (162-263)	89 (68-124)	162 (115-218)	85 (58-95)	188 (96-221)	58 (41-79)	240 (108-264)	105 (76-128)
Chloride	1800 (1640-1920)	860 (800-980)	1920 (1760-1980)	890 (610-920)	2320 (1830-2440)	940 (826-984)	1210 (1140-1380)	810 (740-880)	1230 (1030-1310)	840 (720-860)	1360 (1230-1440)	860 (720-883)	1105 (1080-1210)	780 (640-840)	1140 (1020-1260)	810 (724-960)	1260 (1140-1380)	840 (760-890)
Silica	2.8 (1.6-3.4)	6 (4.2-6.8)	2.9 (1.8-3.1)	7.2 (6.4-7.8)	4.1 (3.0-4.4)	8.1 (6.1-8.6)	2.2 (1.6-3.2)	4.9 (3.0-5.8)	2.8 (1.7-3.4)	6.7 (6.1-6.8)	3.3 (3.0-4.8)	7.6 (5.0-8.1)	2.1 (1.6-3.0)	4.3 (3.0-5.9)	2.2 (1.8-2.6)	6.4 (6.0-6.7)	3.1 (2.8-3.6)	7.2 (5.0-7.8)

Table III. Physico-chemical parameters (mg/l) in the river cooum at unpolluted stations during 1988-1990 (Mean values have been shown along with range in brackets).

