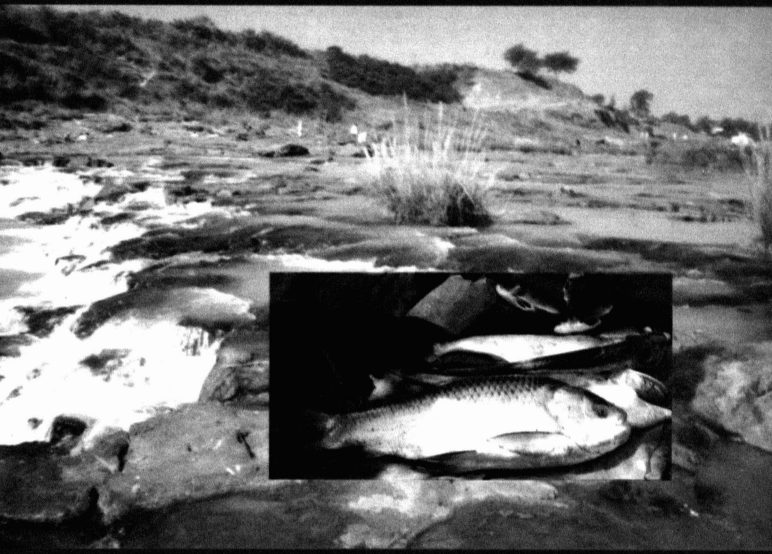
CENTRAL INLAND CAPTURE FISHERIES RESEARCH INSTITUTE BARRACKPORE



RIVER GODAVARI - ENVIRONMENT AND FISHERY

River Godavari - Environment and Fishery

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Central Inland Capture Fisheries Research Institute
(Indian Council of Agricultural Research)
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Foreword

The river systems, which have traditionally supported the inland fishery base of the country, are being subjected to increased environmental perturbations due to population explosion, increased abstraction of water for various purposes, discharge of industrial effluents and domestic sewage and wastes. This has resulted in habitat modifications affecting the biodiversity of the systems.

The Central Inland Capture Fisheries Research Institute, Barrackpore has taken up exploratory survey of all the major river systems of India in order to assess the present status of their environment and fisheries. As part of this survey, river Godavari, the largest of the peninsular rivers was studied by the Bangalore Division of the Institute. The present study, it is hoped, will provide the baseline information to plan future developments, if any. The study has brought out clearly that though the environment by and large is fairly in good condition throughout the course, the fisheries are in an overfished state leading to the reduction of certain indigenous fish stocks. There is a strong case to reduce fishing intensity by diverting part of the fishermen population to other vocations. I hope the information provided in the Bulletin will be useful to State Governments, planners and research workers interested in riverine fisheries.

I take this opportunity to sincerely thank the officials of Department of Fisheries of Andhra Pradesh and Maharashtra for the help and co-operation extended during the investigations.

M. Sinha
Director

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Contents

Physiography and hydrology

The river Godavari is the largest of the peninsular rivers and the third largest in India, next to Brahmaputra and Ganga. It is held in reverence as 'Vridha Ganga'(Old Ganga) or 'Dakshina Ganga'. It rises near Triambakeswar in Deolali hills of Western Ghats, 25 km west of Nasik (Maharashtra state) at elevations ranging from 1219 to 1524 m msl. In its 1465 km long course, the river flows across the Deccan Plateau from Western to Eastern Ghats through the states of Maharashtra and Andhra Pradesh before joining the Bay of Bengal. The catchment of Godavari extends to 3,12, 812 sq. Km with 48.6% in Maharashtra, 23.8% in Andhra Pradesh, 20.7% in Madhya Pradesh, 5.5% in Orissa and 1.4% in Karnataka. It consists of densely forested high precipitation regions of Western and Eastern Ghats and intensely cultivated dry regions with moderate to low rainfall of Deccan Peninsula. More than 90% of the annual run-off in the catchment occur between May and October under the impact of south-west monsoon. The main tributaries are Pranahita, Indravati, Sabari and Manjira. Minor ones are Pravara, Purna, Maner and Kadam (Fig. 1).

The river descends from an altitude of 1524 m at its origin to 17 m in the deltaic stretch. It is swift flowing in its upper and middle reaches forming several riffles and pools. The river has cut deep into basaltic rock forming high banks. Though torrential during monsoon, it generally confines within the high banks and rarely overflows in its lower course. No flood plain lake is there in Godavari or in other peninsular rivers unlike in Ganga-Brahmaputra system.

The river runs about 693 km in Maharashtra and is largely utilised by constructing weirs, barrages and reservoirs for irrigation and domestic purposes. Two reservoirs are situated on the mainstream of Godavari in Maharashtra, the Gangapur reservoir (2230 ha), 15 km below its source and the large Nathsagar (Jayakwadi dam, 35000 ha) at Paithan in Aurangabad district. A 321 m long irrigation barrage is situated at Vishnupuri, 8 km upstream of Nanded and another old weir, the Nandur - Madhyameswar, near Nasik. In addition, there are 12 weirs (Kolhapur type) in this stretch. Due to dams and weirs, the flow in the river is not continuous and water is mainly confined to these points leaving the main course almost dry in post-monsoon and summer months. The important tributaries joining in this stretch are Pravara and Purna.

From Maharashtra, the river enters Andhra Pradesh where Manjira joins at the border. Further down it is joined by tributaries - Kadam, Maner, Pranahita, and Indravathi in succession. The river bed in the upper middle course has disproportionately thin stream after the flood season. Several deep rocky or silty pools occur in this stretch at frequent intervals. These are locally called 'madugulu' in Telugu. One big pool of about 5 km long, *'Lanjanmadugu'*, is situated close to Manthani town (Dist. Karimnagar). These deep pools give shelter to fish during dry months. A large reservoir has been formed at Pochampad in Nizamabad District (Sriramsagar, 45,300 ha) on the mainstream. The tributaries Manjira, Kadam and Maner have reservoirs constructed on them. The river course in the middle stretch

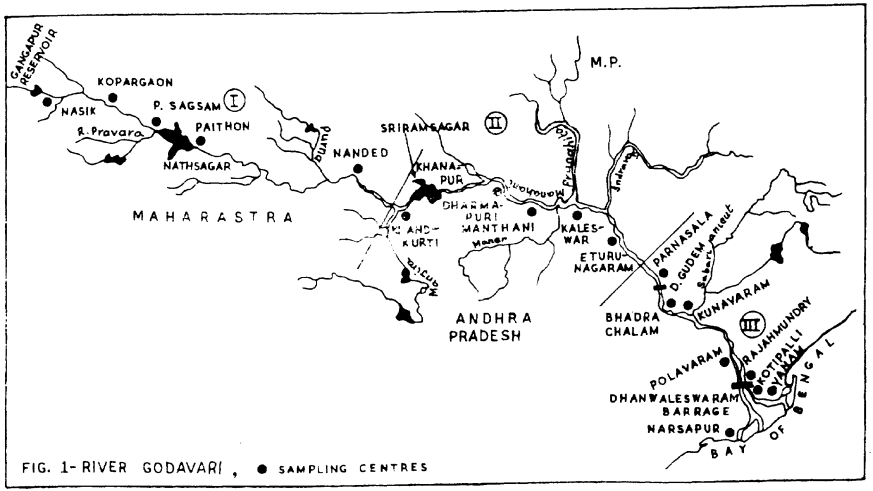


FIG. 1- RIVER GODAVARI , ● SAMPLING CENTRES

passes through intensely cultivated areas except for few kilometers after Lanjanmadugu. At Eturunagaram (Warangal Dist.) the river sprawls nearly 5 km wide over sand and silty stretch forming several islands.

Further down, from Dummagudem and Bhadrachalam extending upto Kunavaram, the river again narrows down to 1 to 1.5 km. At Kunavaram, the river Sabari joins the main stream. After Kunavaram, Godavari pierces through Eastern Ghats, flows through a narrow deep gorge of only 90 m width known as Papi hills. It is the deepest part of the river with depth reaching upto 50 m, but the gradient is only 0.3 m/km. Emerging from the gorge it spreads over the flat area, where it widens to 3-5 km. At Dhawaleswaram, the width is about 8 km. Two anicuts, constructed a century ago, exist in this part of the river, one at Dummagudem and the other at Dhawaleswaram, near Rajahmundry. The river course between the anicuts is used for navigation. The old Dhawaleswaram anicut has been replaced by a barrage in 1985. The barrage has increased the storage level by 0.9 m from + 12.72 to + 13.64 m. Two fish passes (Denil type) have been provided in the barrage, one on the left abutment and the other on the right abutment covering the two distributaries, Gautami and Vasista. From Dhawaleswaram barrage two main canals take off (right & left) irrigating several lakh hectares of land in West and East Godavari districts.

Below Dhawaleswaram, Godavari splits into a northern distributary, the Gautami Godavari and a southern one, the Vasista Godavari. Gautami joins Bay of Bengal 19 km below Yanam. Vasista further divides into the Vainateyam and the main Vasista before opening into the sea. Between the main distributaries lies the extensive fertile delta region.

The Gautami is the widest of the three branches around which most of the fishing villages are located. Below Yanam, it divides into two branches, the northern branch joining the sea at Bhairavapalem and the southern branch further down beyond the fishing village Kottapalem. Vasista opens into the sea near Narsapur whereas Vainateyam at Vadalarevu. The Gautami is linked with Kakinada Bay by its distributaries, the Coringa and the Gaderu, the former taking off at Yanam and the latter at Bhairavapalem. Between Kakinada Bay and Gautami are situated extensive mud flats and dense mangrove forest with several inter connected creeks. Mangrove forests also occur all along the coast between Gautami and Vasista. The tidal effect is felt to a maximum of 49 km in Gautami (upto Kotipalli) in summer.

The annual flood discharge of Godavari varies from a maximum of 80,137 cumecs to a minimum of 42 cumecs. The yield in the river in Maharastra stretch is only 11,000 cumecs. Annual yield at Dhawaleswaram barrage is 1,05,000 cumecs. Thus the contribution of Godavari till it reaches Andhra Pradesh is just 10.5% of the total yield. The tributaries Pranahita (36,810 cumecs) and Indravati (32,650 cumecs) together contribute about 66% of the yield, while Sabari (13,600 cumecs) and Manjira (7,640 cumecs) account for about 20%. The flood discharge at different points of the river is depicted in the flow diagram (Fig. 2)

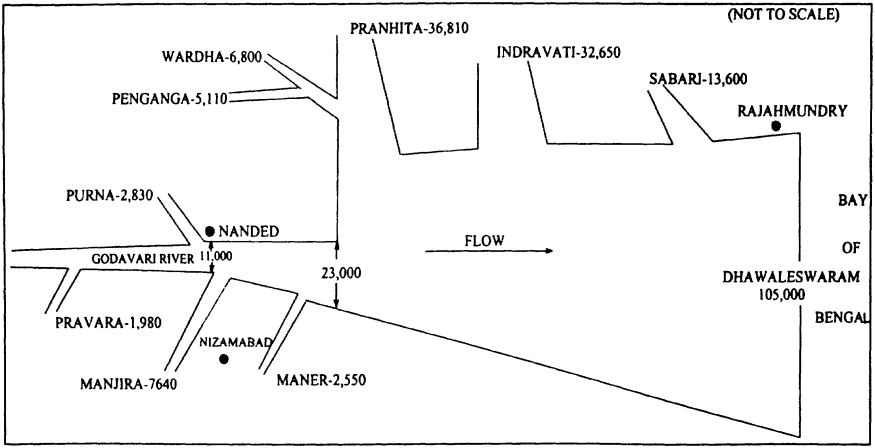


Fig. 2 Flow diagram of River Godavari showing flood discharge (Cumecs) at different points.

