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IMPACT OF POWER PLANT DISCHARGE ON THE PHYSICO-CHEMICAL CHARACTERISTICS OF KALPAKKAM COASTAL WATERS

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ABSTRACT

Measurements of air and sea surface temperature, dissolved oxygen, salinity, Secchi disc depth and seston content of the coastal water at Kalpakkam have been carried out since 1982. The paper discusses the seasonal variations in the above parameters and the impact of power plant operation on these. The annual sea surface temperature during the post-operational period of the reactor largely followed a trend similar to that of the pre-operational period. However, there was a marginal reduction in the difference between annual maxima and minima and a general flattening of the moving average during the post-operational period as compared to the pre-operational period. During the period of study lowest salinity values of 21.94 X 10^{-3} (NE monsoon, November 1985) and 27.81 X 10^{-3} (SW monsoon, July 1985) were observed. A marginal reduction in water transparency and an increase in the seston content (highest 53.1 mg/l) were the other major changes observed during the post-operational period.

Key-words : Reactor, Ecology, Kalpakkam.

INTRODUCTION

Coastal locations are often chosen for setting up power stations, because of the large volume of water readily available for use as condenser coolant. With the setting up of large multimegawatt electric generating systems, the ecological impact of waste heat from power plants has become an area of considerable scientific interest. It is well known that an ecosystem has a highly complex structure and a disturbance in one component leads to a number of interacting effects. The present study was carried out in the vicinity of a nuclear power station at Kalpakkam 65 km south of the city of Madras with a view to follow the seasonal variations in some of the parameters, before the commencement of operation of the power plant and after the plant has gone operational. The investigations involved measurement of air temperature, sea surface temperature, salinity, dissolved oxygen, Secchi disc depth and suspended matter during the period 1982-86. Some of the baseline (pre-operational) data from this study for the period 1979-81, has been reported in an earlier paper (Nair and Ganapathy, 1983). The present paper is an attempt to summarise the observations from 1982-86 on the above parameters and to look for possible impact of power station operations on the physico - chemical characteristics of coastal waters.

The study was carried out in the coastal waters adjacent to Madras Atomic Power Station (MAPS) units I and II which have gone operational on 23rd July, 1983 and 18th September 1985 respectively. Both the reactors together use about 35 cubic metre of sea water per second for the condensers as well as other auxiliary cooling systems. The water is drawn from the coastal waters through a sub-seabed tunnel with the intake located 465 m away from the seashore.

MATERIAL AND METHODS

Samples of surface sea water (1 m depth) were collected in a polythene bucket from the end of the MAPS jetty (about 400 m away from the shore) once a week for the analysis of salinity, dissolved oxygen and suspended matter. In addition, air temperature, surface water temperature and Secchi disc depth were also measured. All observations and sampling were carried out between 11 am and 12 noon. Temperature measurements were carried out by using ordinary mercury thermometer which reads upto 0.1°C, salinity and dissolved oxygen were determined following Mohr's (Lange, 1969) and Winkler's method (Strickland and Parsons, 1972) respectively. Suspended matter was estimated by filtering a known volume of water through a conditioned 0.45 μ millipore filter paper following the method described in Strickland and Parsons (1972). Secchi disc was used to determine the depth of light penetration. Rainfall data were obtained from the micrometeorological laboratory at Kalpakkam.

The data on temperature, salinity and dissolved oxygen have been plotted as moving averages for the years 1982-86 with a view to understand the major trends in their distribution during the pre- operational as well as post-operational period of the power station. The principal features of the seasons and the hydrobiological characteristics of this coast have been described by Nair (1985) and Satpathy, Mathur and Nair (1987).