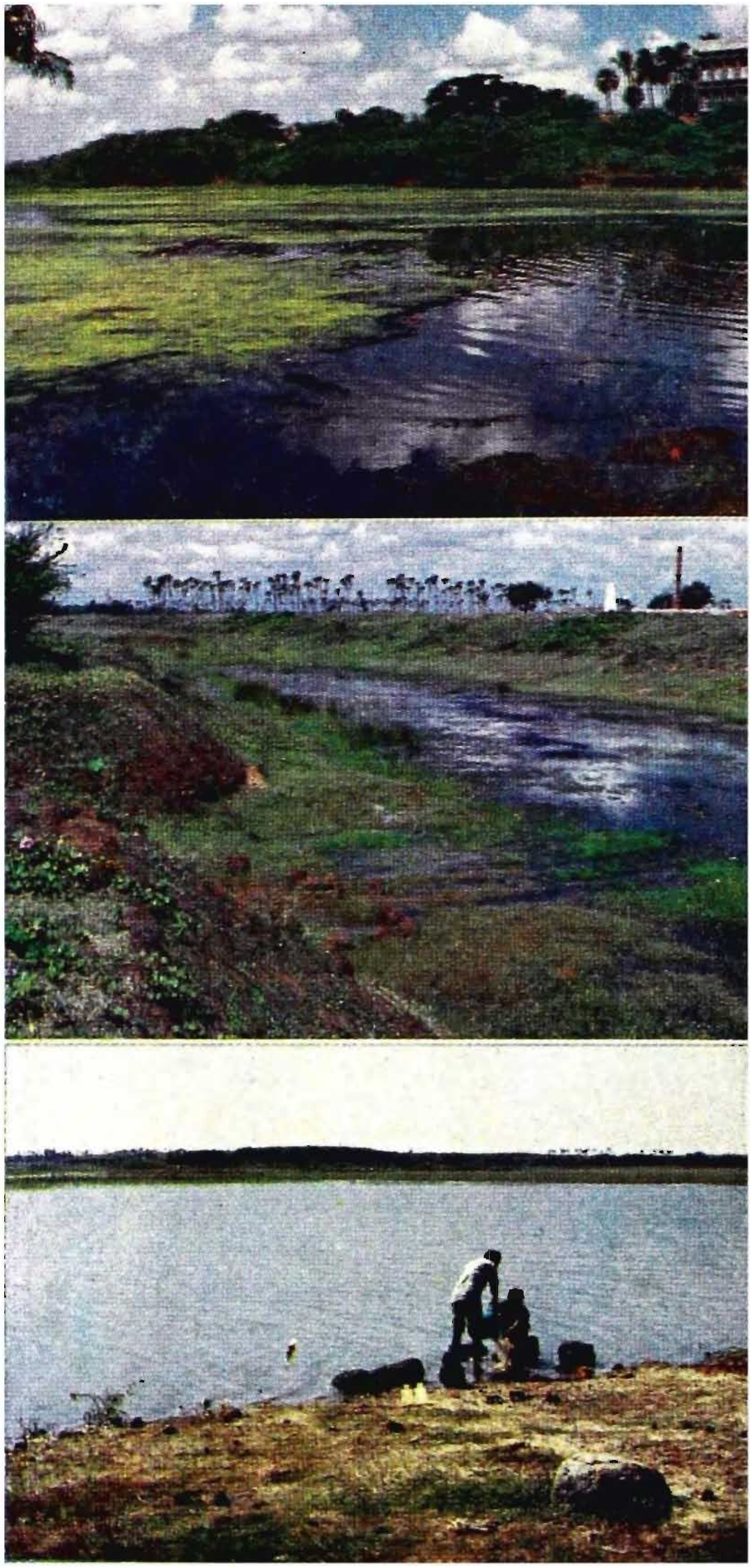
	Station IV						Station V						Station VI					
	1988		1989		1990		1988		1989		1990		1988		1989		1990	
	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy
Air temp°C	28.8 (26.6-30.2)	25.6 (23.0-27.6)	27.8 (22.6-30.8)	25.28 (22.6-28.4)	28.35 (25.2-30.8)	26.32 (22.4-28.5)	28.2 (26.4-30.4)	25.8 (23.2-27.8)	27.8 (22.8-30.6)	19.7 (12.6-27.8)	27.9 (25.0-30.6)	20.4 (22.0-28.0)	28.1 (26.3-30.6)	25.4 (23.0-27.6)	28.2 (26.0-29.4)	20.64 (24.0-27.6)	27.9 (25.0-30.4)	26.12 (22.6-28.1)
Water temp°C	30.6 (29.0-33.6)	19.7 (25.1-28.4)	29.1 (23.8-32.6)	26.1 (23.8-29.2)	28.3 (26.4-30.8)	27.8 (22.4-26.3)	30.5 (29.0-33.0)	26.75 (25.1-28.4)	29.2 (34.1-32.4)	26.8 (22.6-27.8)	29.4 (25.6-31.4)	27.2 (25.6-31.4)	30.6 (29.2-33.2)	26.9 (25.2-28.6)	29.4 (24.2-33.6)	26.3 (24.2-29.0)	29.3 (25.5-31.5)	27.4 (24.2-29.6)
Colour (in units)	210 (160-260)	123 (107-136)	221 (143-248)	131 (122-156)	230 (136-265)	125 (108-138)	325 (240-356)	182 (156-210)	383 (278-395)	176 (162-186)	392 (310-420)	188 (165-214)	121 (96-138)	82 (73-96)	186 (112-198)	86 (73-94)	193 (121-241)	92 (81-118)
pH	6.8 (6.3-7.3)	6.3 (6.1-6.6)	7.1 (7.0-7.5)	6.3 (6.0-7.0)	7.3 (7.1-7.6)	6.9 (6.8-7.0)	6.8 (6.4-7.0)	6.2 (6.1-6.6)	6.7 (6.3-7.1)	6.5 (6.0-7.1)	7.0 (6.8-7.2)	6.9 (6.8-7.1)	6.2 (6.1-6.4)	6.1 (6.0-6.3)	6.1 (6.0-6.2)	6.0 (6.0-6.2)	6.4 (6.2-6.8)	6.1 (6.0-6.2)
Salinity	4.8 (3.6-7.4)	3.9 (3.2-7.6)	9.3 (4.0-9.8)	3.5 (2.8-6.8)	11.0 (6.4-12.6)	4.0 (2.2-7.1)	7.1 (5.6-8.9)	2.4 (0.17-4.0)	6.2 (4.0-9.8)	1.4 (0.16-3.6)	6.0 (4.0-9.8)	1.4 (0.16-3.6)	1.8 (0.69-2.8)	0.74 (0.18-1.9)	1.3 (0.8-2.1)	0.41 (0.13-0.68)	1.2 (0.9-1.8)	0.4 (0.2-0.8)
Total Suspended solids	48 (32-68)	23 (18-25)	54 (48-76)	25 (18-38)	51 (48-73)	28 (19-32)	69 (52-78)	34 (26-42)	65 (58-73)	30 (22-41)	71 (58-86)	29 (18-39)	65 (52-68)	33 (27-45)	68 (52-75)	35 (27-48)	72 (64-86)	31 (28-46)
Free Carbondioxide	55.4 (71-92)	37.25 (26-52)	75.1 (41-94)	40.4 (24-58)	78.8 (76-91)	41 (24-65)	47.7 (36-61)	26.5 (21-31)	52.3 (42-72)	31 (22-40)	51.1 (24-78)	22.2 (17-26)	26.6 (24-31)	18.5 (18-24)	32.1 (29-68)	17.0 (15-28)	30.5 (26-36)	17.2 (13-21)
Dissolved Oxygen	4.9 (4.5-5.8)	11.02 (9.1-12.6)	5.1 (3.8-8.4)	8.94 (6.2-14.2)	7.1 (4.1-13.1)	10.2 (5.1-16.4)	7.35 (6.1-8.3)	14.4 (10.4-17.2)	6.1 (4.1-10.1)	8.9 (5.6-15.8)	8.9 (6.5-17.0)	12.82 (7.8-18.2)	7.35 (6.1-8.3)	14.4 (10.4-17.2)	7.1 (5.6-10.8)	10.7 (6.9-17.4)	10.6 (7.6-18.3)	15.7 (8.2-19.8
B. O. D.	12.6 (12-13)	13.25 (12-14)	12.4 (12-14)	13.6 (13-15)	12 (11-14)	13.8 (12-15)	10.2 (9-12)	10 (9-12)	10.4 (9-11)	9.8 (8-11)	11.1 (9-12)	10.6 (1-12)	8.2 (7-10)	7.7 (6-10)	8.7 (8-10)	8 (6-10)	6.8 (6-8)	8.4 (8-9)
C. O. D.	45.8 (41-52)	47.5 (42-51)	49 (45-52)	47 (42-52)	48.2 (44-52)	46.8 (40-51)	23 (21-26)	23.8 (21-25)	23.5 (22-26)	24 (21-25)	23.5 (21-26)	24 (22-26)	17.6 (14-21)	18 (17-20)	17.2 (13-23)	18.4 (16-21)	19.1 (14-22)	18 (15-26)

MARY BAI **PLATE I**



1. Cooum Estuary at Bay of Bengal.
2. Napier Bridge on Kamaraj Salai near Madras University.
3. Nugambakkam : Opposite to Malaria Research Institute.