Sampling programme

Exploratory survey of the river was conducted during 1997-99 to assess soil and water quality, biological productivity and biotic communities and status of fishery exploitation. An attempt was also made to assess the pollution levels at different centres. For this purpose the river course was divided into upper, middle and lower stretches. From each stretch 5 to 8 centres were chosen for detailed sampling. The criteria adopted in choosing the centres was : location of city discharging sewage, good fishing centres with fishermen assemblage, barrages and dams, confluence of major tributaries and presence of factories discharging effluents.

The river course in Maharashtra from head waters at Nasik to Nanded constitute the upper stretch. The sampling centres in this stretch were : Nasik (Dt. Nasik), Kopargaon, Pravarasangam (Dt. Ahmednagar), Paithan (Dt. Aurangabad) and Nanded (Dt. Nanded).

Andhra Pradesh border, where the river Manjira joins Godavari, down to Eturunagaram constituted the middle stretch. Sampling centres were : Khandkurti (Dt. Nizamabad), Khanapur (Dt. Adilabad), Dharmapuri, Manthani, Kaleswar (Dt. Karimnagar) and Eturunagaram (Dt. Warangal). The big pool near Manthani (Lanjanmadugu) was also sampled for its limnology.

The lower stretch extended from Parnasala (above Dummagudem anicut) to the tidal regions at Yanam and Narsapur. The sampling stations were : Parnasala, Bhadrachalam, Kunavaram (Dt. Khammam), Polavaram (Dt. West Godavari), Rajahmundry, Kotipalli (Dt. East Godavari), Yanam (Pondicherry state) and Narsapur (Dt. West Godavari). Of these, Kotipalli and Yanam are on Gautami branch and Narsapur on Vasista branch.

Each stretch was sampled simultaneously for three seasons *viz.*, pre-monsoon (Apr-May), monsoon (August) and post-monsoon (November). Standard methods were followed for sampling and analyses.

Physical and chemical characteristics of soil

Physical characteristics

Soil texture of Godavari river bed varied from sandy to sandy loam (Table 1). In the upper stretch, structure of the bed appears to have been modified due to weirs and barrages. At Kopargaon and Pravarasangam it is sandy and at other centres it is sandy loam. The middle stretch is predominantly sandy except at the deep pool (Lanjanmadugu), where it is loam sand. In the lower stretch, Bhadrachalam, Kunavaram and Polavaram centres have sandy texture. In other centres it varies from loam sand to sandy loam. In estuarine centres it is predominantly sandy loam. At Nasik, Paithan, Rajahmundry and Narsapur, considerable amount of clay was recorded.

Table 1. Physical and chemical features of sediment of River Godavari

Locations	Mechanical Analysis (%)			pH	Sp. cond. ($mScm^{-1}$)	Organic Carbon (%)	Total Nitrogen (%)	C/N Ratio	Available- N (mg/100g)	Available-P (mg/100g)	Free $CaCO_3$ (%)
	Sand	Silt	Clay								
Nasik	75	11.0	14.0	7.8	0.25	0.44	0.06	8.0	13.5	0.45	3.6
				7.6 - 7.9	0.20 - 0.29	0.45 - 0.48	0.04 -0.09	5.3 -11.3	12.0-15.2	0.40-0.50	3.0 - 3.9
Kopargaon	89	2.6	8.4	8.0	0.34	0.15	0.03	6.4	6.3	0.94	5.5
				7.8 - 8.1	0.30 - 0.38	0.10 - 0.20	0.02 - 0.03	5.0 - 7.5	5.5 - 7.2	0.80- 1.14	4.9 - 5.9
Pravarasangam	87	8.0	5.0	7.8	0.32	0.52	0.06	8.8	13.0	0.64	6.3
				7.7 - 7.9	0.29 - 0.35	0.50 - 0.54	0.05 - 0.07	7.7 - 10.0	10.2 -16.0	0.60 -0.68	6.1 -6.4
Paithan	75	12.0	13.0	7.7	0.25	0.45	0.05	9.5	15.0	1.02	5.6
				7.5 - 7.8	0.23-0.26	0.40-0.50	0.04-0.05	9.0-10.0	12.0-18.0	0.90-1.20	4.3 6.8
Nanded	82	8.0	10.0	8.0	0.31	0.43	0.04	9.8	12.5	0.55	6.2
				7.9 - 8.1	0.27-0.34	0.40-0.46	0.03-0.05	9.2 -10.8	10.5-14.0	0.50-0.58	5.6 - 6.7
Kandkurti	97	2.0	1.0	8.0	0.13	0.05	0.005	8.9	2.2	0.56	5.3
				7.9 - 8.2	0.11-0.14	0.04-0.06	0.004-0.007	8.0 -10.0	1.5 - 3.0	0.50-0.62	4.2 - 6.0
Khanapur	88	5.4	6.6	7.7	0.24	0.27	0.03	11.0	8.2	0.69	2.4
				7.5 - 7.8	0.22-0.26	0.24-0.30	0.02-0.03	10.0-12.0	7.0 - 9.0	0.50-0.80	2.1 - 2.7
Dharmapuri	90	4.8	5.2	7.7	0.19	0.28	0.03	11.5	8.5	0.30	1.7
				7.6 - 7.8	0.18-0.20	0.26-0.32	0.02-0.03	10.7-13.0	7.9 - 9.0	0.25-0.36	1.6 - 1.8
Lanjanmadugu	84	8.6	7.4	7.6	0.34	0.48	0.06	8.8	14.5	0.39	2.1
				7.5 - 7.6	0.32-0.35	0.38-0.56	0.04-0.07	8.0 - 9.5	12.9-16.0	0.36-0.42	2.0 - 2.2
Eturunagaram	85	4.5	10.5	7.9	0.14	0.21	0.03	8.6	7.1	0.30	1.3
				7.8 - 8.0	0.12-0.16	0.20-0.22	0.02-0.03	7.3-10.0	6.6 - 7.8	0.25-0.35	1.2 - 1.4
Parnasala	85	6.5	8.5	7.7	0.36	0.93	0.09	10.0	19.0	0.34	4.1
				7.6 - 7.8	0.30-0.42	0.65-1.25	0.06-0.13	9.6-10.8	17.0-22.0	0.25-0.46	2.8 - 4.8
Bhadrachalam	98	1.5	0.5	7.7	0.13	0.03	0.005	6.0	1.1	0.26	1.1
				7.5 - 7.8	0.10-0.16	0.03-0.04	0.003-0.006	6.7 - 10.0	0.9 - 1.2	0.20-0.30	0.9 - 1.3
Kunavaram	97	1.5	1.5	7.7	0.15	0.03	0.005	6.6	1.1	0.45	0.8
				7.5 - 7.8	0.10-0.20	0.20-0.04	0.003-0.006	5.0 - 8.0	0.9 - 1.2	0.10-0.58	0.6 - 0.9
Polavaram	89	6.0	5.0	7.8	0.48	0.76	0.07	11.3	13.6	0.25	1.8
				7.6 - 8.0	0.30-0.62	0.38-0.98	0.04-0.09	9.5 - 13.4	10.2-17.9	0.20-0.30	1.3 - 2.3
Rajhamundry	80	7.5	12.5	7.9	0.38	1.08	0.11	9.8	27.3	0.39	2.1
				7.5 - 8.2	0.30-0.46	0.80-1.35	0.08-0.14	9.6-10.0	24.9-28.7	0.30-0.52	1.8 - 2.5
Kotipalli	88	3.5	8.5	7.9	0.26	0.58	0.05	12.8	13.4	0.23	3.0
				7.6 - 8.1	0.18 - 0.35	0.46-0.78	0.03-0.07	11.1-15.0	12.1-15.7	0.20-0.26	2.2 - 4.3
Yanam	81	8.0	11.0	8.1	1.29	0.40	0.05	8.0	14.2	0.81	1.0
				7.9 - 8.4	0.82-1.58	0.28-0.54	0.04-0.06	5.6-9.8	12.0-16.0	0.58-1.12	1.0 - 1.2
Narsapur	77	11.0	12.0	7.9	0.80	1.12	0.05	24.4	22.4	0.42	3.4
				7.7 - 8.2	0.50-1.08	0.82-1.36	0.04-0.06	20.5-30.0	20.7-24.2	0.30-0.62	2.3 - 4.3

Chemical characteristics

pH of soil is alkaline throughout the river course and showed no significant variation between stretches (Table 1). The mean pH varied from 7.7 to 8.0, 7.6 to 8.0 and 7.7 to 8.1 respectively in upper, middle and lower stretches. Upper stretch recorded higher values of free $CaCO_3$ (3.6 to 6.3 %). In the middle and lower stretches, the values were in the range 1.3 to 5.3% and 0.8 to 4.1% respectively. The specific conductance of soil was higher in the lower stretch (0.13 to 0.48 μScm^{-1}) as compared to the rest of the freshwater course of the river. Organic carbon varied significantly among the centres. It was 0.15 to 0.52% in the upper stretch, 0.05 to 0.45% in middle stretch, 0.03 to 1.08% in the freshwater zone of lower stretch and 0.4 to 1.12% in estuarine centres. Higher values of organic carbon were recorded near dams and barrages (Pravarasangam, Pamasala and Rajahmundry), deep pools (Lanjanmadugu) and estuarine centres (Narsapur and Yanam). Available phosphorus and nitrogen were very low, the former ranging from 0.23 to 1.02 mg/100 g and the latter from 1.1 to 27.3 mg/100 g of soil. Upper stretch showed relatively higher values of phosphorus. Available N was relatively higher in the lower stretch especially around barrages and cities (Rajahmundry, Narsapur and Pamasala). C/N ratio was in favourable range (6.4 - 12.8) except at Narsapur (Vasista branch) where it was high (24.4).

Physico-chemical features of water

Physical features

Table 2 depicts the physico-chemical features of water at different centres of the river. Water temperature varied from 23.0 - 31.5°C, 26.0 - 31.5°C and 24.5 - 32.9°C respectively in the upper, middle and lower stretches. However, the mean annual temperature fluctuated over a narrow range of 27.0 - 30°C in the entire river course. Transparency (Secchi -depth) was very low in the upper stretch (16-40 cm) except at Paithan. In the middle stretch it varied between 10 and 200 cm and in the lower stretch between 6 and 152 cm. Higher values occurred during post-monsoon and summer months due to reduced flow and relatively stable conditions.