RESULTS AND DISCUSSION

Temperature: Annual distribution of water temperature at Kalpakkam (Fig. 1a-1d) is characterised by two maxima, one in April/May and the other in September/October and two minima one in June/July and the other in December/January. Variations in sea surface temperature was found to be associated more with the pattern of monsoonal rainfall than with seasonal variations in air temperature. In general, temperatures are at their lowest during the month of December/January and steadily increase from February onwards reaching a maximum in April/May. With the onset of SW monsoon, temperature begins to fall and reaches a minimum in June/July. Once again temperature shows a rising trend with the cessation of SW monsoon reaching a maximum in September/October. Again a gradual decline of the temperature was observed coinciding with the onset of NE monsoon reaching a minimum in December/January. The pattern described above was generally similar to that described by

Nair and Ganapathy (1983). On the other hand seasonal air temperature (Fig. 1a-1d) distribution is generally characterised by a maximum in May/June and minimum in December/January although during the period 1982- 83 two maxima were observed, one in May and the other in September. Sea surface temperature during the period February to April/May and September/October to January followed a pattern similar to that of air temperature. However, during the rest of the year, low water temperature were often associated with relatively high air temperature.

Table I – Maxima and Minima of surface temperature (°C) in Kalpakkam coastal waters.

Year	Max.	Min.	Max.	Min.
82-83	32.0 (Apr)	27.5 (Jun)	31.5 (Oct)	27.0 (Dec)
83-84	32.0 (Apr)	26.0 (Jun)	32.0 (Oct)	27.3 (Dec)
84-85	31.5 (Mar)	28.0 (July)	31.0 (Sept)	26.5 (Jan)
85-86	31.0 (May)	28.0 (Jul).	30.5 (Oct)	24.5 (Jan)
86-87	30.0 (Apr)	27.3 (Jun)	30.0(Sept)	24.7 (Dec)
87-88	31.0 (May)	27.0(Aug)	29.9 (Oct)	25.2(Jan)

Table II – Hydrographic characteristics of coastal waters

Year	Salinity ($X\ 10^{-3}$)		DO (mg/1)		Secchi disk (m)		Suspended matter (mg/1)	
	max.	min.	max.	min.	max.	min.	max.	min.
82-83	36.16	29.35	6.8	4.1	4.3	0.5	25.0	3.5
83-84	36.33	23.97	7.0	4.8	3.5	0.3	52.0	5.0
84-85	36.04	22.43	6.7	4.6	3.4	0.4	40.0	4.5
85-86	35.40	21.94	7.6	3.7	4.3	0.6	–	–
86-87	34.69	26.54	6.9	4.1	4.5	0.7	43.5	10.0
87-88	35.36	27.43	6.2	4.0	4.3	0.9	53.1	6.3

The minimum and maximum sea surface temperature observed were 32°C and 24.5°C respectively showing a seasonal variation of about 8°C. The moving averages of temperature as well as the absolute values of seasonal temperature maxima during the years 1982-84 (pre-operational period) and 1984-86 (post-operational period) do not show any marked increase in values indicating that station operation has no significant influence on coastal water temperature. Similar studies carried out on the west coast near Tarapore power station revealed no thermal influence of power station on the coastal water (Jossanto and Desai, 1975). This is in contrast to our own inference on temperature changes reported in an earlier paper (Satpathy, Eswaran and Nair,