MARY BAI PLATE II



4. Koyambedu, near bridge over Cooum.
5. Koratur Puduchatram, near Koratur Puduchatram Village.
6. Cooum lake near Cooum Village.

Table III. (*Continued*)

	Station IV						Station V						Station VI					
	1988		1989		1990		1988		1989		1990		1988		1989		1990	
	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy
Acidity	84.5 (84-89)	77.6 (70-85)	78.2 (58-86)	76.6 (71-84)	71.8 (61-88)	76.2 (64-81)	59.2 (78-72)	46.4 (47-69)	53.8 (24-71)	50.4 (47-51)	48.8 (26-68)	39.4 (28-55)	25.2 (20-28)	22.2 (18-28)	24.7 (18-44)	22 (18-45)	22.7 (16-36)	21.2 (18-25)
Alkalinity	202 (182-210)	190 (157-210)	191.5 (170-210)	172.2 (126-196)	186.4 (132-204)	159 (104-206)	148 (104-186)	114.4 (96-136)	150 (86-185)	123.8 (98-146)	179.7 (88-251)	110 (98-108)	65.5 (59-73)	50 (36-53)	70.1 (61-108)	47.8 (36-52)	73.5 (52-90)	52 (43-62)
Nitrite	.008 (.004-.01)	.004 (.002-.006)	.01 (.008-.027)	.008 (.005-.009)	.015 (.012-.018)	.009 (.006-.01)	.006 (.004-.008)	.002 (.001-.006)	.004 (.002-.005)	.003 (.001-.004)	.006 (.004-.007)	.002 (.001-.004)	.004 (.002-.006)	.002 (.001-.003)	.005 (.001-.006)	.002 (.001-.003)	.006 (.004-.007)	.002 (.001-.003)
Nitrate	3.6 (2.8-3.9)	2.8 (2.4-3.2)	3.65 (2.4-3.8)	2.6 (2.2-2.8)	3.5 (3.1-3.8)	2.4 (2.1-2.6)	3.3 (2.1-3.6)	2.0 (1.8-2.6)	3.5 (2.4-3.8)	2.2 (1.8-2.6)	4.3 (2.9-4.8)	2.4 (1.8-2.6)	3.4 (2.8-3.9)	2.6 (1.9-2.9)	3.6 (2.4-3.8)	2.3 (1.9-2.8)	3.8 (2.9-4.2)	2.6 (2.1-2.8)
Ammonia	1.2 (.08-1.4)	0.08 (.03-.09)	1.4 (1 1-1.6)	.5 (.2-.8)	1.2 (.8-1.4)	.3 (.1-.8)	1.6 (1.1-1.8)	.86 (.72-.9)	1.4 (1.1-1.6)	.6 (.3-.8)	1.3 (1.1-1.5)	.4 (.3-.7)	1.7 (1.1-1.9)	.8 (.6-.9)	1.2 (1.1-1.6)	.6 (.5-.9)	2.1 (1.8-2.4)	.5 (.3-.8)
Phosphate	0.003 (0.001-0.004)	0.001 (0.001-0.002)	0.002 (0.001-0.003)	0.0015 (0.001-0.002)	0.004 (0.003-0.005)	0.002 (0.001-0.003)	0.002 (0.001-0.004)	0.001 (0.001-0.02)	0.003 (0.001-0.004)	0.002 (0.001-0.002)	0.003 (0.002-0.004)	0.002 (0.001-0.003)	0.006 (0.002-0.007)	0.002 (0.001-0.003)	0.009 (0.002-0.009)	0.004 (0.003-0.005)	0.008 (0.008-0.009)	0.003 (0.002-0.004)
Sulphate	62 (53-65)	23 (15-27)	58 (42-61)	21 (19-27)	64 (52-68)	31 (28-37)	52 (48-56)	23 (21-27)	55 (48-56)	27 (22-31)	56 (42-64)	24 (18-28)	56 (48-51)	24 (21-36)	42 (32-56)	27 (22-31)	59 (41-52)	32 (22-46)
Chloride	88 (62-96)	43 (34-48)	96 (81-115)	51 (41-56)	112 (89-118)	64 (52-78)	62 (51-66)	34 (26-38)	76 (62-84)	38 (21-42)	92 (71-98)	42 (31-46)	28 (31-38)	16 (12-24)	32 (18-36)	19 (12-24)	34 (18-42)	18 (12-21)
Silica	2.6 (1.4-3.2)	5.9 (3.8-6.8)	2.8 (1.6-3.0)	6.9 (6.3-7.2)	3.8 (3-4.6)	7.8 (6-8.4)	3.3 (1-3.6)	7.5 (6-8.2)	3.8 (1.6-4.2)	8 (5-8.8)	4.4 (2.6-4.8)	9 (4-10.6)	3.1 (2.1-4.1)	7.2 (6-8.3)	3.2 (3.3-4.4)	7.6 (6.1-9)	4.3 (3.4-5.6)	8.6 (7.2-9.4)

acidic to neutral (6-7.5). In the unpolluted stations it was acidic or neutral through out the year. The same condition has been reported by Manimekalai *et al* (1986) in River Bhavani and Kulshrestha *et al* (1989) in the river Chambal, due to the discharge of effluents into these rivers. The low value in pH in the unpolluted stations may be due to the dilution by rain water, absence of effluents and high concentration of free Carbondioxide (Welch, 1952 ; Jhingran, 1982).