Chemical features

Oxygen values were uniformly high in upper and lower stretches (6.8-8.0 & 8.1-9.8 mgl^{-1}) and some what lower (6.4-7.6 mgl^{-1}) in the middle stretch. pH was in the alkaline range (7.4 to 8.2) throughout the river course. A significant rise in pH during pre-monsoon followed by a drop in monsoon was noted. Barring stray occurrence, free CO_2 was not recorded in the river. Total alkalinity was in the range 99-119 mgl^{-1} in the upper stretch, 137-191 mgl^{-1} in mid-stretch and 96-125 mgl^{-1} in lower stretch. Middle stretch showed distinctly higher values, probably due to inputs from the tributaries (Table 2). At Khanapur and Lanjanmadugu, the values reached beyond 200 mgl^{-1} in summer. Specific conductivity and total hardness showed similar trend as that of total alkalinity in the freshwater part of the river. The conductivity (μScm^{-1}) ranged between 415 and 525 in upper stretch, 373 and 605 in mid stretch

Table 2. Physico-chemical features of water of River Godavari

Centres	Temp. (°C)	Transp. (cm)	DO (mgl^{-1})	pH	Total alka. (mgl^{-1})	CO_3^{-2} (mgl^{-1})	HCO_3^- (mgl^{-1})	Sp.Cond. (μScm^{-1})	TDS (mgl^{-1})	TH (mgl^{-1})	Ca^{++} (mgl^{-1})	Mg^{++} (mgl^{-1})	Chloride (mgl^{-1})
Nasik	27.2 23-30.5	16-34	7.7 7.4-8.1	7.6 7.4-7.8	103 92-114	14 12-16	89 76-102	415 400-430	270 260-280	98 76-120	28.0 19.2-36.9	6.8 -	22.9 17.4-28.9
Kopargaon	28.2 24-31.5	18-25	8.0 7.6-7.4	8.0 7.7-8.4	100 84-116	24 8-40	76 76-76	485 380-591	316 247-384	118 96-140	27.3	12.2 6.8-17.5	69.6 39.8-99.4
Pravara-sangam	29.0 25-32.0	25-32	7.0 5.6-8.4	7.4 7.1-7.7	99 94-104	18 16-20	81 74-88	472 450-493	306 293-320	116 112-120	25.7 -	12.6 11.6-13.6	44.0 42.6-45.4
Paithan	28.2 23.0-31.5	120-180	6.8 6.4-7.2	7.6 7.3-7.8	106 100-112	17 16-18	94 92-96	493 460-526	321 299-342	102 100-104	22.4 -	11.2 10.7-11.6	34.1 25.6-42.6
Nanded	28.3 23.5-31.5	10-40	7.1 7.0-7.2	7.5 7.2-7.8	119 100-138	10 8-12	109 92-126	525 510-540	342 332-351	116 104-128	26.5 24.1-28.9	12.2 10.7-13.6	38.4 34.1-42.6
Kandkurti	28.7 26.0-32.0	10-45	6.4 5.1-7.7	7.7 7.5-7.9	137 136-140	- -	137 136-140	463 420-500	301 273-325	120 100-136	27.0 24.0-30.0	10.8 9.7-11.8	31.0 28-34
Khansapur	29.3 28.0-31.5	15-180	7.4 7.2-7.6	7.8 7.6-8.0	161 88-200	8 -	155 88-196	460 290-560	299 189-364	123 72-156	27.5 22.4-36.3	9.3 3.9-15.9	33.2 25.6-40.0
Dharmpuri	30.0 29.0-31.5	17.75	6.7 6.2-7.2	8.1 7.6-8.7	186 174-196	18 12-24	174 162-188	503 360-650	327 234-423	123 92-140	34.7 25.7-51.3	15.3 2.9-25.6	33.1 25.6-39.7
Lanjan-madugu	29.4 28.8-30.5	110-200	6.6 6.4-6.8	8.2 8.0-8.4	191 180-204	16 -	189 174-204	605 500-710	379 325-462	145 130-156	32.6 24.0-41.7	18.0 10.0-23.3	38.0 36-40
Kaleswar	30.0 29.0-31.0	16-50	6.8 6.5-7.0	8.2 7.9-8.6	158 130-180	8 -	155 122-180	490 390-590	319 254-384	127 98-144	28.3 24.0-32.0	13.7 6.3-20.4	28.0 25-31
Eturu-nagaram	28.6 28.0-29.5	6-150	7.6 6.4-8.8	8.1 7.8-8.4	125 100-148	8 -	123 100-148	373 310-460	243 202-299	112 80-140	27.0 22.0-32.0	11.7 5.8-14.8	29.3 25.6-34.0
Parnasala	27.0 24.5-28.8	8-68	9.1 8.6-10.0	8.2 7.7-8.6	116 92-140	8 -	110 92-130	277 260-300	180 169-195	105 84-138	22.0 19.2-24.0	11 6.8-15.0	25.7 22.7-28.0
Bhadra-chalam	28.0 25.0-30.0	6-120	9.8 8.0-11.5	8.1 7.7-8.4	111 88-136	12 -	107 88-124	343 260-560	223 169-325	99 72-136	23.4 20.8-26.9	9.4 4.8-15.5	27.5 25.6-28.6
Kunavaram	28.3 27.0-30.0	6-120	8.8 8.4-9.5	8.2 7.7-8.6	123 92-140	18 12-24	108 92-120	300 260-340	195 169-221	103 76-120	23.0 20.8-25.0	9.5 5.8-12.6	25.6 22.7-28.4
Polavaram	30.0 28.0-32.9	10-140	8.7 8.0-9.6	7.9 7.6-8.2	96 80-108	8 -	91 72-100	270 230-300	176 150-195	84 64-96	18.4 16.0-20.8	8.7 5.8-10.7	17.0 14.2-19.9
Rajha-mundry	30.0 28.0-32.0	8-120	8.1 7.4-8.8	7.9 7.6-8.2	100 87-120	20 -	93 87-100	267 245-295	174 160-192	85 71-104	22.0 19.7-24.0	7.1 4.8-11.2	22.0 19.9-24.1
Kotipalli	30.0 28.0-32.0	10-152	8.7 8.0-9.6	7.8 7.5-8.3	103 88-130	18 16-20	91 72-110	347 260-450	226 169-293	95 82-108	23.0 20.8-25.7	8.5 6.3-10.7	36.0 14.2-62.5
Yanam	28.0 27.0-29.5	12-120	8.9 8.0-9.9	7.8 7.5-8.2	104 80-120	27 24-30	86 80-96	21413 240-61200	13918 156-39780	1724 72-4800	119.0 24.0-300.0	331.7 2.9-938.8	6837.0 14.2-19880
Narsapur	27.8 27.5-29.0	10-90	8.5 6.9-10.2	7.8 7.5-8.0	125 100-142	27 22-32	107 100-111	36643 336-73600	23818 215-47840	2788 98-5920	374.0 22.0-738.0	450.0 10.0-1219.0	10188.0 28.0-22720.0

and, 267 and 343 in the freshwater part of the lower stretch. The ionic concentration was extremely high at estuarine centers. Total dissolved solids (mgl^{-1}) in freshwater zone varied from 174 (Rajahmundry) to 379 (Lanjanmadugu) with lower values in the lower stretch and higher values in the middle stretch. Total hardness (mgl^{-1}) for the three stretches were in the range of 98-118, 112-145 and 84-105 respectively. Calcium (mgl^{-1}) ranged between 18.4 and 34.7 and magnesium between 6.8 and 18.0 mgl^{-1} in the fresh water zone of the region. Middle stretch recorded distinctly higher values of Ca and Mg, particularly at Lanjanmadugu and Dharmapuri. At estuarine centers these ions recorded extremely high values, Ca in the range 119-374 mgl^{-1} and Mg 331.7 - 450.0 mgl^{-1}. Chloride content was in the normal range (17-44 mgl^{-1}) in the fresh water zone except at Kopargaon (upper stretch) where the values ranged between 39.8-99.4 mgl^{-1} in different seasons indicating stressed environment.

Nutrient status

The mean Nitrate-N values were in the range of 21.0 to 54.5 μgl^{-1} in the entire river course (Table 3). Higher values were noted at Nasik, Kopargaon and Rajahmundry. Phosphate-P ranged between 60 and 180 μgl^{-1} with higher values at Kopargaon, Nanded and Nasik in the upper stretch, Rajahmundry, Polavaram and Bhadrachalam in the lower stretches. All these centres were receiving either sewage and municipal wastes or factory effluents. Silicates were in the range of 8.2-17.8 mgl^{-1} in the freshwater zone. Upper stretch recorded higher silicate content followed by middle and lower stretches. The concentration of nutrients was low during summer but augmented during monsoon.

Primary production

The seasonal means of gross production (GP), community respiration (CR) and production - respiration ratio (P-R ratio) are shown in Fig. 3. The GP in the upper stretch showed wide spatial variation in their magnitude with the values ranging between 0.375 (Nasik) to 2.323 g $C/m^3/d$ (Kopargaon). Kopargaon and Pravarasangam were distinct from the other centres in this stretch and showed significantly higher rates of GP. This could be due to the pool-like conditions prevailing at these centres. Higher level of nutrients at Kopargaon was also reflected in the primary production. The net production (NP) as well as community respiration (CR) rates also exhibited similar trend as that of GP. NP varied from 0.223 to 1.125 g $C/m^3/d$ and CR from 0.223 to 1.20 g $C/m^3/d$. The P-R ratio, an indicator of organic pollution, showed low amplitude of variation and remained high (1.7 to 2.7) suggesting that contribution to respiration component was mainly by phytoplankton.

The GP exhibited limited variation among the centres of middle stretch and the rates were intermediate between the upper and lower stretches. It ranged from 0.183 (Eturunagaram) to 0.549 mg $C/m^3/d$ (Khanapur). The NP and CR also showed identical trends to that of GP with the former ranging between 0.10 and 0.323 g and the latter between 0.05 and 0.25 g $C/m^3/d$. The P-R ratio was within 1.2 to 2.5 at all the centres except at Dharmapuri and Eturunagaram.