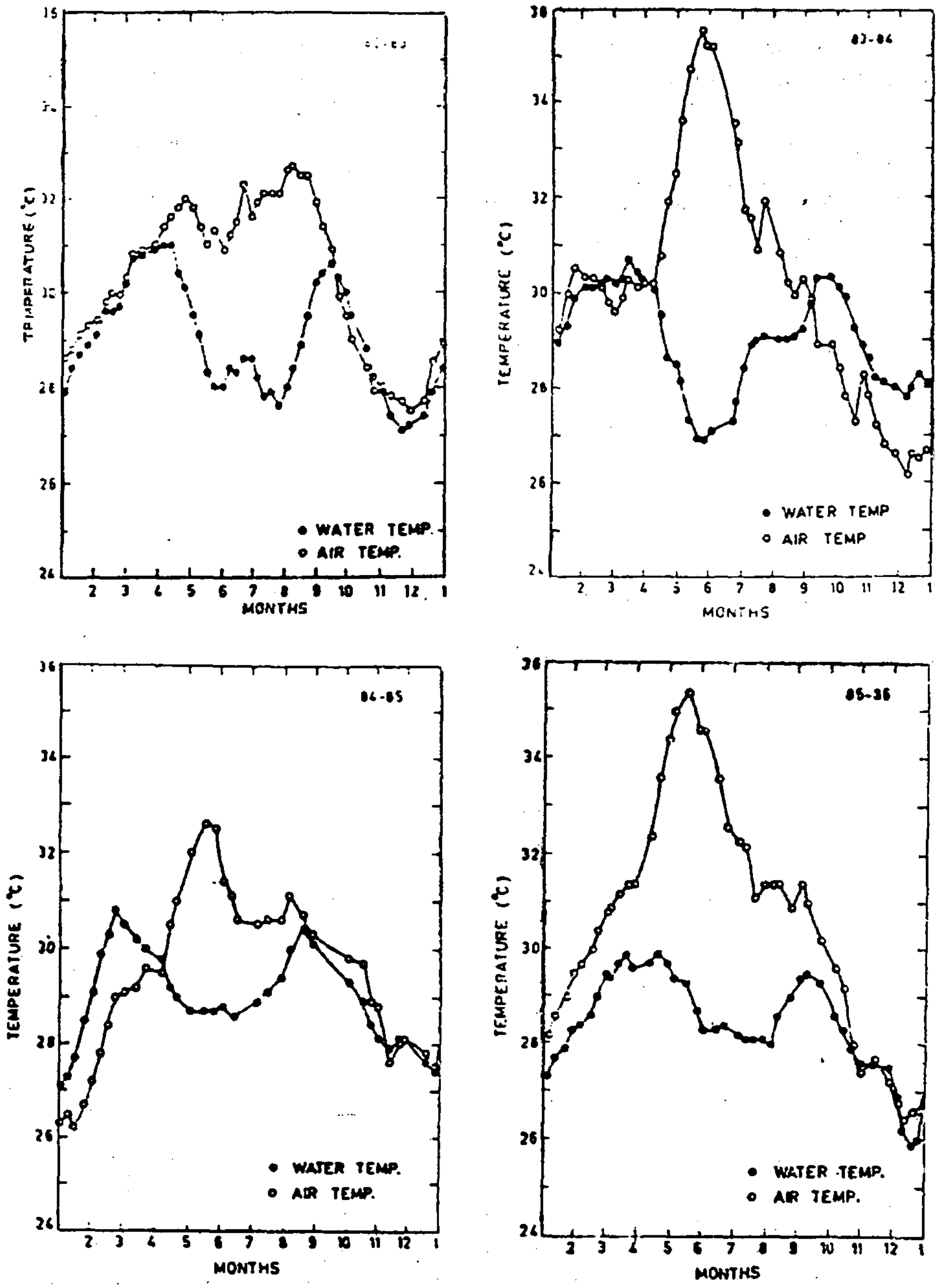

Fig.1a-d. Distribution of moving average of surface water and air temperature in Kalpakkam coast.

1986) wherein it was stated that a general warming up of coastal water was observed and temperature maximum in April/May and minimum in June/July have been elevated by 1°C and 2°C respectively. This observation was found to be not in agreement with the present study when 3 years post-operational data (1983-86) were used for comparison instead of only one year data (1983-84) used for comparison in the earlier paper. Although the seasonal distribution of temperature during the post operational period do not generally show any increase in temperature, the July minimum has been found to be somewhat elevated as compared to the pre-operational period particularly during 1984-85 and 1985-86. It has not been possible to offer any explanation to this observation. Since the July minimum in 1982-83 (pre-operational period) was also relatively high power plant discharges could not be the cause for this surface temperature elevation. The only change observed in the temperature distribution was a flattening of the moving average curve during the post operational period. The seasonal currents at Kalpakkam carry the heated effluents to the north as a stream during most part of the year and this could not be an important reason as to why no significant influence is felt at our point of observation which is 400 m away from the shore on the Jetty.