SALINITY

The salinity of the polluted stations varied from 8.4%° to 44.6%°. The salinity of unpolluted stations varied from 0.13%° to 12.6%°. It is seen from the data that there is a general uniformity in the pattern of salinity variation in all the six stations. The minimum range ocurred in the rainy season and the maximum in the summer season. The pattern of seasonal variation appears to be repetitive year after year. The reduction in the salinity appears to be closely linked with the amount of rainfall (Table IV). The enrichment in salinity at Station I may be due to the incoming sea water during high tide (Narayanan 1980 and Joseph *et al* 1989).

TABLE IV. Rainfall (24 hrs. in mm. data collected from Meteorology Deptt.)

Month	1988	1989	1990
January	000.7	09.0	006.5
February	21.9	Nil	002.9
March	Nil	Nil	16.0
April	.006.1	Nil	Nil
May	29.6	003.0	408.5
June	27.4	128.5	20.3
July	32.5	191.5	096.7
August	291.7	56.0	085.7
September	220.7	148.9	195.0
October	77.2	179.9	573.5
November	477.9	492.3	309.3
December	110.8	196.1	191.9

TOTAL SUSPENDED SOLIDS

It is evident from Tables II and III that the total suspended solids in the polluted stations were much higher than that of unpolluted stations. The maximum values of total suspended solids ranging between 90-570 mg/1 were recorded during summer and the lowest values were observed during the rainy season. (70-150 mg/1) ; (Tables II & III in the polluted stations. This is in consonant to the findings of Somashekar (1985), Manimegalai *et al* (1986), Venkateswarlu (1986) and Sbashikant and Rajkumar Rampal (1989).

Free Carbondioxide

The free carbondioxide values have a direct relation to the dissolved oxygen. The free Co_2 was very high in the polluted stations having a range of 84.5-146 mg/1 in summer and 40-98 mg/1 in rainy season. In the unpolluted stations also the summer values of free Co_2 were high 26-94 while in the other season it ranged between 13-24 mg/1 (Table III). Similar results were reported by Shashikant and Anil Raina (1989) and Kulshrestha *et al* (1989). The annual peak in the month of May is attributed to the increased decomposition of dead organic matter with the rise in temperature. The fall in free Co_2 in rainy season may be due to the reduced decomposition of dead organic matter at low temperature during this season and dilution of water.

Dissolved Oxygen

Dissolved Oxygen influences the distribution and abundance of phytoplankton and zooplankton and is important in bringing about various biochemical changes in water. The distribution of the dissolved oxygen in River Cooum showed marked oscillations. The dissolved oxygen was greater in the unpolluted stations in comparison to the polluted (Tables II & III) ones. The minimum and maximum oxygen values in the Cooum estuary is in Ist station ranged from 2.5 (Feb. '90) to 9.8 mg/1 (Oct. '90). In the polluted stations, second and third stations of the river was devoid of dissolved oxygen except in the months of N. E. monsoon. In the fourth station, the minimum was 3.6 (May'89) and maximum 16.4 mg/1 (Oct. '90). In the fifth station, the D. O. ranged from 4.1 (May'89) to 18.2 mg/1 Oct. '90). In the sixth station the D. G. ranged from 5.6 (May'89) to 19.8 mg/1 (Oct. '90). Similar condition was recorded by Venkateswarlu 1986, Shashikant and Rajkumar Rampal 1989, Jebanesan *et al* 1989, and Kulshresthe *et al* 1989. The D. O. values were high during rainy season at all the stations since the colder water has a greater capacity for holding dissolved gases. (Hutchinson 1957). The absence and lower values of D. O. in the polluted station have been attributed to the heavy organic load at the polluted stations through the addition of raw sewage and other municipal wastes and due to the decomposition processes set in by micro organisms which utilize the oxygen in great quantity. (Narayanan 1980).

B. O. D. and C. O. D.

The B. O. D. Values (Tables II and III) ranged from 24 to 68 at the polluted stations. There was a decreasing trend from IV station. The values ranged from 6 to 15 at the Vth and VIth stations. The C. O. D. ranged from 212 to 485 at the polluted stations and from 14-52 in the unpolluted stations. High B. O. D., C. O. D. and low content of dissolved oxygen (DO) are all indicators of pollution. The high content of B. O. D. C. O. D., and low content of DO in the downstream of River Cooum may be due to the heavy organic pollution. Similar conditions have been reported by Somashekar 1985. Venkateswarlu 1986, Manimegalai *et al* 1986 Jebanesan *et al* 1989. Shashikant and Anil Raina 1989, Kulshresthe *et al* 1989, Joseph *et al* 1989, Shashikant and Rajkumar Rampal 1989. It was also noticed that during summer months the B. O. D. and C. O. D. values were high which may be due to the presence of aerobic micro-organisms which easily degrade organic matter in the presence of oxygen (Shashikant *et al* 1989 and Naryanan 1980).