Table 3. Nutrient status of water of River Godavari

Centres	NO_3-N (μgl^{-1})	PO_4-P (μgl^{-1})	SiO_2-Si (mgl^{-1})	Centres	NO_3-N (μgl^{-1})	PO_4-P (μgl^{-1})	SiO_2-Si (mgl^{-1})
Nasik	**54.5**	**115.5**	**17.8**	**Parnasala**	**33.0**	**85.0**	**11.0**
	32-77	91-140	12.5-23.0		25-47	40-130	5.0-19.3
Kopargaon	**36.5**	**180.0**	**17.5**	**Bhadrachalam**	**33.0**	**92.0**	**8.2**
	35-38	130-230	11.8-23.2		25-44	25-150	3.3-17.8
Pravarasangam	**31.5**	**74.0**	**13.8**	**Kunavaram**	**34.0**	**85.0**	**8.8**
	30-32	38-110	11.0-16.5		22-45	30-150	3.8-17.5
Paithan	**26.0**	**95.0**	**14.2**	**Polavaram**	**30.0**	**97.0**	**11.2**
	22-30	70-120	9.5-18.8		22-43	50-140	2.4-16.3
Nanded	**35.0**	**99.5**	**13.1**	**Rajahmundry**	**37.0**	**100.0**	**10.4**
	32-38	59-140	10.0-16.2		20-66	62-150	5.0-16.6
Kandkurti	**24.0**	**80.0**	**12.4**	**Kotipalli**	**31.0**	**68.0**	**11.1**
	10-40	10-150	8.0-19.3		22-45	10-170	5.0-16.8
Khanapur	**24.0**	**77.0**	**13.6**	**Yanam**	**31.0**	**65.0**	**7.9**
	10-40	10-140	3.8-25.0		20-44	10-140	3.0-16.2
Dharmapuri	**21.0**	**61.0**	**14.2**	**Narsapur**	**33.0**	**62.0**	**1.8**
	11-30	10-140	5.8-19.3		23-50	10-150	0.1-3.5
Lanjanmadugu	**32.0**	**60.0**	**11.1**				
	23-48	6-130	4.0-18.8				
Kaleswar	**23.0**	**83.0**	**11.7**				
	10-38	34-140	4.5-19.3				
Eturunagaram	**32.0**	**73.0**	**12.8**				
	25-42	25-150	3.8-24.5				

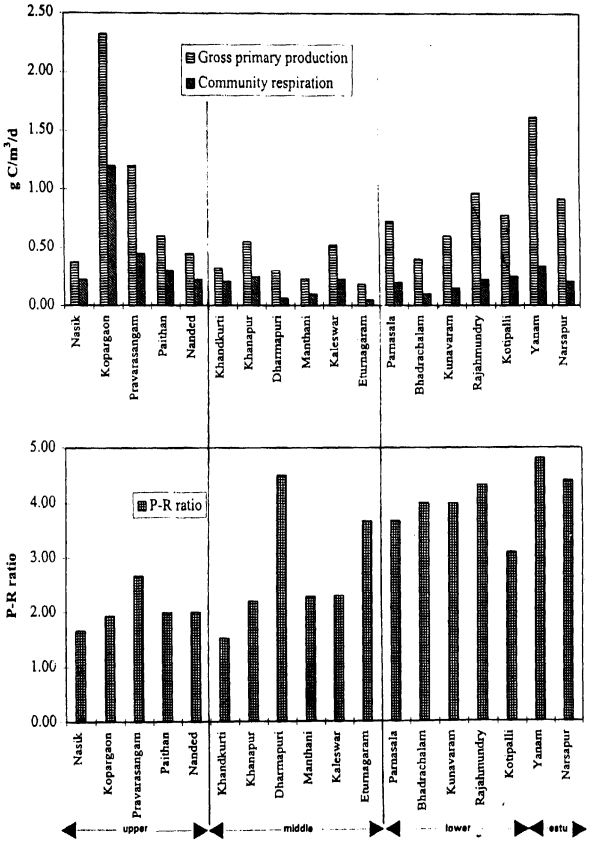


Fig. 3. Primary productivity in River Godavari

The lower stretch showed four-fold variation among the centres, registered high rates of GP than the middle stretch. The rates were between 0.40 (Bhadrachalam) and 1.619 g C/m^3/d (Yanam). Comparatively, Yanam and Narsapur having estuarine conditions were more productive. NP and CR like GP, also showed wide variations with NP fluctuating between 0.429 and 1.29 g C/m^3/d and CR between 0.10 and 0.337 g C/m^3/d. The P-R ratio was distinctly higher in this stretch (3.1 to 4.8) but showed limited variation.

Average GP values for the upper, middle and lower stretches were 0.990, 0.350 and 0.858 g C/m^3/d respectively indicating that the middle stretch is less productive compared to other stretches. The higher production in upper stretch may be due to stagnant water conditions in several parts due to weirs and barrages.

The seasonal variation was not wide in most of the centres of all the stretches with the maximum to minimum ratio being less than 2, barring Manthani, Eturunagaram and Yanam showing the ratio around 5. GP was maximum during post- monsoon in four of the six centres in the mid stretch *viz.* Khanapur, Manthani, Mahadevpur and Eturunagaram. On the contrary, in the lower stretch, production was higher during monsoon in four of the seven centres.

Biotic communities

Plankton

Plankton abundance in Godavari is presented in Table 4. The density of plankton in the upper stretch varied from 11 to 717 u l^{-1}, in the middle stretch from 9 to 6848 u l^{-1} and in the lower stretch 9 to 101 ul^{-1}. Highest density was recorded in the deep pool (Lanjanmadugu) followed by Kopargaon, Kotipalli, Bhadrachalam, Nanded and Rajahmundry. Lanjanmadugu recorded exceptionally high density. The higher nutrient status of water at Kopargaon, Nanded, Bhadrachalam and Rajahmundry was reflected in the plankton production at these centres. These are the centres receiving either city sewage or industrial effluents, especially of paper and sugar factories.

Plankton density in the river showed considerable seasonal variations. During monsoon, due to fast current and turbid conditions plankton crops were poor. It improved considerably in post-monsoon and summer months following cessation of floods and attaining stagnant conditions and increased transparency. The nutrients received during floods seems to have improved plankton production during this period.

Phytoplankton : Phytoplankton showed overwhelming presence in all the centres except in estuaries (Yanam & Narsapur). It was particularly dominant in upper and middle stretches with some centres recording exclusively phytoplankton. The constituents of phytoplankton were chlorophyceae, bacillariophyceae, cyanophyceae and dinophyceae (Table 5). Chlorophyceae occurred in all the centres and was

Table 4. Plankton abundance (ul^{-1}) in River Godavari

Centres	Myxo-phyceae	Chloro-phyceae	Bacillario-phyceae	Dino-phyceae	Rotifera	Cladocera	Copepoda	Phyto (%)	Zoo (%)
Nasik	1	4	3	1	1	1	-	80.0	20.0
Kopargaon	21	570	126	-	5	-	5	99.31	0.69
Pravarasangam	5	4	2	-	-	-	-	100	-
Paithan	1	4	1	-	-	-	-	100	-
Nanded	4	55	20	-	-	-	-	100	-
Kandkurti	3	17	10	-	1	-	5	83.33	16.67
Dharmapuri	1	15	7	-	3	-	2	82.14	17.86
Manthani	-	48	-	3	-	-	10	83.61	16.39
Lanjanmadugu	775	565	5488	-	1	-	10	83.61	16.39
Kaleswar	6	-	-	-	4	4	10	23.08	76.92
Eturunagaram	-	5	-	2	2	-	-	77.78	22.22
Parnasala	-	1	11	-	-	-	-	100	-
Bhadrachalam	4	43	33	-	1	-	1	97.56	2.44
Kunavaram	1	28	1	-	-	-	-	100	-
Polavaram	-	6	1	-	-	-	2	77.78	22.22
Rajahmundry	16	35	16	-	-	-	2	97.1	2.9
Kotipalli	1	76	20	-	-	-	4	92.24	9.76
Yanam	-	-	10	2	13	2	38	18.46	81.54
Narsapur	1	9	9	1	-	-	23	46.51	53.49

Table 5. Plankton diversity in River Godavari

Phytoplankton	Zooplankton
Myxophyceae	***Rotifera***
Microcystis	*Brachionus caudatus*
Oscillatoria tenuis	*Brachionus bidulate*
Amphocapsa sp.	*Notholca sp.*
	Gastropus sp.
Chlorophyceae	***Copepoda***
Pediastrum tetras	*Mesocyclops hyalinus*
Spirogyra singularis	*Cyclops sp.*
Zygnema melanosporum	*Ctenocampus sp.*
Oedogonium oblongum	*Cleptocamptus sp.*
Ulothrix sp.	*Diaptomus forbes*
Sphaerozosma sp.	*Heliodiaptomus viduus*
Tribonema sp.	*Rhinodiaptomus indicus*
Arthrodesmus sp.	*Ctenocampha sp.*
Ceratrias sp.	
Cerastrias sp.	
Protococcus sp.	***Cladocera***
Selenastrum sp.	*Bosmina*
Desmidium sp.	*Ceriodaphnia*
	Diaphanosoma
Bacillariophyceae	
Synedra ulna	***Ostracoda***
Surirella sp.	*Cypridopsis*
Tabellaria sp.	
Gyrosigma scalproides	***Dinophyceae***
Cymbella aspera	*Ceratium hirudinella*
Cyclotella sp.	
Diatoma sp.	
Asterionella sp.	
Gomphoneis sp.	
Fragilaria sp.	
Peronia sp.	
Nitzschia sp.	
Hemantidium sp.	
Centranella sp.	
Staurneis sp.	

particularly dominant at Kopargaon and Nanded in upper stretch, Lanjanmadugu in mid-stretch and Kotipalli and Bhadrachalam in lower stretch. This group was represented by 13 genera. The most common forms were *Spirogyra singularis* and *Zygnema melonosporum.* The next important group was Bacillariophyceae, which also occurred in most of the centres. Lanjanmadugu (mid-stretch), Kopargaon (upper stretch) and Bhadrachalam (lower stretch) recorded higher presence of diatoms. A diatom bloom occurred in Lanjanmadugu during post-monsoon season. The most common diatoms were *Asterionella* and *Tebellaria.* This group was represented by 15 genera. Next in the order of abundance was Cyanophyceae. It also occurred in most of the centres at low concentration, but at Lanjanmadugu it was significant. Myxophyceae was represented by three genera, the dominant forms were *Microcystis* and *Oscillatoria.* The group dinophyceae occurred in only some centres and was represented by a single species *Ceratium hirudinella.*

Zooplankton : Zooplankton abundance improved from upper to lower stretch with highest concentration in estuarine zone, especially at Yanam where it accounted for over 81%. Rotifera, cladocera and copepoda represented zooplankton. None of the groups occurred in all the centres. Copepoda along with their nauplii were relatively more than other groups. This group was represented by eight species, highest among zooplankton (Table 5). The commonly occurring species were *Diaptomus forbesi* and *Cyclops.* Cladocera occurred only at one centre in each stretch and was represented by only 3 genera and the most prevalent form was *Bosmina.* Rotifera was prevalent in mid-stretch and in Gautami estuary. This group was represented by 5 genera, the dominant form being *Brachionus caudatus.*

Plankton studies showed that chlorophyceae is the only group which occurred throughout the river course indicating the freshness of the environment. Myxophyceae occurred in all the centres of upper stretch which may be attributed to the modification of the river course from fast flowing continuous system into discontinuous, shallow and stagnant parts due to construction of weirs and barrages.

Bottom macrofauna

Macrobenthic community is a vital component in the food chain. The invertebrate benthic fauna varied from 261 to 782 organisms/m^2 in the upper stretch, 252 to 2631 organisms/m^2 in the middle stretch and 26 to 2465 organisms/m^2 in the lower stretch (Fig. 4). Upper stretch had relatively less bottom fauna as compared to other stretches. The nature of the river bed had profound influence on the quality and abundance of bottom fauna. Centres with rich fauna were Dharmapuri (2631 no/m^2) and Manthani (1122 no/m^2) in the middle stretch, Polavaram (2465 no/m^2) and Rajahmundry (1217 no/m^2) in the lower riverine stretch and Yanam (1890 no/m^2) in the estuarine zone. In the upper stretch Pravarasangam (739 no/m^2) and Paithan (782 no/m^2) showed higher density than other centres.