Salinity: Salinity data (Fig.2) were generally characterised by stable values during the summer and south-west monsoon seasons. However, following a good rainfall during the southwest monsoon season of 1985 there has been a marked lowering of surface salinity in the coastal waters. The salinity minimum registered a relatively high value of 29.35×10^{-3} during 1982-83 when rainfall figures were particularly low. A heavy rainfall of 1300 mm (Fig. 6) received during the NE monsoon period in 1985-86 brought down the surface salinity to the lowest value (21.94×10^{-3}) since 1979. The data did not show any change between the pre- and post- operational periods suggesting that the discharges from the power station has no influence on the salinity of the coastal water.

Dissolved Oxygen (DO) : The moving averages of dissolved oxygen (Fig.3) showed that the DO levels were relatively high during northeast monsoon period as compared to the southwest monsoon period. This could probably be due to the incursion of fresh water rich in DO from the adjoining estuaries to the coastal waters during the NE monsoon period. This is particularly evident in the 1985 data when coastal waters had low salinity, high DO and high rainfall (Fig. 6). There is no noticeable change in the DO distribution pattern between pre- and post-operational periods.

Secchi disc: Seasonal variation in water transparency (Fig.4) is characterised by high Secchi disc depths during the period February to May and low during the rest of the year. A comparison of the data between pre- and post-operational periods showed a marginal decrease in water transparency during the latter period indicating that the station operation has marginally increased the turbidity in the nearby coastal water.

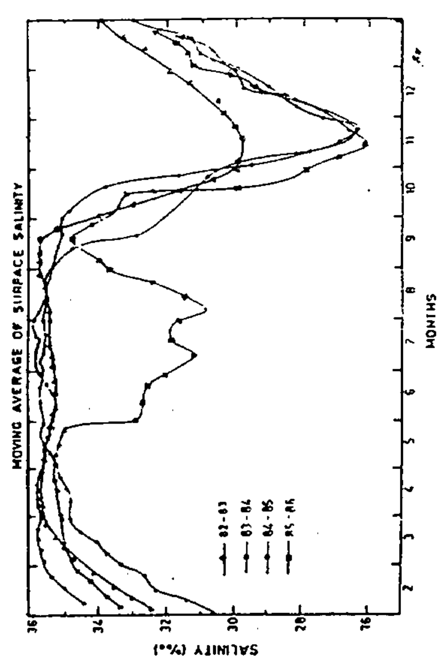

Fig.2. Seasonal variation of moving averages of surface salinity in Kalpakkam coastal waters.

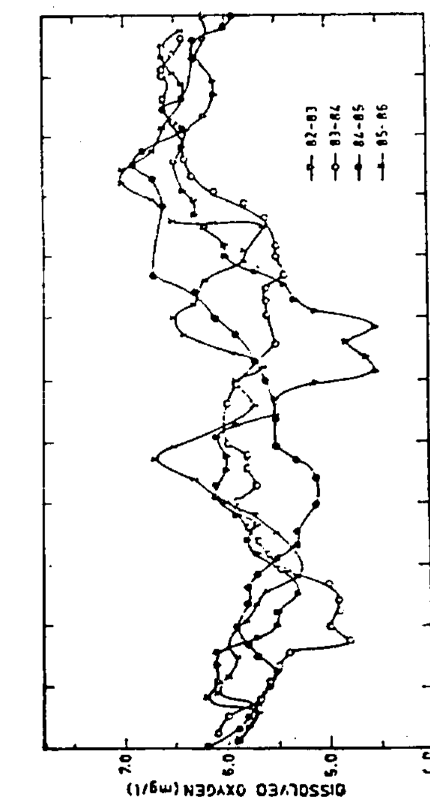

Fig.3. Moving averages of dissolved oxygen in Kalpakkam coastal waters.

