# BENTHIC STUDIES IN SOUTH GUJARAT ESTUARIES

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## ABSTRACT

Benthic biomass and faunal composition in relation to various environmental conditions of the four South Gujarat estuaries namely the Auranga, Ambika, Purna and Mindola were studied and compared. Mean population density of benthos in Auranga, Ambika, Purna and Mindola were 318690, 54727, 122350 and 88368 m-2 respectively. Mean benthic biomass (dry wt.) in Auranga, Ambika, Purna and Mindola were 7085, 411, 1814 and 1922 mg m-2 respectively. Differential abundance of macro and meiofaunal groups was noticed among the four estuaries. The predominance of meiofauna both in terms of biomass and numerical abundance in the benthic productivity of the four estuaries, was clearly, indicated. Foraminifera was the dominant group in all the four estuaries. All the four estuaries had the sandy bottom at their mouth and the percentage of silt and clay increased towards the upstream regions. On an average, the higher percentage of organic matter in the sediment was found associated with clayey silt. It was observed that wherever industrial pollution occurred benthos were badly affected.

Key-words: Benthos, biomass, estuary, Gujarat,

#### INTRODUCTION

Studies on benthos in the estuaries and backwaters along the west coast of India were mostly confined to central (Parulekar and Dwivedi, 1973; Dwivedi, Bhargava, Parulekar. Selvakumar, Singbal and Sankaranarayanan, 1974; Parulekar and Dwivedi, 1974; Parulekar, Rajamanickam and Dwivedi, 1975 and Parulekar, Dhargalkar and Singbal, 1980) and southern parts (Desai and Krishnan Kutty, 1967a and b) and only little is known about northern part (Varshney, Govindan and Desai, 1981) of the west coast. The present communication deals with biomass and composition of benthos in 4 estuaries of South Gujarat namely Auranga, Ambika, Purna and Mindola (Fig. 1), with a view to understand the subtidal benthos in relation to the existing water quality of these estuaries. The riverine and estuarine region of Ambika and Mindola receive considerable amount of industrial and domestic wastes and thereby polluting the quality of water to a great extent (NIO, 1980b).

These estuaries are mostly navigable during flood tides. All the four estuaries receive considerable quantity of fresh water during south west monsoon. Freshwater discharges to these estuarine systems are considerably reduced during premonsoon. The tidal currents were strong at the mouth of these estuaries and gradually decreasing towards upstream. They have good flushing at ebb tide (NIO, 1980).

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### MATERIALS AND METHODS

The studies were carried out during premonsoon (April/May) and early postmonsoon (late September/October) in 1979. Station 2 (Fig. 1) represents a location upto which the salinity intrudes considerably and the estuary is navigable. Benthic samples were collected using a Van-Veen grab of 0.04 m<sup>-2</sup> area. Benthos samples were collected in duplicate from each station and the mean values were taken into account. The samples for meiobenthos were collected from the grab by pushing a plastic core (2 cm diameter and 15 cm length) and were preserved in buffered formalin Rose Bengal (1:500) solution.

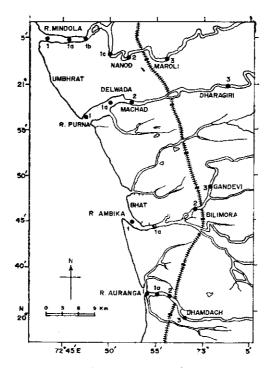


Fig. 1. Map showing the location of stations.

For macrobenthos fresh grab samples were taken. The details pertaining to the seiving and laboratory analysis of meio and macrobenthos have been reported earlier (Varshney, Govindan and Desai, 1981). Biomass is expressed on dry tissue weight basis. The sediment texture and percentage of organic matter in the sediment for 28 samples were also studied following method of Holme and McIntyre (1971) and EL Wakeel and Riley (1956) respectively.

