

ZOOPLANKTON VARIABILITY IN POLLUTED AND UNPOLLUTED WATERS OFF BOMBAY

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ABSTRACT

Zooplankton abundance in the waters around Bombay was studied at Versova, Bombay Harbour (less polluted), Mahim and Thana (highly polluted) from October 1977 to December 1978. A rich zooplankton population was observed throughout the period of study especially during the low tide with peaks in October/November and March/April. Mean zooplankton dry weight at the different stations were 8.7 mg/100 m³ (Thana), 5.8 mg/100 m³ (Versova), 4.04 mg/100 m³ (Harbour) and 3.84 mg/100 m³ (Mahim). Eventhough numerically Mahim station sustained the maximum population of zooplankton, the recorded mean biomass was the lowest for the area studied. No correlation was found between the population density peak of either the high or low tide of any month among the four stations. Group diversity of zooplankton was relatively more in unpolluted waters than in polluted waters.

INTRODUCTION

Zooplankton are considered to be the ecological indicators of water bodies. The distribution and abundance of these organisms in polluted and unpolluted waters can provide useful information on the health of the area where they are found. Studies on zooplankton of Bombay waters are limited to a few reports. Gae Piroja (1934), pioneered studies on zooplankton off Bombay water, followed by the Lele Gae (1935, 1936), Bal and Pradhan (1945, 1952), Bapat and Bal (1950, 52), Chopra, (1960), Gogate (1960), Sudarsan (1964), Pillai (1968). Recently Belsare, Mhasawade and Gore (1975) and Desai and Gajbhiye (1976) have studied some aspects of zooplankton population. However, these investigations were mostly confined to Bombay Harbour and very little attention has been paid to the zooplankton in the nearshore waters of Bombay, particularly of Thana and Mahim creeks which form important waterways of Bombay.

Bombay being one of the largest city in India and having a population of 7.5 million and with almost 1/3 of the national industries, generates large quantities of waste water which are directly discharged into the surrounding water. As a result some areas have been badly polluted but the offshore waters are comparatively cleaner. The present work was undertaken with a view to determine whether the discharge of domestic and industrial waste has made any impact on the ecology of the waters surrounding Bombay compared to the baseline data provided by earlier workers.

MATERIAL AND METHODS

Four stations were selected for the study of zooplankton under different ecological conditions and the station locations are shown in Fig. 1.

1. *Versova* – The station was located in the Arabian Sea off Versova at a depth of 10–15 metres. The station represents more or less clean water mass, where no known discharges takes place and the area is relatively unpolluted (Gupta and Sankaranarayanan, 1974).
2. *Mahim* – The station was located in the Arabian Sea off Mahim at depth of 9–12 metres. Large amount of domestic sewage and some industrial effluents are discharged at this station (NIO Report, 1972, 1978).
3. *Harbour* – The sampling station was selected near the Bombay harbour mouth at a depth range of 10–14 m. The collective effluent from the Thana creek flows with the tidal water but having strong tidal currents providing sufficient mixing and dispersal.
4. *Thana creek* – The station at Thana creek was located about 1 kilometre to the interior of the creek mouth near the new Washi Bridge. Large number of industries in the area discharge effluent in the Thana creek near the station.