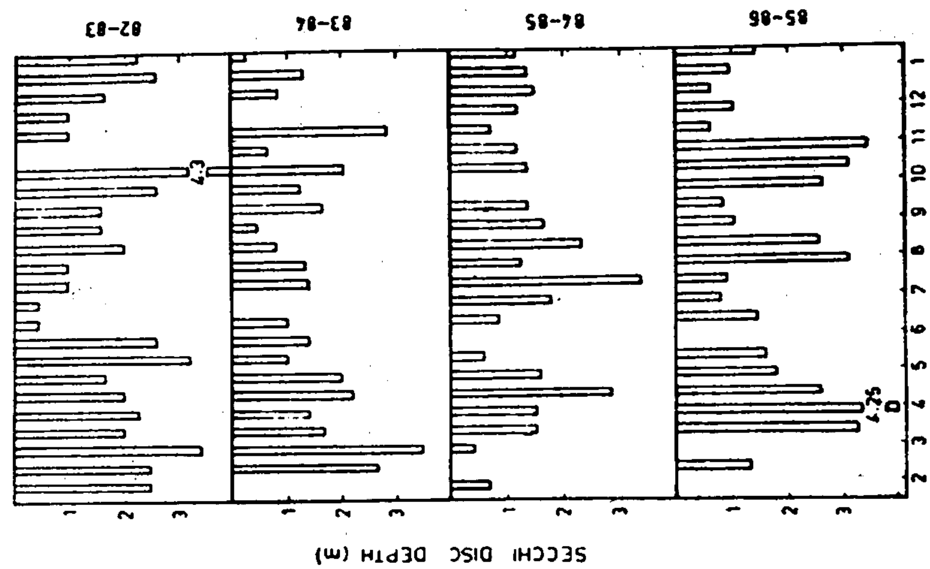

Fig.4. Seasonal variation in water transparency in Kalpakkam coastal waters.

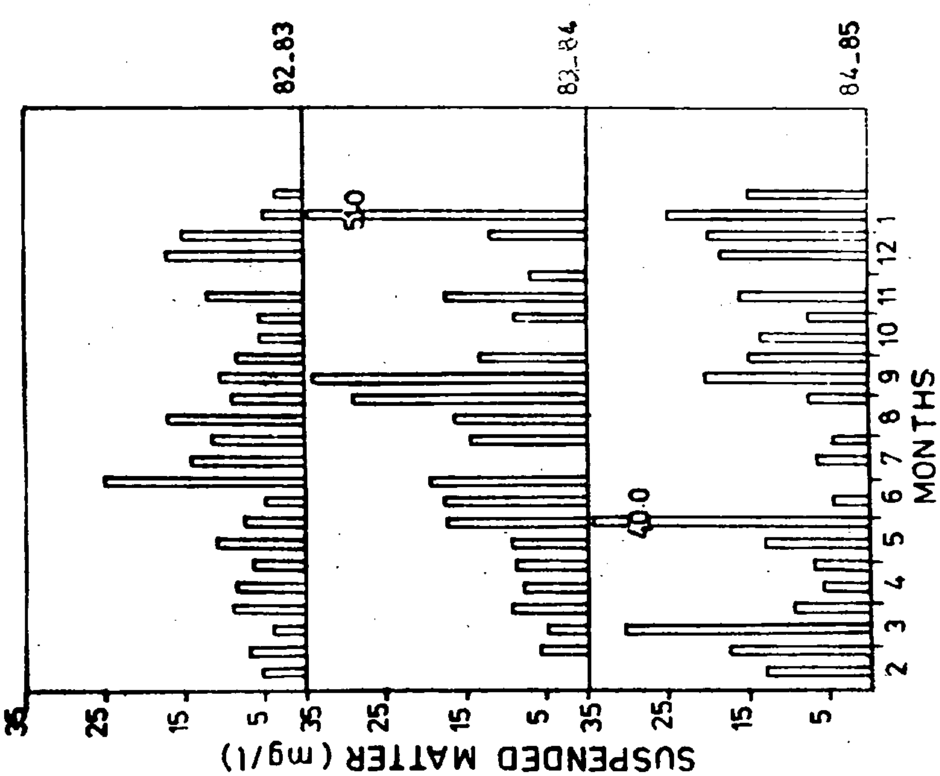

Fig.5. Seasonal variation in seston content in Kalpakkam coastal waters.