#### RESULTS AND DISCUSSION

## Environmental parameters

The data obtained (NIO Report, 1980) on the physico-chemical parameters are presented in Table I. No appreciable change in the temperature for

the period of study, among the four estuarine systems was noticed. Salinity of the bottom waters fluctuated within a wide-range at the mouth of the four estuarine systems and their values were almost comparable. Salinity fluctuations at the upstream station 2 of Purna (0.43-26.95%) and Ambika (0.12-16.39%) estuaries were moderate. Among the four estuaries salinity at the upstream station 2 of Auranga (3.72-32.93%) was comparatively higher. On the other hand, the salinity was very low (0.06-0.59%) at the upstream station 2 of Mindola. Comparatively, high dissolved oxygen and low BOD were observed in Auranga and Purna. An increase in BOD and decrease in DO associated with considerable amounts of waste discharge were noticed during certain periods at the upstream station 2 of Mindola and Ambika (NIO, Report, 1980b). This clearly indicates the deteriorating conditions at the upper reaches of these two estuaries. In general, nutrient values varied and are not comparable among the four estuaries (Table 1).

Four types of substrate were noticed in these estuaries viz. sandy, silty sand, sandy silt and clayey silt (Table II). All the four estuaries had a sandy bottom at their mouth. The Zuari (Parulekar, Rajamanickam and Dwivedi, 1975) and Narmada estuaries (Varshney, Govindan and Desai, 1981) also have the predominance of sandy bottom in their lower reaches. The percentage of silt and clay portions gradually increased towards upper reaches of these four estuaries.

The mean percentage of organic matter in sediment was poor in Mindola (0.44%) and Purna (0.75%) as compared to Auranga (1.32%) and Ambika (1.27%). Higher percentage of organic matter in sediment was found associated with clayey silt.

Table I. Ranges of hydrographic parameters and mean standing stock of benthos in Auranga. Purna, Mindola and Ambika estuaries during 1979.

							Benth	los
St. No.	Temp. °C	Salinity %°	DO mg/l	BOD mg/1	PO <sub>4</sub> -P μg-at/1	NO 3-N μg-at/I	Population No/m <sup>2</sup>	Biomass mg/m <sup>2</sup>
Auranga	:						<del></del>	
1.	26,2-32.5	4.12-35.80	4.8-9.2	0.7 - 7.0	2.77-45.36	0.28 - 19.13	318690	7085
2.	27.7-32.5	3.72-32.93	3.4-10.8	1.8-7.5	0.09- 7.19	0.64-16.42	310030	7(70.7
Ambika :	:							
1.	27.0-32.7	2.24-36.58	3.6 - 7.3	1.5-7.9	0.77 - 19.08	0.85-29.43	54727	411
2.	25,5-32.5	0.12-16.39	0.3-6.8	1.7-32.6	0.06 - 5.26	0.14-16.70	.14727	711
Purna :								
1.	29.0-33.0	1.46-32.89	1.3-8.7	0.8 - 5.9	1.55- 8.85	1.57-14.99	122350	1814
2.	26.0-34.2	0.43-26.95	2.9-9.4	0.8 - 4.2	1.32-11.07	0.99-33.34	122330	1014
Mindola	:							
í.	25,0-32.0	4.72-33.78	3.4-10.2	1.5-12.4	0.22-54.85	0.71-43.83	88368	1922
2.	27.0-32.5	0.06- 0.59	1.8-8.3	1.8-14.2	0.67-62.27	0.07-24.63	60208	1944

Table II. Population and biomass of benthos in relation to depth, sediment type and organic matter in Auranga, Ambika. Purna and Mindola estuaries during 1979.