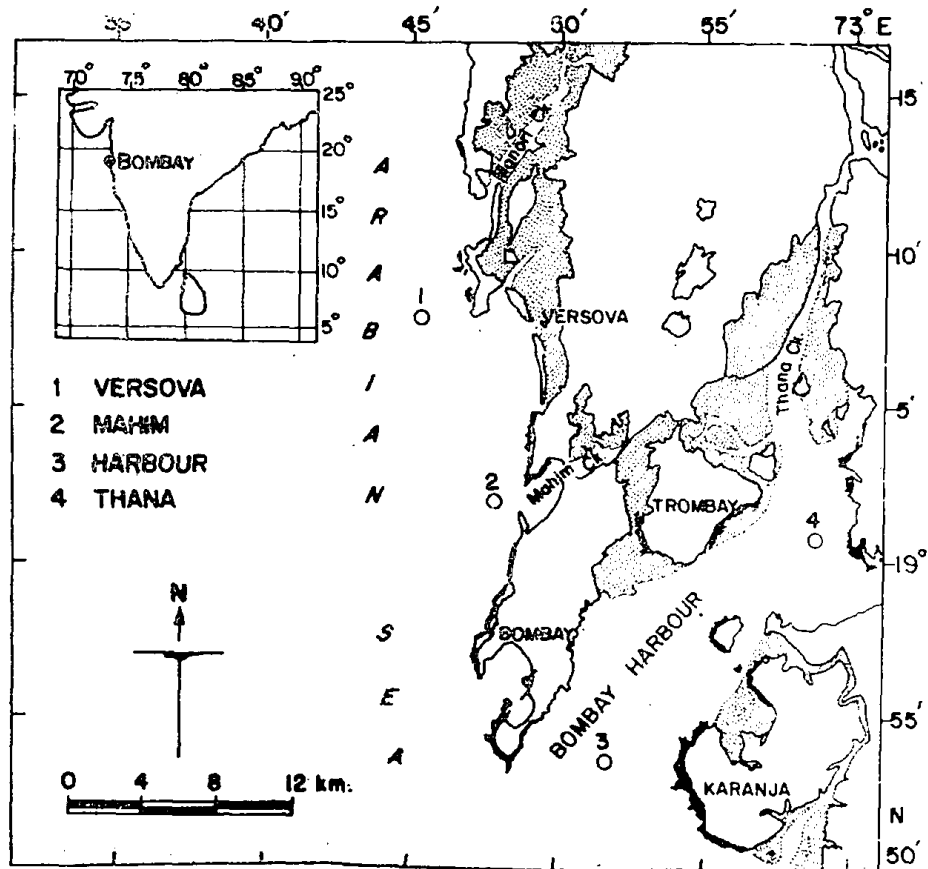


Fig. 1. Map showing location of stations.

The present study was carried out over a period of 15 months from October 1977 to December 1978. The samples were collected during the flood and ebb tide conditions from all the four stations using a modified Heron Tranter Net (Tranter, Devi and Balakrishnan, 1972) with a mouth area of 0.25 m² and mesh size of 0.2 mm. A TSK flow meter was attached for obtaining the volume of water filtered.

All the samples were from horizontal hauls of 5 minutes duration. The total volume of zooplankton was determined by displacement method, and data are expressed as ml/100 m³. An aliquot of the sample was taken for dry weight estimation. The remaining samples were preserved in 5% seawater-buffered formalin and tagged for the taxonomical and numerical studies.

RESULTS

Environmental conditions

The aquatic environment around Bombay is mainly influenced by monsoon which brings large amount of freshwater. Thana creek is connected to several freshwater creeks and 2 major rivers. As a result in the Thana creek, the salinity varied widely from 16.48‰ to 38.8‰ while the range at Versova, Mahim and Harbour were 25.44-36.98‰, 25.0-36.65‰ and 23.53-37.19‰ respectively. Water temperature was showing a bimodal fluctuation with maximum in April/May (average 32.6°C) and in October/November (average 30.5°C). The minimum value was observed in January/February (average 23.6°C).

During the period of survey relatively higher dissolved oxygen values were recorded at Versova (3.2-5.8 mg/l) and Harbour (2.0-6.3 mg/l) and lower values at Mahim (0.8-5.6 mg/l) and Thana (0.8-6.5 mg/l). Very high BOD values were reported from Thana and Mahim (Zingde, Trivedi and Desai, 1979). The prevailing water quality indicates fairly good conditions at Versova and Harbour. The estimated nutrient values were quite high at Thana and Mahim compared to the other two stations (Gajbhiye, 1979).

Distribution of zooplankton

The distribution and seasonal variation in the standing crop and total population density of zooplankton at the four stations are shown in Fig. 2 and Tables I, II. Copepods formed the dominant group throughout the period of study. Other common groups were chaetognaths, decapod larvae, hydromedusae, ctenophores, gastropods and fish larvae.