The bottom fauna was characterised by poor diversity with only molluscs occurring throughout the river course. Dipteran larvae were confined only to the upper stretch with predominant presence at Kopargaon and Pravarasangam. The

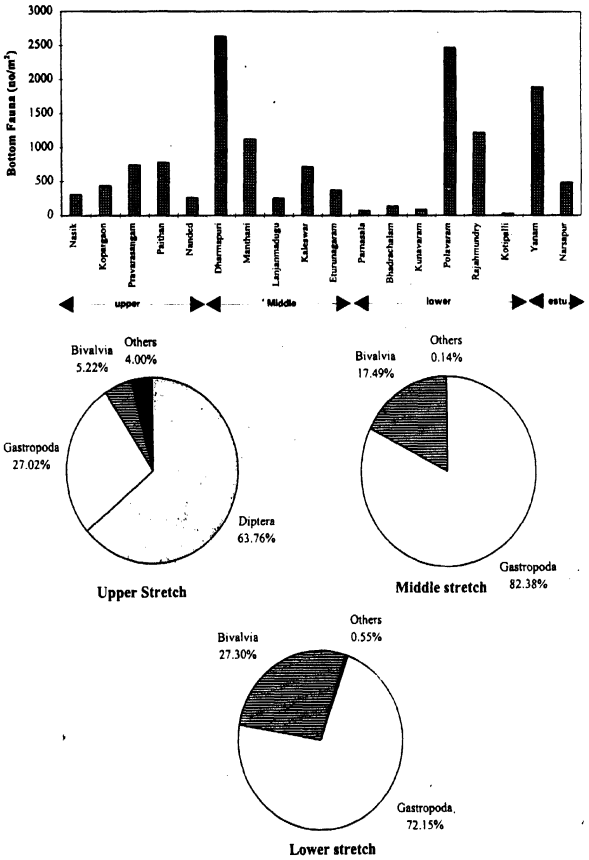


Fig. 4. Bottom fauna of River Godavari

stagnant conditions due to weirs and low water levels probably favoured the establishment of dipteran larvae in this stretch. Molluscs (gastropods and bivalves) were dominant in middle and lower stretches accounting for 97 to 100% of the fauna (Fig 4). Gastropods formed the major,segment of molluscan population and occurred in most of the centres. Common molluscs encountered were *Bellamya bengalensis*, *Thiara tuberculata*, *Brotia costula*, *Pila globosa*, *P. virens*, *Lymnaea acuminata* (gastropods), *Corbicula striatella*, *Lamellidens scutum and L. marginalis* (bivalves).

Littoral fauna consisted of insects, insect larvae and bottom dwelling fishes and prawns. Common insect forms were *Corixa*, *Belostoma*, *Ranatra*, stone fly larvae and nymphs of mayfly and dragon fly.

Periphyton

Periphytic communities settled on submerged substrata were collected from different centres and the average values are depicted in Fig. 5. Upper stretch recorded largest periphytic concentration with an average of 23260 u/cm^2 followed by middle (3926 u/cm^2) and lower stretches (2223 u/cm^2). Centres with rich periphytic deposits were Kopargaon, Nasik, Nanded, Lanjanmadugu and Polavaram. Favourable nutrient features and static water conditions appear to have favoured rich deposition at these centres.

Bacillariophyceae was predominant in periphyton in all the centres except at Pravarasangam and Yanam where Chlorophyceae was dominant. It is interesting to note that Chlorophyceae and Desmidaceae were encountered only in the upper stretch. Diatoms contributed exclusively to periphyton in almost all the centres of mid and lower stretches. A total of 31 genera were recorded in periphyton contributed by Bacillariophyceae (26), Chlorophyceae (4) and Desmidaceae (1). Important forms were *Synedra*, *Fragilaria*, *Gyrosigma*, *Navicula*, *Gomphonema* and *Stauroneis* among diatoms, *Spirogyra* and *Ulothrix* in Chlorophyceae.

Aquatic plants and associated fauna and flora

Macrophytes were recorded in post- and pre-monsoon seasons and were confined mainly to stagnant pools and around islands. Higher densities were recorded in the upper stretch especially around weirs in winter and summer. Some stretches of the river in Maharashtra were completely choked with weeds. In the lower stretch dense growth of weeds and grasses occurred around islands between Rajahmundry and Polavaram. Common plants were *Hydrilla verticillata*, *Potamogeton pectinatus*, *Vallisneria spiralis*, *Ceratophyllum demersum*, *Typha elephantina*, *Najas*, *Eichhornia crassipes*, *Pistia and Spirodela*.

A variety of fauna and flora were found associated with macrophytes. Important flora were *Nitzschia*, *Navicula*, *Gomphonema*, *Pinnularia* and *Amphora*. The macro-invertebrates associated with aquatic plants were *Viviparus bengalensis*, *Melania striatella*, *Indoplanorbis*, *Corbicula peninsularis* (molluscs), insects (*Ranatra Corixa*, *Belostoma*), insect larvae (may fly nymphs), nematodes and oligochaetes.

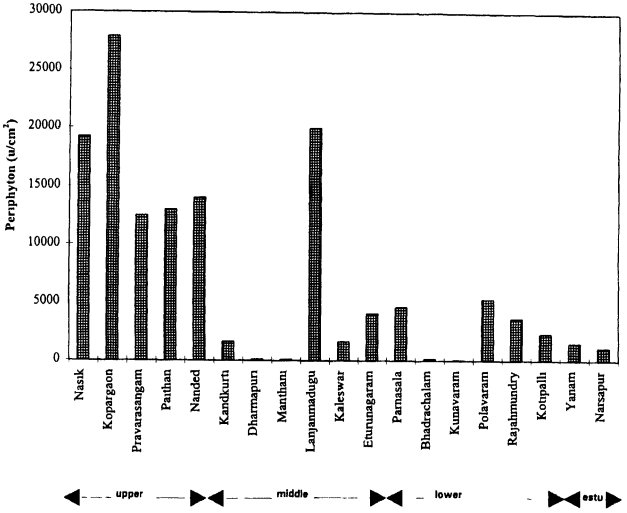
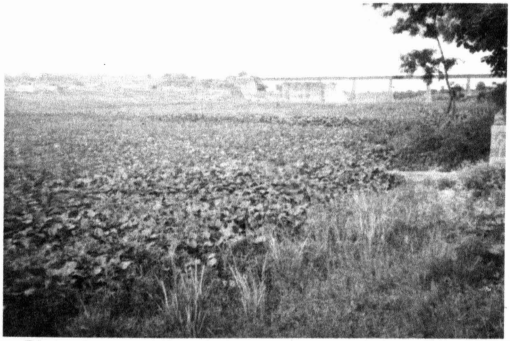


Fig. 5. Periphyton abundance of River Godavari

River course near Paithan in post-monsoon shrunk and invaded by reeds



River course choked with weeds in the upper stretch near a weir

Fishing effort, craft and tackle

In the Maharashtra stretch of Godavari, fishing is free except in certain specified areas. Fishing is also free in the estuaries of Gautami and Vasista. Licensing system is prevailing in Andhra Pradesh from Maharashtra border upto Dhawaleswaram barrage. Lanjanmadugu (Dist. Karimnagar) and the Nandur - Madhyameswar weir (Nasik Dist.) have been declared as sanctuaries for crocodiles and birds respectively. Effort is generally low in upper and middle stretches due to poor catches. It is highly concentrated in the third stretch especially in estuaries and around barrages (Rajahmundry and Dummagudem). The craft and gear used in Godavari vary in different stretches as per the local conditions of the river.

Craft

Boat : The most widely used craft is the flat bottomed plank-built boat, locally called *Nava*. It is mainly owned by full-time fishermen of lower reaches. Besides fishing, it is also used for transport of nets and family belongings when the fishermen migrate to upper reaches of the river. Some of the boats have been mechanised for operation around the river mouth.

Canoe : These are either dug-out or plank-built narrow crafts. Plank-built canoes are generally owned by part-time fishermen resident at Polavaram and around Dummagudem. Fishermen parties from Kolleru lake operate dug-out canoes at Rajahmundry, Dummagudem and Parnasala. Dug-out canoe made from palmyra trunk is a popular craft in Kolleru lake.

Raft: Thermocole rafts are common in upper and middle stretches. It is made up of 2 to 3 thermocole pieces tied together and useful only for plying nets. Inflated motor tubes are also used around Rajahmundry and Polavaram for rod and line fishing.

Gear

Gillnets, seines, castnets, bag nets and several miscellaneous gears are employed in river Godavari. The type of gear operated is mainly determined by the target species and the conditions prevailing in the river.

Drift gillnet : Locally called *Teluvala*, drift gillnets are mainly used in Gautami and Vasista branches and also in the main river, a few kilometers above Dhawaleswaram anicut. It is usually made of nylon monofilament of 40-60 mm mesh bar. It is employed largely for exploiting hilsa during flood season and mullets in estuaries.

Set gillnet : It is usually a multifilament gillnet observed throughout the river course. In A.P. it is called *silukuvala* and is plied during post-monsoon and summer months. Mesh size varies from 25 to 60 mm bar and exploit mainly minor carps and catfishes. Even the drift gill nets are used as stationary nets in post-monsoon months to exploit mullets and carps. In upper stretch, gillnet operation is restricted to specified areas.

Large seine *(Alivivala)* : It is a large shore seine operated by 8 to 10 people, mainly concentrated between Rajahmundry and Polavaram, and between Kunavaram and Parnasala. In earlier years, carps, catfishes and miscellaneous species formed the dominant catch while in recent years, miscellaneous fishes and prawns account for the major portion of the catch. It was a popular gear during 60's but its operation has come down significantly in recent years.

Shore seine *(Jaruguvala)* : The main operational area of *Jaruguvala* is between Rajahmundry and Polavaram. It is operated by 6 to 8 people in combination with *Kontevala* (dragnet) and exploits prawns and small fishes. The number of units have largely come down in recent years.

Small seine *(Lanjavala)* : *Lanjavala* is an abridged version of *Jaruguvala* operated by 2 people, generally from the same family. It is a recent innovation and has become popular in the stretch above Rajahmundry for exploiting prawns. In Khammam district, the Integrated Tribal Development Agency (ITDA) is promoting this net among tribals who have been initiated to fishing in Godavari.

Cast net *(Visuruvala)* : It is the most common net found throughout the river course. Almost every fisherman owns a cast net to exploit prawns and small fishes. Few units with bigger mesh (15-20 cm) exploit large sized major carps (catla and rohu) around anicuts (Dhawaleswaram & Dummagudem).

Bag net : This is known locally as *Gidasavala* or *Tokavala*. Large number of bag net units were found across the river in the estuaries of Vasista and Gautami exploiting estuarine prawns and fishes.

Hook and line : These are mainly observed between Rajahmundry and Polavaram exploiting catfishes and prawns. Individual fisherman operated 2 to 3 units from boats and canoes.