ACIDITY AND ALKALINITY

In the polluted stations, the acidity value range from 54 to 342 mg/1 and in the unpolluted stations it ranged from 18 to 89 mg/1 (Tables II and III). In the polluted stations, the total alkalinity value ranged from 94 to 746 mg/1 and in the unpolluted stations from 36 to 210 mg/1. Both the values were high during summer i.e. May and low during the rainy season i.e. in November-December. The values of acidity and alkalinity were high at the first three stations indicating the pollution. (Kulshresthe *et al* 1989 ; Shashikant and Anil Raina 1989 and Patil *et al* 1984). Of these, two parameters, the total alkalinity seems to be high, indicating the alkaline nature of the effluent.

INORGANIC NITROGEN (NITRITE, NITRATE AND AMMONIA)

The chemical composition at the polluted stations in River Cooum, reveals that in the nitrogen complex, nittates were more like that of river Tungabhadra (Venkateswarlu 1986). The three forms of nitrogen indicated high level during summer season in the polluted station (nitrite .02-.042 mg/1, nitrate 4.5-6.9 mg/1, NH_4 2.8-4.5 mg/1) and during rainy season the values were low. Low values of nitrite—.004-.015 mg/1, Nitrate 3.3-4.3 mg/1, Ammonia 1.2-2.1 mg/1 (all in summer) and lowest values of Nitrite .004-.009 mg/1, Nitrate 2.0-2.8 mg/1 and Ammonia .08-.86 in rainy season were recorded in unpolluted stations. This find support from the studies Narayanan (1980). Shashikant and Anil Raina (1989). Very high amounts of nitrogen compounds are indicative of organic pollution due to sewage. The lack of rainfall was the reason for maximum concentration in summer and minimum value in rainy season. Increase in ammonia concentration results in the biochemical, physiological, histological and immunological changes in the vital organs of fish (Colt and Techobanoglous 1978 and Hillaby and Randal 1979).

PHOSPHATES

Phosphates are essential for the growth of algae but are usually present in low concentration in natural, unpolluted freshwaters. The phosphate in the unpolluted stations of the River Cooum ranged between 0.001 mg/1 and 0.007 mg/1 during rainy season with maximum values of 0.009 mg/1 during summer months. In contrast, in the polluted stations, the Po_4 concentration was very high. The maximum values ranging between 5.6 to 8.1 mg/1 were recorded in Station III during summer and the minimum being 1.3-2.3 mg/1 during rainy season. (Willam *et al.* 1972, Shahshikant and Anil Raina 1989 ; Venkateswarlu 1986). This condition of higher amount of Po_4 in the polluted stations indicates a higher level of pollution in Cooum river, probably due to sewage contamination (Welch, 1952) or due to chemical compounds used in industries (Manimegalai *et al*, 1986).

SULPHATE

In the present study, the sulphate content of the polluted stations ranged between 85-240 mg/1 in summer and 54-160 mg/1 in rainy season. In contrast, in the unpolluted stations the values ranged between 58-64 mg/1 in summer and 21-32 mg/1 in rainy season. Sulphate is involved in biodegradation and is converted to sulphide which may cause obnoxious odour in polluted stations in River Cooum. This is common in sewage comtaminated streams (Welch 1952). Similar results were observed by Govindan and Sundaresan (1979) in Adyar river in Madras.

CHLORIDE

Chlorides are present in all potable water supplies and in sewage, usually as a metallic salt. The high amounts of chlorides are also indicators of large Amounts of oaganic matter in the water. In the present study (Table III & IV), the same trend is noticed. Chloride was very his in polluted stations (780-2320 mg/1) compared to the unpolluted stations (16-112 mg/1) (Venkateswarlu, 1986, Manimegalai *et al*, 1986 and Sahhshikant and Rajkumar Rampal, 1989). The chloride content was minimum during rainy season and maximum during summer season (Sangu and Sharma 1985, Joseph *et al* 1989), The increase in Chloride in the first station is attributed to sea water intrusion during high tide. The addition of allochthonous materials in the form of domestic sewage, human wastes and the effluents discharged from the industries located adjacent to the river finally leads to nutrient enrichment.

SILICA

Silica normallv exists as an oxide (Sio_2 as in sand) or as a Silicate. It has no known toxic effect. Davis 1964 observed that Silica is less variable in natural waters than the other dissolved constituents. In the presect study, silica is estimated in SiO_2. Variations in the silica volues in all the six stations show that it is independent of the effluent discharge (Table II and III). The higher amount of silica at station V may be due to the sandy nature of the substratum with small pebbles and stones (Venkateswarlu 1916). The high value of silica during rainy season may be due to the floods during this season and weathering of rocks and mineralisation in the catchment area (Manimegalai *et al* 1986).

PLANKTON

Plankton not only indicate the level of pollution but provide insight in the composition of their substratum. Indicator organism concept is based on the presence of particular taxa indicative of the existence of certain environmental condition, whereas its absence is indicative of the absence of that condition (Warren 1971).