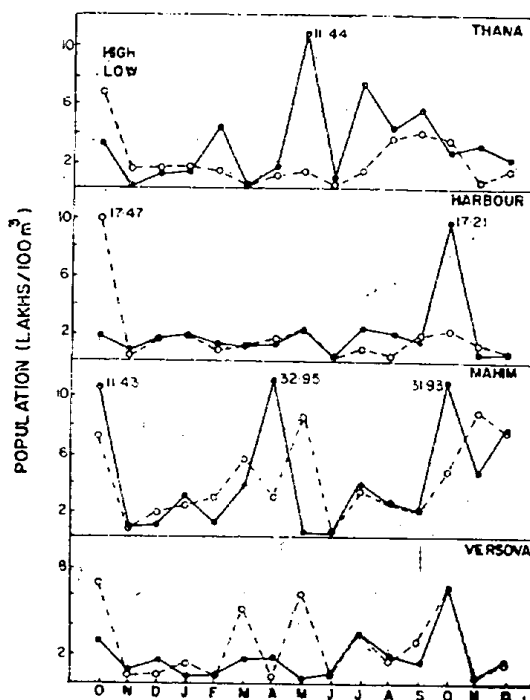


Fig. 2. Monthly variation of total population density of zooplankton.

Versova

The highest biomass in terms of volume (86.80 ml/100 m³) and in terms of dry weight (9.03 mg/100 m³) was observed during low tide in September 1978. The lowest value in terms of volumes (1.56 ml/100 m³) and dry weight (0.18 mg/100 m³) was recorded at low tide during May 1978. During high tide the maximum biomass in terms of volume was obtained in December 1978 and minimum in April 1978.

The maximum and minimum population densities of zooplankton organisms were recorded during high tide in the month of October 1977 and April 1978 respectively. Whereas the population maxima and minima during low tide appeared in October 1978 and November 1978, respectively. The intermediate peaks for high tide appeared in April and July 1978. The highest population density (6.83 lakhs/100 m³) obtained during high tide in October 1977 was represented by 7 faunal groups. Of these copepods contributed 99% of the total zooplankton population. The highest number of organisms (6.79 lakhs/100 m³) obtained during low tide in October 1978, was represented by 14 faunal groups, of these copepods contributed 97.6%. The other important groups were brachiopods (1.4%), chaetognaths (0.3%), gastropods (0.3%), decapod larvae (0.1%), pteropods (0.1%) and cladocerans (0.1%). The rest of the groups formed the remaining 0.1% of the total zooplankton.

The lowest population density (0.23 lakhs/100 m³) consisted of 10 faunal groups was recorded during high tide in April 1978. Of these 10 groups, copepods contributed 97% of the total zooplankton. The minimum population density (0.30 lakhs/100 m³) recorded during low tide in the month of November, 1978 consisted of 8 faunal groups with copepods contributing 66.4% of the total population. The other important groups were brachiopods (18%), medusae (3.6%), chaetognaths (3.6%), fish eggs (2.4%), fish larvae (2.4%), decapods larvae (1.9%) and gastropods (1.7%),

The maximum number of faunal groups recorded during high and low tide in the month of June 1978 at Versova were 18 and 17 respectively. Whereas, the mini-

Table 1. Monthly variation of zooplankton biomass (volume ml/100 m³) during high tide and low tide.

Months	Versova		Mahim		Harbour		Thana	
	High	Low	High	Low	High	Low	High	Low
Oct-77	83.37	17.50	40.60	39.25	63.00	10.68	35.00	42.14
Nov	3.90	4.56	3.56	21.01	2.25	4.01	14.61	238.00
Dec	15.20	8.77	6.86	4.00	10.10	29.00	144.77	87.34
Jan-78	30.58	16.95	14.00	12.18	9.46	33.52	30.72	6.65
Feb	4.14	3.16	8.69	1.80	5.09	4.53	30.72	67.63
Mar	22.20	11.16	11.20	9.46	6.74	42.03	97.14	85.92
Apr	1.94	8.16	9.40	40.16	26.07	20.80	10.28	18.22
May	18.92	1.56	17.36	0.97	11.30	16.00	6.38	66.66
June	6.80	7.64	3.57	0.53	22.48	3.45	0.87	24.26
July	18.30	23.05	11.53	23.00	9.90	19.82	9.48	29.79
Aug	6.95	8.89	14.89	14.89	4.60	5.88	26.44	16.00
Sep	41.27	86.80	15.08	27.38	18.07	18.79	17.91	22.20
Oct	57.73	52.89	29.75	118.73	21.93	129.92	35.90	22.47
Nov	84.10	86.70	14.59	20.05	22.40	28.00	32.87	144.75
Dec	85.00	65.65	31.01	29.56	15.85	19.00	47.00	21.00

imum number of faunal groups recorded during high tide and low tide were 6 (September 1978) and 4 (May 1978) respectively.