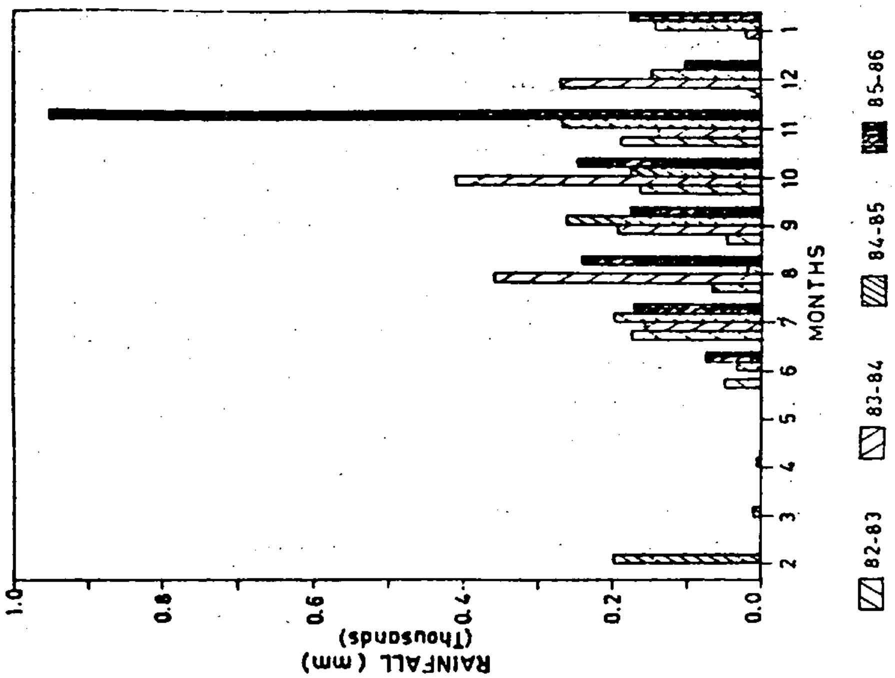

Fig.6. Seasonal variation in rainfall at Kalpakkam.

Suspended matter: The suspended matter data (Fig.5) are characterised by high seston content during the monsoon period compared to the rest of the year. During the post-operational period the absolute values have shown marginal increase compared to the pre-operational period. Marginal decrease in water transparency and increase in suspended matter values in the coastal waters observed during the post-operational period are probably due to the sustained turbulence in the coastal waters induced by the operation of large circulating seawater pumps. A comparision between suspended load and Secchi disc depth showed that generally Secchi disc depth decrease was associated with the increase in suspended matter load.

Thus an analysis of the hydrographic and chemical features of the coastal waters during the period 1982-86 show that there has been no marked change between the pre-operational and post-operational period of the power station. Of particular interest is the distribution of temperature which did not reveal any warming up of the coastal waters although the heated effluent is discharged nearshore. The influence, if any of these warm water discharges, 7 to 10°C higher than the ambient (Satpathy, Eswaran & Nair, 1986) appears to be in bringing about a relatively more even temperature distribution in the areas adjoining the outfall as seen from the general flattening of the moving average curves during the post operational period. However, it is felt that to precisely quantify the temperature changes in coastal waters a continuous record of air and sea surface temperature during the pre- as well as post-operational period would be far more useful than the weekly data which have been used during the present study. The distribution of dissolved oxygen in the coastal water seems to be more influenced by fresh water run off than by any other seasonal phenomena or power plant related impact. One significant change noticed after the commencement of the power plant operation is the increase in the suspended matter content and an associated decrease in water transparency, a consequence of turbulence associated with the pumping of large quantity of seawater for condenser cooling.

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