Phytoplankton : Three groups of algae were commonly represented in the river and percentages in unpolluted and polluted stations are shown in Tables V and VI (Fig. II).

In general in polluted stations Bacillariophyceae (diatoms) dominated followed by cyanophyceae ceae and chlorophyceae. In unpolluted stations chlorophyceae dominated followed by Bacillariophyceae and Cyanophyceae like the river Moosi of Andhra Pradesh (Venkateswarlu he 1986). Of all the stations, unpolluted stations (i.e. IV-VIth) supported the highest amount of algae. The species composition at the unpolluted and polluted sites of the River Cooum indicates a clear demarcation, certain species always occurring only in the uncontaminated waters whereas some species live in polluted waters. (Table V). Similar results have been reported by Venkateswarlu, 1986, Shashikant and Anil Raina (1989), Kulshrestha *et al* (1987), Ray *et al* (1979). This distinction can be attributed to the type of effluents entering the river. Seasonally, the highest standing crop of total phytoplankton was recorded in summer particularly April-May. Similar conditions have been reported by Gopinathan (1972). The highest population of phytoplankton groups during summer months can be correlated to the higher temperature (optimum for algal growth) and higher concentration of essential nutrients particularly phosphates, nitrates and nitrites during these months.

Zooplankton : The quality and quantity of zooplankton offers additional evidence for the poor quality of water. 14 species of zooplankton were identified from River Cooum (Table V). Among these, Vorticella, Rotifers and Moina were represented abundantly at the polluted stations and moderately at unpolluted stations whereas copepodes and ostrocodes were abundant at unpolluted stations and rare in polluted stations (Narayanan 1980).

Rotifers as biological indicators of pollution have been recorded earlier. (Rao and Chandramohan 1977, Michael 1964 and 68, Sampath *et al* 1979 and Ramesh Konnur *et al* 1986). *Brachionus calvciflorus* Pallus, *B. rubens* Ehr, *B. guadridenta*, *B. forficula*, *Filium longiseta* were found to be predominant in River Cooum suggesting that these five species are more pollution tolerant than the other species. (Ramesh Konnur *et al*