Mahim

The highest values of biomass in terms of volume (118.73 ml/100 m³) and dry weight (12.26 mg/100 m³) were recorded at low tide during October 1978. The lowest biomass was also recorded at low tide in the month of June 1978. During high tide the maximum biomass value of 40.60 ml/100 m³ and the minimum value of 3.56 ml/100 m³ were recorded in the month of October and November 1977 respectively.

The maximum and minimum zooplankton population densities at high tide were recorded during November and June 1978 respectively. While at low tide it was noticed during April and June 1978 respectively.

The highest zooplankton population density (8.56 lakh/100 m³) during high tide was represented by 12 faunal groups. Of these groups, copepods contributed 99.6%, chaetognaths 0.2% and decapods 0.1% of the total zooplankton. The rest of the groups contributed less than 0.1% of the total population. The highest density (32.95 lakhs/100 m³) during low tide consisted of 4 faunal groups. Copepods contributed 99.9% of the total zooplankton population whereas the remaining groups contributed less than 0.1% of the total population.

The lowest population density both during the high tide and low tide periods, was recorded in June 1978. The lowest population density (0.08 lakhs /100 m³) recorded during high tide was represented by 8 faunal groups. Copepods contributed 86.5% of the total population. The other important groups were decapod larvae (7%) prawn larvae (2.4%) and chaetognaths (2.2%). The remaining groups had contributed less than 1%. The lowest population density (0.08 lakhs/100 m³) reported during low tide was represented by 11 faunal groups. Copepods contributed 92.3%, chaetognaths 1.5%, gastropods 1.5%, decapods 1.2% and brachiopods 1.0% were some of the important

Table II. Monthly variation of zooplankton biomass (mg dry wt/100 m³) during high and low tide.

Months	Versova		Mahim		Harbour		Thana	
	High	Low	High	Low	High	Low	High	Low
Oct-77	9.03	1.90	3.94	3.91	6.34	1.18	3.34	3.81
Nov	0.42	0.42	0.38	0.23	0.21	0.37	1.39	18.11
Dec	1.72	0.91	0.71	0.42	1.08	2.78	13.78	7.87
Jan-78	3.83	1.79	1.29	1.18	0.98	3.07	2.87	0.68
Feb	0.41	0.38	0.88	0.19	0.51	0.48	2.81	6.18
Mar	2.23	1.19	1.12	1.01	0.59	4.08	8.81	7.21
Apr	0.19	0.83	0.97	4.46	2.24	1.98	1.12	1.64
May	1.91	0.18	1.89	0.12	1.05	1.39	0.54	5.92
June	0.59	0.61	0.36	0.08	2.03	0.28	0.08	1.92
July	1.81	2.42	1.07	2.34	0.95	2.03	0.95	2.98
Aug	0.71	0.97	1.56	1.43	0.53	0.61	2.91	1.72
Sept	3.97	6.73	1.37	2.43	1.69	1.83	1.72	2.25
Oct	5.71	5.34	3.07	12.26	2.31	13.12	3.36	2.12
Nov	7.85	8.86	1.19	2.03	2.13	1.87	2.97	15.42
Dec	8.09	6.07	3.06	2.76	1.21	1.69	4.17	2.09

groups noticed in the zooplankton during low tide and of the remaining groups each had contributed less than 1% of the total population. The maximum number of faunal groups recorded during high tide and low tide periods at Mahim were 12 (January 1978) and 13 (October 1978) respectively. The minimum number of 7 groups (August and September 1978) during high tide and 4 groups (April 1978) during low tide were recorded at Mahim.

Harbour

The highest total biomass value of 129.92 ml/100 m³ accounting for a dry weight of 13.12 mg/100 m³ was recorded at low tide during October 1978, on the other hand the lowest biomass value 2.25 ml/100 m³ (0.21 mg/100 m³ dry weight) was recorded at high tide during November 1977. The maximum biomass value during high tide 63.0 ml/100 m³ (6.34 mg dry wt/100 m³) and the minimum value in low tide of 3.46 ml/100 m³ (0.28 mg dry wt/100 m³) were recorded in the month of October 1977 and June 1978 respectively.