Traps : These are employed mainly at Polavaram for prawn fishing. At Rajahmundry and Parnasala few migrant fishermen from Kolleru lake were found operating basket traps.

During sixties *Benduvala* (drag gillnet), *Kattuvala* (barrier gillnet) and *Kontevala* (dragnet) were popular in specified areas. These nets have been largely withdrawn in recent years.

Fish and fisheries

Fish fauna

Earlier studies- a)on 189 km stretch of Godavari (between Dhawaleswaram and Dummagudem anicuts) by Krishna - Godavari unit of CIFRI and b) the ICAR sponsored project, 'Hydrobiological and faunistic survey of Godavari estuary' by the Zoology Department of Andhra University- brought out the richness of fish fauna of

Fishers with thermocole rafts in middle stretch

Fishing boats in the lower stretch

Laying a monofilament gillnet

Godavari river. The Krishna-Godavari unit recorded 83 species of fish belonging to nineteen families in the freshwater zone of the river. The Andhra University team recorded 224 species belonging to sixty seven families in the estuarine zone. These, however, included a good number of marine species which frequented the lower estuary during summer and freshwater fishes in upper estuary during floods, besides the euryhaline species.

During the present investigation, three species were recorded for the first time. These are - *Rhinomugil corsula*, *Osteobrama vigorsi* and *Oreochromis mossambicus*. *R. corsula* is a Gangetic species introduced inadvertently in reservoirs and rivers of Peninsular India, along with carp spawn brought from Calcutta. Similarly tilapia has been introduced into Kolleru lake accidentally in late eighties and now has found its way into the irrigation canals of Godavari and its estuaries.

Some of the large and medium sized fish recorded earlier, *viz. Tor musullah*, *Thinnichthys sandkhol*, *Labeo kontius*, *L. gonius*, *Cirrhina horai* and *Bagarius bagarius*, were not encountered during the present study. Probably these fishes might have become rare.

Fish catch and composition

Estimation of catch and catch composition in riverine fisheries pose considerable problems due to absence of specific landing and marketing centres. An organised sampling programme spread over a reasonably long time is needed to get a true picture of the catch and composition. The present study, being a rapid survey, gives only a broad picture of the fishery that could be obtained through market survey and interaction with fishermen.

Upper stretch

Fishing activity in the upper stretch of Godavari is mainly centered around weirs, barrages and reservoirs. Fishery was very poor in the head waters and consisted mostly of miscellaneous fishes. In Nanded district, 134 km stretch of the river has been leased to co-operative societies. The annual catch in this part is reported to be around 100 t consisting of carps (catla, rohu, mrigal, fimbriatus), catfishes (seenghala, aor) and miscellaneous fishes. Nanded centre used to be an important prawn fishing ground *(M. malcolmsonii)* before the construction of Sriramsagar dam at Pochampad in the middle stretch. Now this species has disappeared from this stretch. It is significant to note the occurrence of poecilids, *Gambusia affinis* and *Poecila (Lebistes) reticulata*, in the isolated pools of the river.

The Nathsagar reservoir at Paithan is in neglected condition with very little fishing activity.

Middle stretch

Fishing in middle stretch commences from October and continues till May. Castnets and gillnets (12-50 mm mesh bar) are employed to exploit carps, catfishes and miscellaneous species. Fishermen are part-time operators and the catches are at subsistence level. Among carps *L. fimbriatus* was the dominant species followed by *L. rohita* and *C. mrigala*. *L. fimbriatus* occurred in the size range 29-42 cm (mode 35 cm), *L. rohita* 45-75 cm, and *L. calbasu* 32-45 cm in the post-monsoon months. Large catfishes *M. seenghala*, *M. aor*, *S. childreni* and *W. attu* also occurred significantly. The mahseer, *T. khudree* was encountered rarely. Prawns *(M. malcolmsonii)* were caught at Eturunagaram and Manthani centres by migratory fishermen. The deep pool Lanjanmadugu is productive but it has been declared a crocodile sanctuary.

The Sriramsagar reservoir has so far remained undeveloped and any development of fisheries in this reservoir will have a positive impact on the upstream and downstream fisheries of the river.

Lower stretch (Riverine zone)

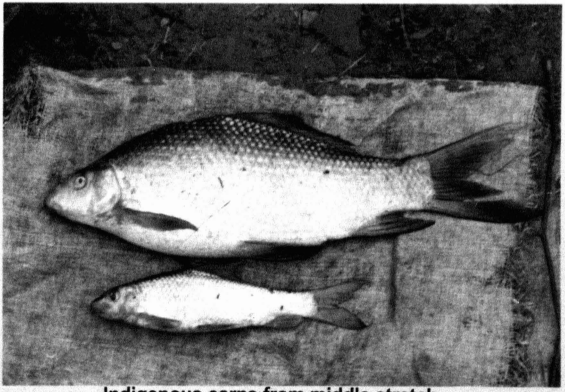
With the cessation of floods, some fishermen parties from down stream of Gautami and Vasista migrate upstream along with their families and live in temporary settlements all along the river above Rajahmundry. They migrate as far as Eturunagaram in mid-stretch and return to their homes with the onset of monsoon. Fishing in the stretch from Rajahmundry to Parnasala and above is mainly conducted by these migratory fishermen parties during October to May/June.

The stretch between the anicuts Dummagudem and Dhawaleswaram is the most productive part of the river. Fishing activity is intense between Dhawaleswaram and Polavaram. Beyond Polavaram fishing is subdued due to deep gorges and poor communication facilities. The activity again picks up after Papi hills and is centered around Jidiguppa, Kunavaram, Bhadrachalam, Dummagudem, Parnasala and Cherla.

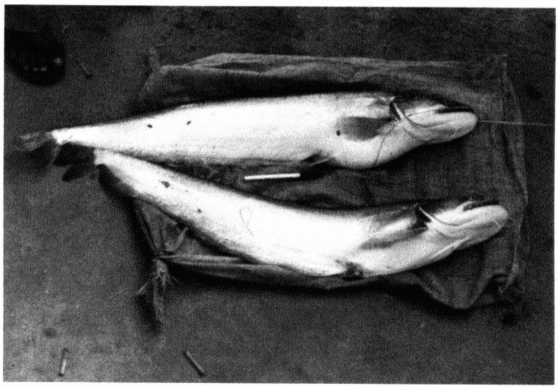
At Dhawaleswaram and Rajahmundry, fishing is done almost throughout the year. During monsoon the target species is hilsa. Though fishing is prohibited close to the barrage in the two distributaries, intense fishing was observed in this part of the river. Fishermen were found operating close to the barrage with set gillnets at Dhawaleswaram, Bobbar lanka, Maddur lanka and Vijjeswaram parts of the barrage thus blocking the migratory route of the fish both in Gautami and Vasista branches. Hilsa catches were not recorded beyond Rajahmundry during the present study. Stray specimens, however, occurred at Kunavaram in river Sabari. Incidentally bumper catches of hilsa were obtained during 1996 as far as Dummagudem.

During monsoon and post-monsoon large sized major carps, catla (70-80 cm) and rohu (50-78 cm) were caught using castnets at Rajahmundry. From January to June, fishing is mainly for prawns using seines, traps, castnets and lines. Fish occurs

Major carps and catfishes from middle stretch



Indigenous carps from middle stretch



***Wallago attu* from middle stretch**

Prawn (*M.malcolmsonii*) catch from rod and line at Polavaram

in these gears only as a by-catch. Besides miscellaneous fishes, juveniles of commercial fishes such as *M. seenghala* (13-19 cm), *S. childreni* (11-16 cm) and *L. fimbriatus* (13-15 cm) occurred in considerable numbers. At Polavaram, traps and lines are common. Each fisherman exploits daily upto 0.75 kg of prawns through line fishing. The annual prawn catch is around 1.2 t. in the stretch. Between Kunavaram and Parnasala / Cherla, each migratory fisherman catches on an average 0.6 kg of prawns daily and about 100 to 120 kg in the season. Thus each family earns around Rs. 12,000 to 15, 000 through prawn fishing. The fish they get as by-catch (1-2 kg/day) sustains the family on daily basis.

Dummagudem used to be a good fishing ground for *L. fimbriatus*, but the fish is no longer available here. The *Benduvala* (drag gillnet) which was specific to *L. fimbriatus* has been withdrawn due to paucity of the species.

Estuarine zone

At Narsapur (Vasista) and Yanam (Gautami), penaeid prawns, mullets, hilsa, perches, sciaenids, clupeids and catfishes accounted for the commercial catch. The bagnets are mainly used to exploit prawn. However, large number of miscellaneous fish occurred in the bag nets as by-catch. Drift and set gillnets are employed for hilsa, mullets, perches and other commercial fishes.

At Kotipalli (above Yanam), fishing is mainly done with set and drift gillnets for hilsa, major carps, mullets and other fishes. Above Narsapur on Vasista, fishing operations are similar to Gautami.

A single species of prawn *Macrobrachium malcolmsonii* accounted for the prawn catch in the riverine zone while several species in the estuarine zone. The important ones are *Penaeus indicus*, *P. monodon* and *Metapenaeus* spp.

In the riverine zone major carps *L. rohita*, *C. catla*, *C. mrigala* and *L. fimbriatus* occurred in the stated order of abundance. Catfishes were represented by *M. seenghala*, *M. aor*, *S. childreni*, *P. pangasius*, *P. taakree* and *W. attu*. Miscellaneous group included *Osteobrama* spp. *Oxygaster* spp. *N. notopterus*, *C. reba*, *Puntius* spp. and others. In the estuaries *Mugil parsia*, *M. cephalus*, *Lates calcarifer*, *Thryssa* spp. *Pseudosciena coibor*, *Arius* spp., *Gerres* spp. were the common fishes.

Changes in the catch and catch structure with time

The fisheries of Godavari in the 189 km stretch between Dhawaleswaram barrage and Dummagudem anicut have been investigated by the Krishna-Godavari unit of CIFRI, Rajahmundry, during 1963-69. In the seven year period, the fishery witnessed spectacular changes with several fold increase in fishing effort, but the catch per unit effort and total catch declined. The average size of individual fish species declined in the catch continuously, compelling the fishermen to reduce the mesh size. With the result, the total catch declined over the years from 330 to 218 t.

Species which showed sharp decline were *L. fimbriatus* (from 35.0 to 11.7 t), *M. seenghala* (21.9 to 6.4 t), *P. pangasius* (5.2 to 0.5 t), *S. childreni* (4.1 to 1.6 t) and *B. bagarius* (7.8 t to negligible quantity). Only *C. catla* increased by 100% (1.5 to 3.1 t). Prawns and hilsa fluctuated around a mean, characteristic of migratory species. The decline in the catch of indigenous carps and catfishes despite increased effort and reduction of mean size in the catch, all pointed that these stocks are overfished.

During the present investigation, it was observed that fishing was mainly concentrated on hilsa (July-October), prawns (November-June) and major carps (Aug-Sept). *L. fimbriatus* appears to have declined further in this stretch. It is no more a target species at Dummagudem as it used to be during sixties. *Benduvala* operation discontinued and the set gillnets operated here exploited rohu and mrigal. *L. rohita* which was insignificant during earlier years have greatly improved.