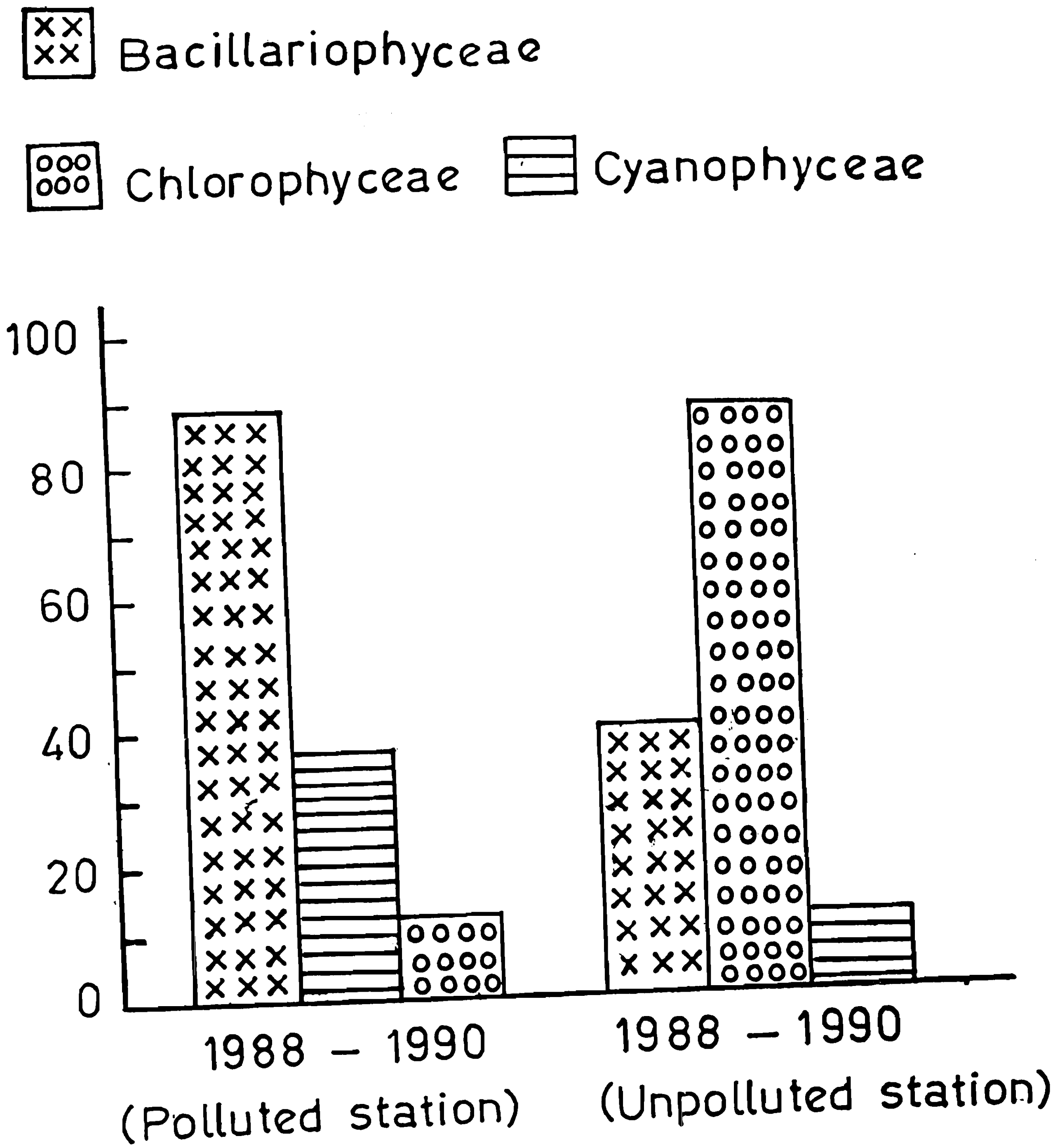


Fig.II Algal composition (%) in R.Cooum at polluted and unpolluted stations.

1986). Presence of rotifers throughout the year and their abundance during April and May suggests the constancy in occurence of pollution in the River Cooum.

The macroinvertebrates are also valuable indicators of environmental quality in aquatic ecosystem because of their life cycle stages, their comparatively stable mode of life and their convenient size and distinct characters which offers an easy sorting and identification of these organisms (Kulshrestha *et al* 1989 and Rao and Jain 1985). Larvae and pupae of dipterans are the second large group of macro-invertebrates in River Cooum.

Dipteran larvae correlate well with the physico-chemical data to suggest that these groups can be taken as the indices of pollution as in River Tawi at Jammu (Shashikant and Anil Raina 1989). The larvae and pupae of Diptera were abundant in stations I, II & III, the maxium in Station III. They were completely missing in stations IV to VI which indicates that these can also be used as a biological indicator. Chironomous larvae and mosquito larvae were also represented in the polluted stations (Kulshrestha *et al* 1989).

Aquatic Hemipterans population was more in IV to VI stations. *Diplonychus indicus, Anisops sp., Ranatra sp., Limnogonus fossarum fossarum, Lacctrephes sp.* were abundant in the unpolluted stations.

The semi aquatic insects such as *Gerrid* sp. and *Hydrometra, Micronecta punctata* were also present in the unpolluted stations. These insects were not at all found in the polluted stations indicating that they are all sensitive to organic pollution. The plausible reasons for their absence are intolerable conditions of the water and the non-availability of vegetation and food organisms. (Jebanesan *et. al.* 1989, Krishnamoorthy and Sarkar 1979).

Crustacea : Crustaceans like *Macrobrachium rosenbergi, Macrobrachium lamarrei, Macrobrachium javanicum* and *Scylla serrata* were found only in unpolluted station IV to VI. The polluted stations I to III were charcterised by the absence of crustaceans.

Molluscs : There were many species of molluscs like *Planorbis exustus, Aniscus hypotoclos, Pila virens, Pila globosa* and *Vivipara balonsis* in the unpolluted stations while they are completely absent in the polluted stations (Krishnamoorthy and Sarkar 1979). Thus the total absence of macroinvertebrates in polluted stations where Dissolved Oxygen is completely depleted and sludge smells of H_2S is indicative of high degree of pollution. (Krishnamoorthy and Sarkar 1979).

Pisces : Fifteen species of fishes (Table V) were noticed in unpolluted stations (IV to VI). But the polluted stations were characterised by rare presence of *Magalops cyprinoides* (Broussonel), *Mugil cephalus* (Linnaeus), *Mugil macrolepis* (Smith) and *Therapon jarbuva* (Forsk). The fishes appear generally to avoid the chlorine containing water. The polluted stations of River Cooum are devoid of large number of fishes due to the toxicity of chlorine. (Zillich 1972).

The amphibian like *Rana cyanophyctis, Rana limnocharis* and reptile *Natrix* sp. were restricted only to unplluted stations. The severely altered depressed macrofauna in polluted stations indicated the numerous discharges invariably exceeded the waste assimilative capacity of the river, causing alarming deterioration in the water quality.

The higher values of all physicochemical parameters except DO and low representation of micro and macro fauna in the polluted stations and during summer months are in accordance with the earlier findings of Shashikant and Rajkumar Rampal (1989).

The analysis of physico-chemical and biotic factors of River Cooum confirm the high degree of industrial and sewage pollution, which needs care and treatment to sustain aquatic life. It is recommended that there should be regular monitoring of River Cooum to maintain the comprehensive picture of its characteristics as a basis for management of this river.

TABLE V. List of dominant phyto-zoo-plankton and Macrofauna in polluted stations of River Cooum.

CYANOPHYCEAE

Apanozomenon flosaguae

Microcystis elebans

Pleurocapsa sp.

Oscillatoria chalybea

Oscillatoria putrida

Oscillatoria formosa Bory

Phormidium anbigenum

Spirulina jenneri (Stizb) geitler

Anabaena constricta

Anabaena circinalis

Anthrospira sp.

Merismopedia blauca

Euglena acus

Euglena polymorpha

Spirulina gigantea

CHLOROPHYCEAE

Chlorella vulgaris

Closterium acerosum (Schrank) Ehr

Eudorina sp.

