

MARINE POLLUTION MONITORING AND COASTAL PROCESSES OFF ANDHRA COAST

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1. INTRODUCTION

Coastal and nearshore areas are gaining importance due to several factors. Protection of marine environment from industrial and domestic effluents into the coastal waters, development of harbours, Jetties and other offshore structures, global warming and the consequent sea level rise due to greenhouse effects, development of beaches for recreation purposes etc. are few of them. IOC/WMO have already prepared documents for the longterm monitoring of coastal and nearshore processes in detail, under various international programmes.

Andhra Pradesh has a coastline of about 640 Km. Several industries are going to be set up along Visakhapatnam-Kakinada Coast, in the next few years. A 1000 MW power plant by NTPC, a big oil refinery, two Magnesia plants are some of them. ESSAR group is going to invest Rs. 1000 crores to set up industries in this belt. In addition to the industrial and domestic effluents, prawn culture which is in full swing all along the coast will pose a threat to coastal environment. In view of the above, regular monitoring of pollution concentration in the harbour and coastal waters is being done by NIO, RC, Visakhapatnam under the DOD project, 'COMPAS'.

1.1. Marine Pollution Monitoring

From the measurements, it is identified that the concentration of effluents are much higher in Visakhapatnam harbour and Kakinada Bay. They were designated as 'hot spots' and intensive monitoring in those areas is being done.

Visakhapatnam harbour (Fig. 1) extends 4 Km from northwestern arm to outer harbour and is connected to open sea through the entrance channel. Industrial effulents into the harbour through western and north western arms and domestic sewage joins the harbour through the south lighter canal of the turning basin. Knowledge of the natural mixing characteristics of the harbour waters is essential for study of the environmental problems such as dispersion of chemical or biological pollution.

Mixing parameters for Visakhapatnam harbour are given in Table 1. Replacement time (T) is defined as the time required for a slug of material initially concentrated at one end of an estuary to reach approximately Uniform Concentration throughout the estuary. Flushing time (F) is defined as the mean time that a particle of tracer remains inside the estuary.

Fig. 2 represents the variation of saline water fraction and phosphate concentration with distance from the mouth of the harbour. Phosphate in the harbour follows the distribution of saline water fraction during pre-monsoon (Fig. 2). Estimated inputs of nutrients discharged into the nearshore waters are presented in Table 2. The values are very high during south-west monsoon season and low in post monsoon season (Ramaraju et al, 1990).

1.2 Heat Budget

Air-sea interaction processes play a significant role in atmospheric circulations. Small changes in any of the heat budget terms alters the atmosphere circulation on a regional scale. Information on heat budget parameters are useful for air-sea coupling models, mixed layer models and for climatological studies.

Heat budget equation for an ocean column can be represented as,

$$Q_n = Q_t + Q_v$$

Where, $Q_n = (1-\alpha) Q_i - Q_b - (Q_e + Q_s)$

$$Q_t = \frac{\partial H}{\partial t} D$$

$$H = \rho_o C_{\rho_o} \int_0 \bar{T} \cdot dz$$

$$Q_v = - \left[U \frac{\partial H}{\partial x} + v \frac{\partial H}{\partial y} \right]$$

$$Q_b = \epsilon \sigma T_s^4 \left(0.254 - 0.00495 ea \right) (1-0.7c)$$

$$Q_e = \rho C_E L (q_s - q_a) v_{10}$$

$$Q_s = \rho C_P C_H (T_w - T_a) v_{10}$$

where,

Q_n = Net heat exchange across the sea surface (W/m^2)

Q_t = Rate of change in heat storage ($\partial H/\partial t$)

Q_v = Heat advection

α = albedo of the sea-surface (normally taken as 0.06 for all practical purposes)

D = Depth of water column (40m in the present case).