Large catfishes such as *M. seenghala*. *S. childreni* and *P. pangasius* occurred mostly by their juveniles. The juveniles of *P. pangasius* used to occur in large quantities at Dhawaleswaram anicut. They have become insignificant after the replacement of anicut with barrage. Dhawaleswaram anicut was also a place of collection of prawn seed in large quantities. The replacement of anicut has changed the scenario in prawn seed availability. Though it is still being collected, fishermen complained about the decline in abundance.

Problem of overfishing

The studies of Krishna-Godavari unit have brought out clearly that the fish stocks of Godavari, especially *L. fimbriatus*, *M. seenghala* and *S. childreni* have been overfished. Though some remedial measures were suggested to recover the stocks, no effort seems to have been made in that direction in the last 30 years. A 25% reduction in the effort of all gears has been suggested, but it appears to have gone up further by several fold during the last 30 years. Though a direct evidence could not be obtained on the increased effort, the following indications are available.

The fishermen exploiting the stretch of the river are predominantly full-time operators. They are skilled in river fishing and depend fully on the river for their sustenance. They generally do not go for any other work other than fishing. Every family has more than three children as the small family norm was not appreciated. The natural increase in population seems to have contributed to the increase in effort to a great extent.

The lucrative price fetched by prawn and hilsa has attracted other communities such as schedule caste and tribes and other backward classes to fishing. Even fishermen from Kolleru lake migrate to exploit prawns in the river during summer months when fishing is suspended in Kolleru. There are also indications of tremendous increase in seining operations. Small seines *(Lanjavala)* have replaced large ones *(Jaruguvala)* due to operational advantage enabling each family to own and operate a seine.

The net result is that fishing intensity increased enormously and different fish species reacted differently. The indigenous carp (*L. fimbriatus)* and large catfishes *(M. seenghala, S. childreni*) which together contributed about 70 t in 1963 have reduced to insignificance. By and large, quantum of flood flows determine the abundance of Hilsa as it is a migratory species. Unprecedented catches of hilsa was recorded in 1996 but the catches were meagre during 1998 season. The juveniles of hilsa are not likely to be affected by the seining as their nursery grounds are mainly situated in the Gautami and Vasista branches where large scale seining is not practiced. Intensive seining appears to have improved the populations of the miscellaneous fishes. This may be due to their short life span, prolonged breeding, higher survival (absence of predation) and higher relative growth.

Socio-economic status of fishermen

In Maharashtra, though a large number of fishermen exist, only handful of them are active in river fishing. The fishermen belong to the castes *Bhoi, Koli, Kahar, Danger* and *Matanga.* Adivasis and other communities also have taken to fishing at some points. Most of them are part-time operators. Average daily income from fishing during the season range between Rs. 20 and 25. They are mostly illiterate and distressingly poor.

Along the river Godavari in Andhra Pradesh, there are several castes whose vocation is fishing . The methods of fishing and the type of craft & gear employed largely depend on the individual castes and their location on the river. The traditional fishermen castes in the lower reaches of Godavari are : *Agnikulakshatriya, Jaalari, Vaddi* and *Bestha.* In recent years other castes have also entered into selective areas of fishing. Thus other backward classes and schedule castes around Dhawaleswaram barrage have taken to hilsa fishing during monsoon. The ITDA has initiated tribals in Khammam and Warangal districts to fishing, providing them with nets (*Lanjavala*) and boats.

The largest fishermen community in Godavari belt is *Agnikulakshatriya.* Fishing in middle and lower stretches of Godavari is mostly done by this community. Some families regularly migrate to upper reaches as far as Eturunagaram during October and return with the onset of rains. Some families have permanently settled in villages along Godavari. These are full-time fishermen and do not take up any other activity unconnected with fishing. They are mostly illiterate. Children join parents in the vocation at young age and help them in sundry activities. Other than a house (constructed with government help) and a boat, they have no permanent assets such as land and animals. Generation after generation, they have been depending for their sustenance on the limited resource of the river. As fishing provides only hand to mouth existence, they have remained in poverty. Family welfare programmes have been practiced only by the younger generation. Getting a male child is still a priority and in that process the family size increases. Women folk generally attend to the marketing of the fish catch and house keeping. Some actively participate in seining.

The economic condition of the community has not changed significantly over the years in spite of their hard work and fishing skills. Their main recreation is listening to radio and having a drink of country liquor after day's hard work.

Other communities such as *Jaalari*, *Vaddi*, *Gangaputra* and *Bestha* form small part of fishermen and are less dependent on the river. They reside permanently at one place and are part-time operators. They have canoes & rafts and operate gillnets, traps, castnets and rod & lines. Some work as agricultural labourers and others cultivate the piece of land they possess. They compete poorly in fishing skills with migrant fishermen (*Agnikulakshatriya*) from coastal districts. Majority of them live in penury with hand to mouth existence.

The socio-economic conditions of the major fishermen community (AKS) and others are depicted in Table 6. All the communities come under the backward category and are entitled to reservation in education and employment. Most of them are not able to take advantage of benefits because of the nature of their vocation. The children do not enjoy the kind of benefits available to SC and ST categories for education.

Conservation of fish stocks *vis-a-vis* socio economic status of fishers

The limited resource of riverine sector is being subjected to intensive exploitation. With the result the resource has been over exploited with disastrous consequences to the biodiversity of the system. Legislations aimed at limiting effort, declaring closed seasons and sanctuaries have not made any impact. Enforcing legislations in riverine fisheries is a daunting task for obvious reasons. Without the willing co-operation of fishermen, implementation of various conservation measures is well-nigh impossible. Improvement of socio-economic status of the community holds the key for the success of conservation measures in riverine sector. The following measures are suggested for improving the socio-economic condition of the fishers.

- Government should help the community to settle permanently at one place. NGOs may also be involved in this task.

- Children of the community should be imparted compulsory education. This will help the children to attend school and other childhood activities.

- Scholarships and hostel facilities, presently available to SC and ST communities, should be extended to the children of fishermen community.

Migratory fishermen at Lanjanmadugu (middle stretch)

Migratory fishermen at Polavaram

Interaction with fisheres

Table 6. Socio-economic status of fishermen communities

Characteristics	AKS [1]	Others [2]
No. of families sampled	71	78
Ave. age of head of family (yrs)	42.0	41.1
Ave. family size	5.21	5.41
Sex ratio (Male : Female)	1:0.96	1:0.89
Literacy Level (%)		
Primary	15.5	23.1
High School	23.9	14.1
College	9.9	1.3
Illiteracy	50.7	61.5
Housing (%)		
Pucca	38.1	62.8
Katcha	57.7	26.9
Others	4.2	10.3
Craft (%)		
With craft	84.5	66.7
Without craft	15.5	33.3
Gear (%)		
Castnet	Almost all	Almost all
Gillnet	57.8	34.6
Drift Gillnet	38.0	14.1
Seines	21.2	9.0
Others	12.7	15.4

1 - *Agnikula Kshatriya Community.*

2 - *Includes communities such as Jalari, Gangaputra, Gundla, Namasudra, Bestha, Vaddi, Yanadi, Pallekaru, etc.*

- The community should be weaned away from river fishing by providing alternate avenues such as leasing the water bodies to them on reasonably long periods.

- The large number of tanks and reservoirs in the state should be developed for fisheries and settle fishermen around these water bodies.

- Govt. should discourage non-traditional fishermen entering this sector.

Proposed dams on Godavari - changes envisaged in fish stocks

River Godavari is the least utilised river in Peninsular India in terms of its water usage for irrigation and power. Several projects in A.P. on this river are awaiting clearance for execution. One of the long pending projects is a dam at Polavaram, 50 km upstream of Dhawaleswaram barrage. The 120 ft high dam, when it comes up, will have far reaching influence on the fisheries of Godavari above and below the dam.

The prawn, *M. malcolomsoni*, which at present migrates as far as Manthani in the middle stretch of Godavari and also into the tributaries in Madhya Pradesh and Maharashtra, would vanish above the Polavaram dam. The species has already vanished beyond Sriramsagar. The prawn fishing ground will be restricted upto the Polavaram dam.

The anadromous hilsa, hitherto migrating upto Dummagudem anicut during years of good flood discharge would be restricted upto Polavaram, a loss of 150 km of migratory route. The vulnerability of the fish may also increase.

Major carps which breed and use Dhawaleswaram barrage area as nursery ground may be affected as the breeding grounds get restricted to the 50 km stretch. If that happens, the recruitment of carp juveniles into the irrigation canals of Godavari and Kolleru lake will be affected.

Reservoirs are known to serve as sanctuaries for rare and endangered species. The reservoir to be formed above Polavaram may have a positive impact on some carps and catfishes which have become rare at present due to overfishing. The species which are likely to flourish in the new impoundment are : *L. fimbriatus*, *M. seenghala*, *M. aor*, *S. childreni and P. pangasius*. Besides several minor carps and catfishes may also flourish.

Pollution scenario

Rapid urbanization coupled with industrialization have generated organic and inorganic pollutants which finally find their way into the riverine ecosystem causing environmental degradation. River Godavari is no exception to this process. The main source of pollutants are effluents of paper board factory at Bhadrachalam, paper mills at Rajahmundry and Yanam and Rayon factory at Eturunagaram. The sewage and municipal wastes are also being discharged at Narsapur, Rajahmundry, Nanded and Nasik. The effluents from the paper mills at present appear to have no adverse effect on aquatic life. The effluents of Bhadrachalam paper boards are being used as fertilizer to dry-land crops situated on the banks of the river. Several pump sets are installed on the bank to lift the discharged effluents, before it gets into the main stream, for irrigating cotton and chilli crops.

The determinants of pollution are the biological oxygen demand (BOD), chemical oxygen demand (COD) and concentration of heavy metals in different strata such as water, sediment and living organisms. The average BOD and COD values were in the range 0.2-1.5 mg/l and 4.0-42.0 mg/l respectively. Higher values were observed during pre-monsoon. Only two centres, Kopargaon (upper stretch) and Rajahmundry (lower stretch) showed signs of pollution in pre-monsoon in respect of BOD and COD.

Heavy metals

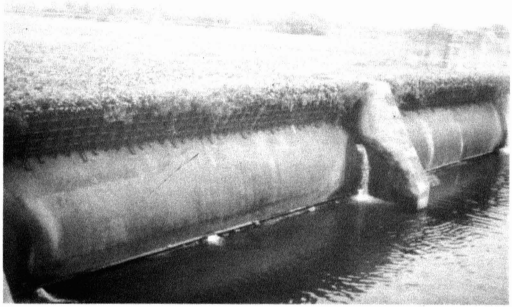
Heavy metal concentration in sediment, water and fish flesh is presented in Tables 7 and 8. The beneficial trace metals like Zn and Cu were recorded at higher levels in the sediments of upper and middle stretches in the range 119.6-198.4 mg kg^{-1} and 46.9-117.9 mg kg^{-1} respectively. From Kaleswar (mid stretch) and down below, all the centres except Kunavaram showed relatively low levels of Zn (62.9 - 104.7 mg kg^{-1}) and Cu (35.7 - 86.1 mg kg^{-1}), probably due to dilution effect of the major tributaries, the Pranahita and Indravati. However, river Sabari appeared to have contributed to the high level of Zn (157.7 mg kg^{-1}) at Kunavaram. Among toxic metals Cd occurred in the range 1.5-3.3 mg kg^{-1} in upper and middle stretches and 0.3-1.1 mg kg^{-1} in lower stretch. Lead was in low concentration throughout the river course in the range Tr - 2.0 mg kg^{-1}.