Oxystis sp.

Seenedesmus quadricauda (Turp) Brela

Schroederic

Ankistrodesmus

Cryptomonas ovata

Spriogyra crassa kuty

Staurastrum punctulatum Brel

Ulotrix zonata (Weber and Mohr) Kutz

Volvox globator

BASCILLARIOPHYCEAE

Amphora

Cyclotella menghiniana

Fragilaria halophila

Navicula pupala F. Capitata

Navicula pygmaca

Fitzschia acicularis var

Nitzschis palea (Kutz)

Asterionella japonica

Bacteriastrum

Biddulphia sinensis

Thalassionemo

DIATOMS

Tabellaria fenestrata (Lyngb) Kutz

Navicula pupula capitate

Rhizosolenia

Carcinodiscus

Asterionella formosa Hass

ROTIFERS

Brachionus rubens Ehr

Brachionus calyciflorus Pallus

Brachionus quadridenta

Brachionus forficula

Filium longiseta

Cladocera

Moina sp.

COPEPODA

Diaptomus sp.

Mesocyclops sp.

Naupluis

Platyhelminthes

Nematode worm

Crustacea

Balanus sp.

Larval forms

Chironomous larva

Culex fatigans

Dipetran Larva, *Brachydeutera longipes* Hendel

Culecine pupa

Dipteran pupa

FISHES

Magolops cyprinoides (Broussonel)

Mugil cephalus (Linnaeus)

Mugil microlepis (Smith)

Therapon jarbuva (Forsk)

TABLE VI. List of dominant phyto-zoo-plankton and Macrofauna in unpolluted station of River Cooum.

CYANOPHYCEA

Coelospharium huetzingianum

Gleocapsa

Polycystis

Protococcus

Aphanocapsa pulchra (Kutz) Raben

Spirulina

Euglena viridis Ehr

Mougeotia indica Randhawa

BACILLARIACEA

Navicula cryptocephala Kutz

Synedra acua Kutz

Synedra ulna (Nizt) Ehr

Fragilaria capucina Desmaz

Gomphonema parvulum (Kutz) green

Gomphonema sphacrophorum (Ehr). f. subscapitata

Navicula pygmaca (Kutz) green

Navicula laterostrata Hust.

Nitzschia obtusa Wrn. Srn. Vi

Nitzsbhia palea (Kutz) wrn. srn.

CHLOROPHYCEAE

Closterium

Stauroneis parvula green

Tetraedron tumidulum

Hydrodictyon

Actinastrum sp.

Ankistrodermus falcatus (corda) Ralfs.

Chiamydomonas sp.

Chlorococcum humicola (Naeg) Raben

Crucigenia guadradata

Crucigenia tetrapedia

Eudorina elegans Ehr

Eudorina indica Iyengar

Oxystis ecballocystiformis Iyengar

Pandorina morum Mull Bory

Pediastrum duplex

Scenedesmus bernardii G. M. Smith

Scenedesmus dimorphus (Turp) Kutz

Oxfistis crassa Wittrock

Staurastrum iotanum

ZOOPLANKTON

Rotifers

Brachionus calyciflorus

Brachionus guadridenta

Asplanchna sp.

Filinia sp.

Cladocera

Moina

Ostracod

Cypris

Copepoda

Eucalanus elongatus (Dana)

Undinull vulgoris Var. Sewell

Lucifer sp.

Mesocyclops sp.

MACROFAUNA

Mollusca

Anisus (Diplodiscus) *Hyptocylos* (Bensen)

Pilaglobosa (Swainson)

Pilavirens (Lamark)

Planorbis exustus (Deshayes)

Vivipara sengalensis

CRUSTACEA

Macrobrachium javanicum (Heller)

Macrobrachium lamarrei (H. Mibre Edwards)

Macrobrachium rosenbergi (de Man)

INSECTA

Anisops nivea Fieber

Hydrometra sp.

Micromecta punctata (Fieb)

Nepa sp.

Gerrid sp.

Ranatra sp.

Laccotrephes sp.

Sphacrodema annulatum Fabr.

Diplonychus indicus

Limnogonus fossarum fossarum

FISHES

Amblypharyngodon mola Hamilton

Channa punctatus (Bloch)

Colisa fasciata (Schneider)

Esomus dandricus (Hamilton)

Etroplus maculatus (Bloch)

Glossogobius giuris (Hamilton)

Leiognathus aculeatum (L)

Macrognathus aculeatum (Bloch)

Muraena sp.

Mystus vittatus (Bloch)

Oxygaster bacaila Hamilton

Puntius amphibia (Valencienes)

Puntius sophor (Hamilton)

Rasbora daniconius (Hamilton)

Tilapia mossambica (Peters)

AMPHIBIA

Rana hexadactyla

Rana syanaphlyctis Schneider

Rana limnocharis Boie

REPTILES

Natrix sp.

SUMMARY

Ecological investigations in the river Cooum have been made for three years (1988-90). Physical, Chemical and Biological Parameters were analysed at both unpolluted and polluted stations in the river for summer and rainy season. The results suggest that a group of phytozooplankton and Macrobenthos can prove very successful indicators of pollution and can be very useful in monitoring sewage pollution in inland waters.

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