The maximum and minimum zooplankton population densities during high tide were recorded in October 1977 and August 1978 whereas during low tide the population maximum and minimum were obtained in October and June 1978 respectively. The intermediate peaks appeared both during high tide and low tide in the month of January, May and July 1978.

The highest population density (17.47 lakhs/100 m³) during high tide (October 1977) consisted of 12 faunal groups. Copepods dominated and accounted for 99.6% of the total zooplankton population. Chetognaths and decapods contributed 0.2% and 0.1% respectively. The rest of the groups accounted for 0.1% of the zooplankton population. The highest population density (17.21 lakhs/100 m³) during low tide (October 1978) was represented by 7 faunal groups. Of these, copepods dominated over other faunal groups and they accounted for 99.9%. The remaining faunal groups contributed less than 0.1% of the total population.

The lowest population density (0.40 lakhs/100 m³) recorded during high tide in August 1978 was represented by 7 faunal groups. Copepods were the dominant group and accounted for 97% of the total population. The other important groups were decapods larvae (1.7%), fish eggs and larvae (1%) and gastropods (0.2%). The rest of the groups contributed only less than 0.1%. The lowest population density (0.40 lakhs/100 m³) of zooplankton recorded during low tide in June 1978 was represented by 16 faunal groups. Of these, copepods and lucifer accounted for 93% and 4.9% of the total zooplankton population respectively. The rest of each faunal group contributed less than 0.5%. The maximum number of faunal groups recorded in Harbour during low tide was 16 (June 1978) whereas during high tide it was 15 (March 1978). On the other hand, the minimum number of groups recorded during high tide was 3 (October 1978) as compared to low tide condition where it was 5 (July 1978).

Thana

The highest biomass value recorded in terms of volume and dry weight during low tide in the month of November 1977 was 238.0 ml/100 m³ and 18.11 mg dry wt/100 m³ respectively, whereas the lowest biomass value of 0.87 ml/100 m³. (0.08 mg

dry wt/100 m³) was recorded at high tide during June 1978. The maximum biomass value for the high tide was recorded as 144.77 ml/100 m³ (13.78 mg dry wt/100 m³) during the month of December 1977. The minimum biomass value for the low tide was recorded 6.65 ml/100 m³ (0.68 mg dry wt/100 m³) during the month of January 1978.

The highest and lowest population densities of zooplankton during high tide were recorded in October 1977 and March 1978 respectively. During low tide the highest and the lowest population densities were recorded in May and March 1978 respectively. The intermediate peaks appeared during high tide in May 1978 and low tide in February, July and September 1978.

The highest population density (6.62 lakhs/100 m³) recorded during high tide in October 1977 was represented by 9 faunal groups. Copepods predominated the other groups by accounting for 86.8% of the total population. The other important groups were decapods and gastropods, each of which contributed 7.5% and 4.7% respectively. The rest of the groups together contributed 1% of the total population. The highest population density (11.44 lakhs/100 m³) of zooplankton recorded during low tide in May 1978 was consisted of 8 faunal groups. Copepods and chaetognaths accounted for 99.2% and 0.7% of the total zooplankton respectively. The rest of the faunal groups contributed less than 0.1%.

The lowest population density both during high tide and low tide was recorded during the month of March 1978. The lowest population density (2327/100 m³) recorded during high tide was represented by 9 faunal groups. Ctenophores and copepods accounted for 55.3% and 16.4% of the total zooplankton. The other important groups were lucifers (9.6%), medusae (8.2%), decapods (5.5%) and chaetognaths (4.1%). The rest of the faunal groups contributed less than 1% of the total population. On the other hand lowest population density (2264/100 m³) during low tide was consisted of 8 faunal groups. Of these, ctenophores and medusae accounted for 55.7% and 35.1% of the total population. Others were decapods (2.1%) and *Lucifer* (1.7%). The rest of the faunal groups recorded less than 1% of the total population. The maximum number of faunal groups recorded in Thana both during high tide (June 1978) and low tide (August 1978) were 12. The minimum number of faunal groups recorded during high tide was 3 (April, 1978) and during low tide it was 5 (September and November, 1978).