Q_i = Total incoming solar radiation

Q_b = effective back radiation

Q_e = Latent heat flux

Q_s = Sensible heat flux

H = Heat content (J/m^2)

ρ_o = Density of sea water; C_{ρ_o} - specific heat of sea water

\bar{T} = Mean temperature of the water column

\bar{U} & \bar{V} = Components of current (cm/s) in x,y directions respectively

ϵ = Emmissivity of sea surface (0.97)

σ = Stefan Boltzman constant

ea = Vapour pressure

c = Total cloud amount (Octas)

ρ = Density of air

L = Latent heat of evaporation

U_{10} = Wind speed at 10m height

$Q_s - q_a$ = Specific humidity gradient

$T_w - T_a$ = Sea-air temperature difference
 C_p = Specific heat of air at constant pressure.
 C_E & C_H = Bulk transfer coefficients for latent and
sensible heat fluxes (Kondo, 1975; Sadharam 1991)

[For details refer, Sadharam, 1988; Sadharam et. al., 1992]

Heat flux divergence or heat advection (Q_v) is computed ($Q_n - Q_t$) [Sadharam et al, 1994a] for a small area off Visakhapatnam [Fig. 3], from the above set of equations. Figs. 4 and 5 show the variation of various meteorological and heat budget parameters as a monthly time scale. Q_n is found to be maximum (220 W/m^2) in the months of May and it is close to zero during Nov-Dec. SST is high (30°C) during pre-monsoon and post-monsoon seasons. Q_t is found to be maximum and positive in May (Fig. 5).

A good correlation ($\gamma = 0.9$) is found between alongshore wind stress (τ_y) and Q_v (Fig. 6). Overall study indicate that net heat gain at the sea surface (114 W/m^2) is almost lost through advection (115 W/m^2) and making Q_t almost close to zero, on annual scale.

1.3 Coastal Processes

Coastal processes are highly complex in nature in view of the fact that this zone is subjected to land-ocean-air interaction processes. They are highly variable on short time and space scales. The general properties of temperature and current vectors of the coastal waters are shown in Figs. 7 and 8.

1.3.1 Temperature and Currents

The thermal structure is highly variable from season to season. It is interesting to notice that the coastal waters are dominated by sub-surface inversions during the month of October and early November. (Fig. 7) [Sadharam et al., 1994b].

Fig. 8 gives you an idea on the mean speed (cm/s) and direction of the current in the surface (0-10m) and bottom (30-40m) layers. Since the sea is normally very rough in SW monsoon due to strong wind and wave conditions, data could not be collected during South-West monsoon season. At surface, the currents are directed towards N-NE with speeds around 40-50 cm/s, during Feb-May while the flow is more or less westerly during Sept-June. At bottom, the currents are weak and more or less following the same direction as seen at the surface. [Fig. 8].

We have found strong currents of the order >100cm/s, in the end of October, 1989. Similar currents were also noticed in the months of Feb. and April. Mechanism for driving such a strong current in the transition periods between SW and NE monsoon seasons is not known.

1.3.2 Dispersion

Dispersion studies are important to know the mixing characteristics of the waters which is useful for the discharge of effluents from the industrial sources. Estimation of eddy diffusion coefficients (K) from dye studies is very much desirable for our coastal region. From the available information on currents, temperature and heat advection, the value of K is approximated from the equation

$$Q_v = \rho C_p K \frac{\partial \bar{T}}{\partial x}$$

The value is found to be about $3.0 \times 10^4 \text{ cm}^2/\text{s}$ for the month of October [Saduram et al., 1994b]. This value appears to be small due to the fact that the observations were carried out under highly stratified conditions, where sub surface inversions were noticed. (Fig. 7). From the recent measurements in the Visakhapatnam harbour, the value of K is found to be about $1.83 \times 10^5 \text{ cm}^2/\text{s}$. Further studies in this direction are very much essential in coastal and harbour Waters, in view of the rapid growth of the industrialization along Visakhapatnam-Kakinada Coast.