No. (m) Population Biomass Population Picture	:	Depth	h Macrof	rofauna	Mei	Meiofauna	Sec	Sediment C	Characteristic	ristic				Organic
No/m2 mg/m2 Mo/m2 mg/m2   1000 p   500 p   250 p   125 p   63 p   9/0   1.5	ó,	Œ	Population	8	Population	Biomass	Sand	(%)				silt & Clay	Texture	matter
GA : MAY,   A	ŀ		~m/oN	- m/gm	~m/oN	mg/m <sup>2</sup>	1000 €	500 /-	250 μ			%		(%)
3.5         —         89600         1702         89         2         3         2         1         3           4.0         44         6         23400         6174         41         6         2         1         2         36           4.0         88         115         88000         3600         2         1         1         4         24         36           4.0         88         115         4         84000         3912         29         7         7         1         2         35           2.5         110         4         84000         1176         40         35         10         5         7         3           2.0         110         4         8400         1176         40         35         10         5         7         3           2.0         110         4         4         6         10         4         25         30         3         2         3         4         3         2         3         4         3         4         4         24         4         4         24         4         4         24         4         4         24         <	IURA	NGA:	MAY								-	0/		
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OCTOBER         A-5         25         3         89600         560         —         1         4         24         70         7         1         4         24         70         7         1         4         24         70         3         4         8         4         70         3         4         8         4         70         3         4         7         1         2         3         4         70	7	1.5	980	4	274400	1848	:	;	1	٠, ر	, ا	96	Olley Sand	3.5
4.5         22         3         89600         560         —         1         4         24         70         Sandy           2.5         110         88         115         840000         30912         29         7         7         1         2         54         Sandy           1.5         10         18         40000         30912         29         7         7         1         2         54         Sandy           1.5         2.2         3         207200         1176         40         35         10         5         7         3         Sandy           2.5         2.2         3         10         4         20         6         9         7         Sandy           2.0         48         6         16800         34         20         6         9         7         Sandy           2.0         48         201         22400         34         3         2         20         5         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3         3			-5	~		)			l	4	7	Ç	Clayey Sift	1.7.1
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Biomass: The biomass distribution in the four estuaries is given in Table II. Mean macrobenthic biomass values for the four estuaries varied from 9 mg m<sup>-2</sup> (Ambika) to 48 mg m<sup>-2</sup> (Purna). In general, all the four estuaries contributed a poor macrofauna. Mean meiobenthic biomass values for the Auranga, Ambika, Purna and Mindola estuaries were 1056, 363, 1805 and 1888 mg m<sup>-2</sup> respectively. Contribution of meiobenthos to the total biomass significantly varied for the four estuaries. Table II clearly indicated the predominance of meiofauna both in terms of numerical abundance and biomass. Similar observation has been reported earlier for the Narmada estuary (Varshney, Govindan and Desai, 1981).

Faunal Composition: The macrofauna of the four estuaries consisted of polychaetes, crustaceans, gastropods and fishes with varying percentages (Fig. 2). The differential abundance of various macrofaunal groups was noticed. Polychaetes were the dominant macrofaunal group in Ambika and Purna whereas gastropods predominated the macrofauna in Auranga estuary. Crustaceans (35%), gastropods (32.5%) and polychaetes (30%) contributed almost

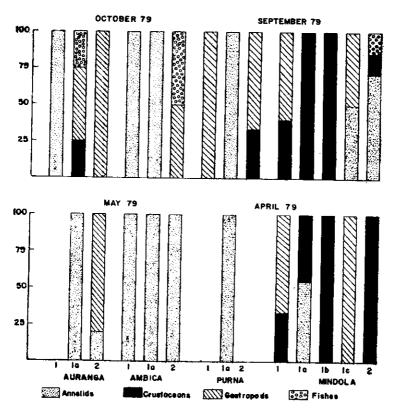


Fig. 2. Percentage composition of macrobenthos at different stations in the four estuaries.

equal percentage in Mindola estuary. Mean population density of macrobenthos for Auranga, Ambika, Purna and Mindola estuaries were 191, 128, 84 and 88 m<sup>-2</sup> respectively. Comparatively, a higher numerical abundance of macrofauna was noticed in Auranga than the other three estuaries. The numerical abundance of macrofauna of the four estuaries was found comparatively lower than that of Goa estuaries. (Parulekar Rajamanickam and Dwivedi, 1975).

Meiofauna was chiefly represented by foraminiferans, nematodes, polychaetes, crustaceans and gastropods (Fig. 3). Foraminifera was the dominant

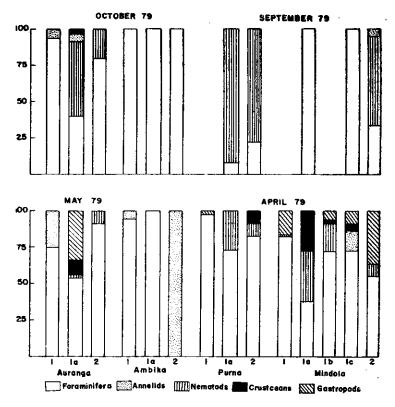


Fig. 3. Percentage composition of meiobenthos at different sations in the four estuaries.