DISCUSSION

The foregoing account indicates that zooplankton in the nearshore waters of Bombay is quite rich. At most of the stations high density of zooplankton was observed during low water period with the maxima during Oct/Nov and March/April months. A similar trend with a bimodal peak in Bombay waters has been reported by Pillai (1968) and Belsare, Mahsawade and Gore (1975). The highest and lowest population density has been noticed during the postmonsoon and summer months respectively at Versova and Harbour whereas at Mahim and in Thana creek higher population was recorded during summer months.

The highest population density of zooplankton both during high tide and low tide was recorded in the month of October 1978 at Versova and Harbour stations. There was no such relationship found between Mahim and Thana, since the highest

biomass peaks during high tide and low tide, appeared in different months. On the other hand the lowest population density of zooplankton recorded during both the tides during June 1978 at Mahim and it was during March 1978 at Thana. The lowest zooplankton population density was recorded in different months both at Versova and Harbour stations. No correlation was found between the population density peak of either high tide or low tide of the same month among the four stations. As a result, either the highest or the lowest population density of zooplankton recorded either during high tide or low tide have not shown any monthly correlation amongst the four stations. The highest population density of zooplankton was recorded at Harbour (17.47 lakhs/100 m³) during high tide in the month of October 1977 and Mahim (32.95 lakhs/100 m³) during low tide in April 1978. The lowest population density of zooplankton (2327/100 m³) was recorded at Thana both during high tide and low tide (2264/100 m³) in the month of March 1978.

The mean numerical abundance of zooplankton at the four stations studied fall in the following order: Mahim (10.81 lakhs/100 m³), Harbour (6.01 lakhs/100 m³), Thana (4.91 lakhs/100 m³) and Versova (4.15 lakhs/100 m³). In general, a high numerical density of zooplankton in the order of 1.5 times more had been noticed during low water average (3.84 lakhs/100 m³) as compared to high water (2.63 lakhs/100 m³) for the four stations studied. Mean zooplankton biomass in term of dry weight, at the four stations studied falls in the following order: Thana (8.7 mg/100 m³), Versova (5.8 mg/100 m³), Harbour (4.04 mg/100 m³) and Mahim (3.84 mg/100 m³). It is also observed that although a high population density was recorded at Mahim, in terms of biomass it was only 50% of Thana values.

An increase in the zooplankton population density in the order of 2 to 8 folds has been reported by Youngbluth (1976) from the polluted tropical environment of Guayanilla Bay-Puerto Rico. Similarly, an increase of 5 to 10 times and 20 to 50 times of zooplankton population density has been reported by Yannopoulos and Yannopoulos (1973, 1976) from the Saronikos proper and Elefsis Bay respectively. The numerical abundance of zooplankton in the Mahim area was 1.5 to 2 times more than the other stations which can very well be attributed to the sewage pollution of this region as also reported by Desai (1971), Gupta and Sankaranarayanan (1974). Clutter (1972) has shown that continued increase in influx of nutrients and possibly of organic load to the Kaneotae Bay increased the general level of plankton productivity. Wiktor and Plinske (1975) showed that the eutrophication due to pollution results in a change in the plankton besides disturbing the seasonal course of the nutrients concentration, has increased the plankton production.

Among the four stations, Versova was represented by the maximum number of faunal groups of zooplankton both during high tide (18 groups) and low tide (17 groups) in the month of June 1978. The minimum number of faunal groups recorded during high tide was 3, from Thana and Harbour in the month of April 1978 and October 1978 respectively. During high tide Versova, Harbour, Mahim and Thana stations were represented by an average 10, 9, 8 and 8 faunal groups of zooplankton respectively on the other hand, during low tide the average number of faunal groups from Versova, Harbour, Thana and Mahim were 11, 10, 9 and 8 respectively. Mahim and Thana were represented by lesser number of faunal groups as compared to Versova and Harbour.

The stability of the environment is dependant on the external stress. A stable environment can sustain a diversified faunal assemblage, indicating healthy condition. Stability in biomass and representation of faunal groups at Versova and Harbour are more than that observed at Mahim and Thana, suggesting the influence of external stress. Therefore it may be concluded that the pattern of zooplankton distribution is providing a clear difference between polluted and unpolluted waters.

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