References:

1. Kondo, J. 1975. Air Sea bulk transfer coefficients in diabatic conditions. *Boundary Layer Meteorology*, 9, pp. 91-112.
2. Ramaraju, V.S., Sarma V.V., Raju G.R.K. and Subba Rao, V. 1990. Mixing in Visakhapatnam harbour and nutrient inputs in the nearshore waters, east coast of India Mahasagar. Vol. 23, No. 1, pp. 49-54.
3. Sadharam, Y., Rao, B.P., Subba Rao, V. and Rao, T.V.N. 1992. Diurnal Variability of heat fluxes and heat content at a few locations off central east coast of India during April, 1989. *Mausam*, 43, 2, 147-150.
4. Sadharam, Y., Rao, B.P. and Rao, D.P. 1994a. Alongshore wind stress and heat flux divergence off Visakhapatnam, east coast of India. *Indian J of Marine Sci.*, Vol. 23, pp. 18-21.
5. Sadharam, Y., Rao, B.P., Rao, D.P. and Rao, V.S. 1994b. Spatial and temporal variations of the heat budget parameters and currents in the coastal waters of Visakhapatnam. *Indian Journal of Marine Sciences* (In Press).
6. Saduram, Y. 1988. Effect of an oil slick on the albedo of the sea surface. *Boundary layer Meteorology*, NO. 45, pp. 202-204.
7. Sadharam, Y. 1991. Estimation of bulk transfer coefficient for latent heat flux (C_e). *Boundary Layer Meteorology*, 54, pp. 411-414.