group of the meiofauna in the four estuaries of which Ambika accounted for the higher percentake (93%) as compared to the other three estuaries (56 to 76%). Similar observation has been already reported for Narmada estuary (Varshney, Govindan and Desai, 1981). Nematodes were next to foraminiferans in abundance in these estuaries excepting Ambika where they were not recorded. The observed mean population of meiofauna for the Auranga, Ambika, Purna and Mindola estuaries were 318499, 54599, 122266 and 88280 m<sup>-2</sup> respectively.

From the foregoing account of the benthic studies it is concluded that Auranga which maintained good water quality and relatively a stable substratum contributes comparatively a higher population of biomass of benthos among the four estuaries (Tables I and II). Purna and Mindola contribute relatively a moderate benthic fauna in terms of biomass. Whereas the population of benthos is poor in Mindola as compared to Purna. This, perhaps, can be attributed to the pollution load at the upstream sections of the Mindola estuary (NIO Report, 1980). Ambika which is affected by industrial pollution as revealed from its water quality (NIO Report 1980) contributes poor benthos both in terms of numerical abundance and biomass of the four estuaries. In general, the upstream stations of the estuaries contributed comparatively a higher benthic biomass than the down stream stations excepting Ambika.

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# **REFERENCES**

- Desai, B.N. and M. Krishnankutty, 1967a. Studies on benthic fauna of Cochin backwater. Proceedings of Indian Academy of Sciences, 66, 123-142.
- Desai, B.N. and M. Krishnankutty, 1967b. A comparison of the marine and estuarine benthic fauna of the nearshore regions of the Arabian Sea. Bulletin of National Institute of Sciences of India, 38: 677-683.
- Dwivedi, S.N., R.M.S. Bhargava, A.H. Parulekar, R.A. Selvakumar, S.Y.S. Singbal and V.N. Sankaranarayanan. 1974. Ecology and environmental monitoring of Mandovi, Zuari and Combarjua canal complex during monsoon months. *Journal of Indian Fisheries Association*, 3 & 4 (issued in 1977), 113-130.
- E! Wakeel, S.K. and J.P. Riley, 1956. The determination of organic carbon in marine muds.

  Journal du Conseil Permanent International Pour l' exploration de la mar, 22: 180-83.
- Holme, N.A. and A.D. McIntyre, 1971. Methods for the study of Marine Benthos, IBP Hand Book No. 16. Blackwell Scientific Publications, Oxford and Edinburg, 334 pp.
- NIO, 1980. Pollution and hydrographic survey of Auranga, Ambika, Purna and Mindola Rivers (South Gujarat). Sponsored by the Gujarat Water Pollution Control Board, Govt. of Gujarat. 377 pp.
- Parulekar, A.H. and S.N. Dwivedi, 1973. Ecology of benthic production during southwest monsoon in an estuarine complex of Goa. In Recent Researches in Estuarine Biology, edited by R. Natarajan (Hindustan Publishing Corporation (1), Delhi), 21-30.
- Parulckar, A.H. and S.N. Dwivedi, 1974. Benthic studies in Goa estuaries: Part L-Standing crop and faunal composition in relation to bottom salinity distribution and substratum characteristics in the estuary of Mandovi River. Indian Journal of Marine Sciences, 3: 41-45.

- Parulekar, A.H., G. V. Rajamanickam and S.N. Dwivedi, 1975. Benthic studies in Goa estuaries: Biomass and faunal composition in the Zuari estuary. *Indian Journal of Marine Sciences*, 4: 202–205.
- Parulckar, A.H., V.K. Dhargalkar and S.Y.S. Singbal, 1980. Benthic studies in Goa estuaries:
   Part III Annua; cycle of Macrofaunal distribution, production and tropic relations.
   Indian Journal of Marine Sciences, 9: 189-200.
- Varshney, P.K., K. Govindan and B.N. Desai, 1981. Benthos of the Narmada estuary, Mahasagar—Balletin of the National Institute of Oceanography, 14: 141-148.