Higher concentration of heavy metals in sediments was not reflected in ambient water where all are in low levels. Toxic metals could not be detected in water except at Nasik where Pb was recorded at 0.3 mg l^{-1}. In fish flesh all trace metals occurred within the permissible levels.

Table 7. Heavy metals in sediment and water of River Godavari

Centres	Sediment ($mgkg^{-1}$)				Water (mgl^{-1})			
	Zn	Cu	Cd	Pb	Zn	Cu	Cd	Pb
Nasik	168.7	54.5	2.7	Tr - 0.2	0.03	Tr - 0.03	ND	0.3
Kopargaon	198.4	58.8	1.6	Tr - 0.2	0.02	Tr - 0.02	ND	ND
Pravarasangam	141.2	53.3	1.7	Tr - 0.2	0.05	Tr - 0.02	ND	ND
Paithan	148.8	68.0	1.6	-	0.03	Tr - 0.02	ND	0.07
Nanded	135.5	117.9	3.3	Tr - 0.03	0.04	Tr - 0.02	ND	ND
Kandkurti	127.7	62.8	2.7	Tr - 0.5	0.03	Tr - 0.01	ND	ND
Khanapur	119.6	48.7	2.9	Tr - 0.2	0.03	Tr - 0.01	ND	ND
Dharmapuri	142.9	46.9	2.1	Tr - 0.4	0.02	Tr - 0.01	ND	ND
Lanjanmadugu	116.5	63.1	4.2	Tr - 0.3	0.03	Tr - 0.01	ND	ND
Kaleswar	82.1	41.5	1.9	Tr - 0.2	0.03	Tr - 0.01	ND	ND
Eturunagaram	62.9	39.0	1.5	Tr - 0.2	0.03	Tr - 0.02	ND	ND
Parnasala	78.2	55.5	1.1	Tr - 1.0	0.04	Tr - 0.03	ND	ND
Bhadrachalam	63.3	37.8	0.5	Tr - 0.2	0.04	Tr - 0.02	ND	0.01
Kunavaram	157.7	35.7	0.7	Tr - 0.3	0.03	Tr - 0.01	ND	ND
Polavaram	66.9	56.2	0.3	Tr - 0.3	0.04	Tr - 0.02	ND	ND
Rajahmundry	83.2	53.0	0.5	Tr - 0.5	0.10	0.04	ND	ND
Kotipalli	74.6	69.2	0.3	Tr - 0.2	0.03	Tr - 0.02	ND	ND
Yanam	95.4	48.0	0.7	Tr - 1.5	0.04	Tr - 0.02	ND	Tr - 0.03
Narsapur	104.7	86.1	1.0	Tr - 2.0	0.05	0.03	ND	Tr - 0.01

Effluent of paper mill discharged at Bhadrachalan



River course choked up with hydrophytes at Eklahare

Table 8. Heavy metal accumulation ($mgkg^{-1}$) in fish of River Godavari

Centres	Species		Zn	Cu	Cd
Parnasala	*P. kolus*	(Tissue)	16.3	2.7	ND
		(Gill)	31.4	4.6	ND
Kunavaram	*M. corsula*	(Tissue)	12.9	3.1	ND
		(Gill)	22.5	5.3	ND
Polavaram	*M. cavasius*	(Tissue)	16.3	3.1	ND
		(Gill)	36.1	6.2	ND
Rajahmundry	*M.cavasius*	(Tissue)	18.5	3.8	0.1
		(Gill)	29.7	7.9	0.3
Kotipalli	*M. aor*	(Tissue)	19.2	2.8	ND
		(Gill)	3.6	6.9	ND
Yanam	*C. chanos*	(Tissue)	16.6	3.2	0.1
		(Gill)	45.2	5.8	0.2
Narsapur	*P. coibor*	(Tissue)	16.0	2.2	0.1
		(Gill)	27.1	4.6	0.4

Summary

River Godavari, the largest of Peninsular rivers, takes its origin in Western Ghats near Nasik, flows eastward through the states of Maharashtra and Andhra Pradesh and joins Bay of Bengal. The catchment of the river includes densely forested high rainfall zones of Western and Eastern Ghats and intensely cultivated dry regions of Deccan peninsula with low rainfall. The main tributaries are the Pranahita, the Indravati, the Manjira, the Sabari and the Purna. In the Maharashtra stretch two reservoirs, two barrages and 12 small weirs have been constructed on the main stream, tapping the river for irrigation and domestic purposes. In the middle stretch (Maharashtra border to Eturunagaram in A.P.) major tributaries join the river. Deep rocky or silty pools are found at frequent intervals. A large reservoir (Sriramsagar) and a deep pool, the Lanjanmadugu extending to over 5 km, are situated in this stretch. In the lower stretch, two old anicuts exist, one at Dummagudem and the other at Dhawaleswaram (189 km downstream near Rajahmundry). The Dhawaleswaram anicut has been replaced by a barrage recently. After Dhawaleswaram the river divides into a northern distributary called Gowthami and a southern one Vasista, the latter gives off the branch Vainatheyam ,before joining Bay of Bengal.

Sand dominated the river sediment (75-97%) with significant clay content in deep pools, around anicuts and estuarine zones where organic carbon was also high (0.5-1.12%). Nutrients in general were in poor concentration except around cities where sewage and municipal wastes are discharged. Water quality generally reflected soil condition. pH was in alkaline range (7.6-8.1). The alkalinity varied between 98 and 191 ppm with middle stretch showing higher values. Conductivity, hardness, Ca, and Mg showed similar trend as that of alkalinity. Nutrients (phosphate & nitrate) were generally low (60 -180 & 21-545 μgl^{-1}).

Upper stretch showed higher rates of primary production (GP 0.375-2.323 g $C/m^3/d$) due to stagnant water conditions created by weirs and barrages, followed by lower (0.40-1.169g $C/m^3/d$) and middle (0.183-0.549g $C/m^3/d$) stretches. Plankton in general was poor except at barrages, weirs and deep pools. Phytoplankton was overwhelming in most of the centres. Green algae occurred predominantly throughout the river course indicating the freshness of the environment. A total of 31 genera of phytoplankton and 14 of zooplankton were recorded from the river. Macrobenthic fauna varied from 261-782 organisms/m^2 in upper stretch, 252-2631 organism/m^2 in the middle stretch and 26-2465 organisms in the third stretch. Molluscs dominated bottom fauna except in the upper stretch. Periphyton was rich in the upper stretch followed by middle and lower stretches, mainly contributed by Bacillariophyceae. Macrophytes were recorded in post and pre-monsoon months mainly confining to stagnant pools and around islands, largely contributed by *Hydrilla*, *Potamogeton*, *Ceratophyllum*, *Pistia and Eichchornia*.

Fishery is exploited mainly by seines, castnets and gillnets. Plank-built boats are the main craft in the lower stretch, canoes and rafts in the middle and upper stretches. Fishing intensity increases from upper to lower stretches. *Hilsa ilisha*, the

prawn *Macrobrachium malcolmsonii*, major carps *C. catla*, *L. rohita*, *C. mrigala* and *L. fimbriatus*, catfishes *M. seenghala*, *M. aor*, *S. childerni*, *W. attu* and miscellaneous fishes constituted to the catch in the riverine zone. In the estuarine zone penaeid prawns (*P. indicus*, *P. monodon*, *Metapenaeus* spp.) and estuarine fishes (mullets, perches, scienids, silver bellys etc.) occurred in the catch. The effort is mainly oriented to exploit prawn during January to June by large scale seining and hilsa during July to October by drift gillnets. Miscellaneous fishes, juveniles of large catfishes and *L. fimbriatus* occurred in the seines as by-catch.

Investigations conducted by Krishna-Godavari unit, Rajahmundry during 1963-69 in the stretch between Dhawaleswaram and Dummagudem anicuts have shown the continuous decline in the catch (from 330 to 218 t), catch per unit effort and mean size in the catch, all indicating the over-fished state of the fishery. The species most affected are *M. seenghala*, *S. childreni and L. fimbriatus*. The situation has not changed even after 30 years although certain conservation measures have been followed to revive the fishery. The effort further increased targeting the prawn, due to the price it fetches.

In the middle stretch large carps and catfishes represented by *L. fimbriatus*, *C. mrigala*, *L. rohita*, *L. calbasu*, *M. seenghala*, *M. aor* and *W. attu* are caught. In the upper stretch, catches are extremely poor except around barrages and weirs. Catfishes, minor carps and miscellaneous species formed the main catch. Nanded used to be a good prawn fishing ground but the Sriramsagar dam has effectively blocked the migration of prawns.

There are several fishermen communities in Andhra Pradesh and Maharashtra fishing in Godavari but only a single caste, *Agnikulakshatriya* (residents of Godavari districts in AP) are full-time fishermen and wholly dependent on the river for their sustenance. However, some other comunities have taken to part time fishing in some parts of Godavari. With the result the fishery resource is over-exploited depleting fish stocks. The catch per unit effort decreased and the fishers remained in poverty. Their literacy level too remained low as they migrate to different parts of the river with their families seeking better fishing, depriving their children the benefits of schooling and other childhood activities.

The limited resource of riverine sector is being subjected to over-exploitation. Legislation's limiting effort, declaring closed seasons and sanctuaries have not made any impact. Enforcing legislation in riverine fisheries is a daunting task without the willing co-operation of fishermen. The conservation of riverine fishery is closely linked with the improvement of socio-economic status of fishermen. A part of the community should be weaned away from river fishing by providing alternate avenues. The tanks and reservoirs in the state should be developed for fisheries and settle them around these water bodies.

The proposed dam at Polavaram (50 km upstream of Dhawaleswaram barrage), when comes up, will have far reaching effects on the fishery of Godavari above and below the dam. The prawn, *M. malcolmsonii*, which at present migrates to upper reaches and even into the tributaries in Madhya Pradesh and Maharashtra, will vanish above the Polavaram dam. The anadromous hilsa would be restricted upto Polavaram dam losing 150 km of migratory route. Major carps which at present breed and use Dhawaleswaram barrage area as nursery ground may be affected as the breeding grounds become restricted to the 50 km stretch. However, the reservoir to be formed above Polavaram may serve as sanctuary for some carps and catfishes which have become rare at present due to over-fishing.

At present there is no large scale discharge of pollutants in the river. The municipal wastes and sewage at Nasik, Nanded, Rajahmundry and Narsapur and paper mill effluents at Bhadrachalam and Rajahmundry are the major pollutants. No adverse effect has been observed on the aquatic communities at these points.