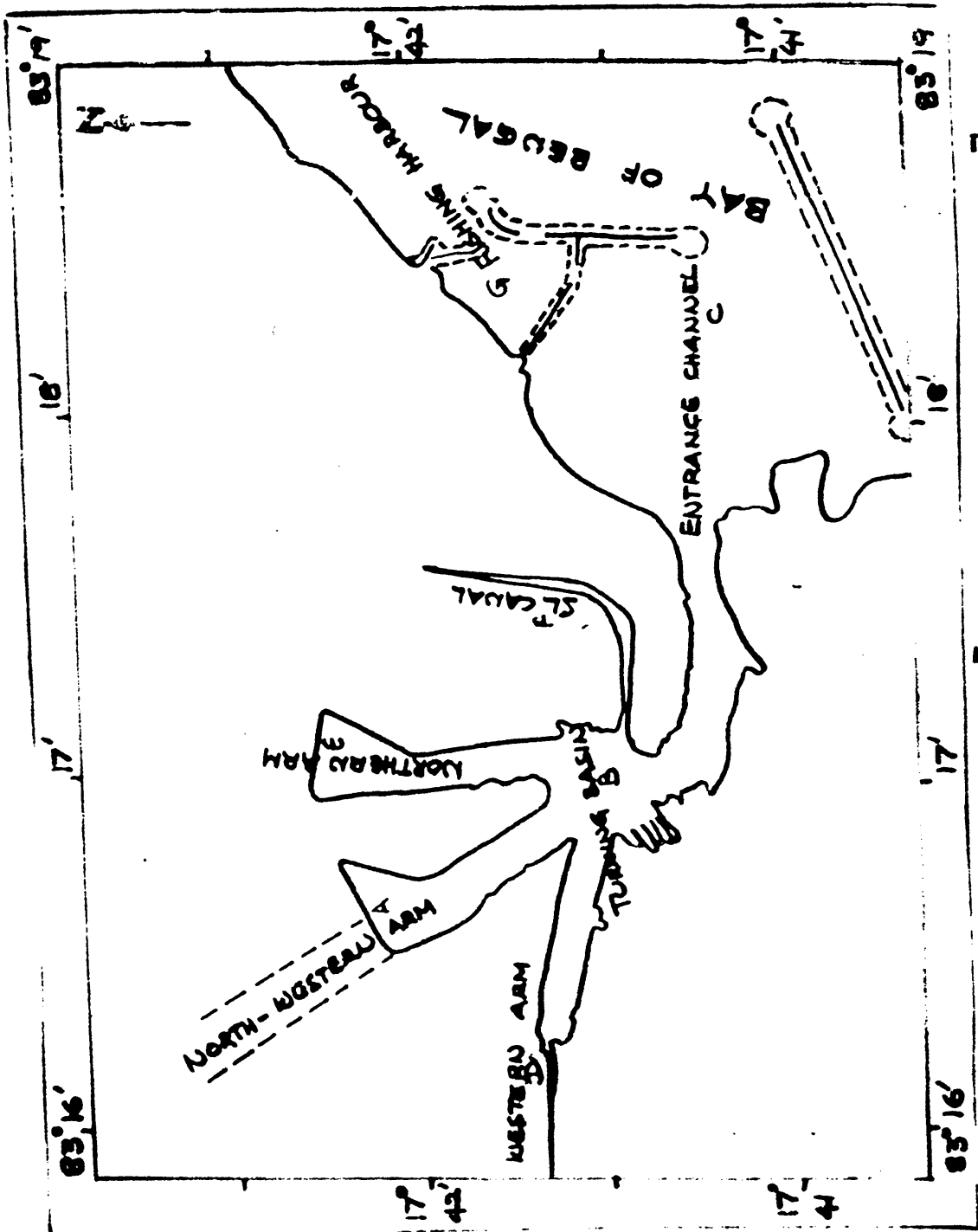


Fig. 1. STATION LOCATIONS [VISAKHAPATNAM HARBOUR] 'HOT SPOT' AREA-I

Distribution of Phosphate (%) and Saline water fraction (%)

Fig. 2.

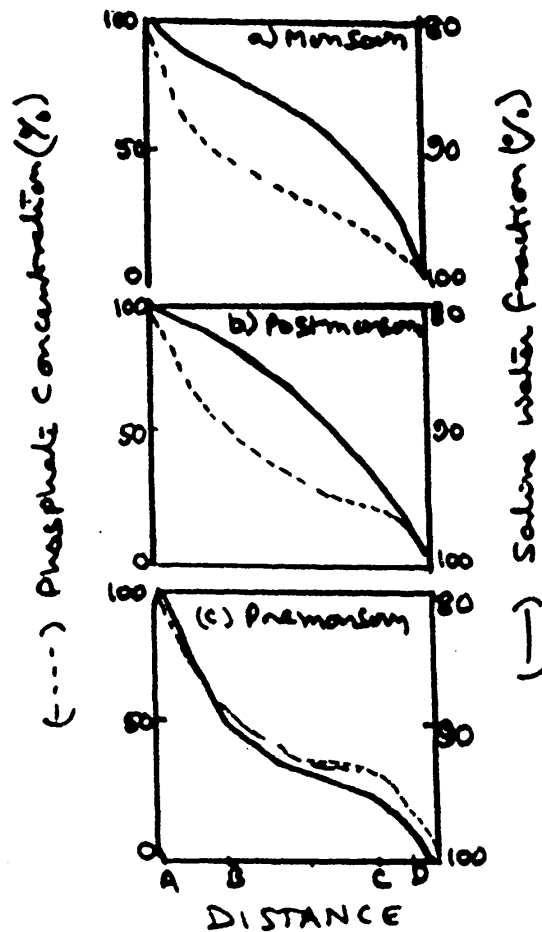


TABLE-1
Mixing Parameters:

Season	Net cross sectional Discharge (R) $m^3 sec^{-1}$	Longitudinal Dispersion coefficient (K) $m^2 sec^{-1}$	Flushing time (hr) $t = f \cdot V/R$	Replacement time (hr) $T = 0.4L^2/K$
Premonsoon	26.51	15.4	46	115
Monsoon	47.30	27.5	28	64
Postmonsoon	19.64	11.4	70	155

TABLE-2. Nutrient inputs from harbor ($tons \cdot day^{-1}$) into coastal waters

Season	Nitrate	Phosphate	Silicate
Premonsoon	4.67	1.67	2.05
Monsoon	5.85	2.19	4.42
Post-monsoon	3.14	1.14	1.93

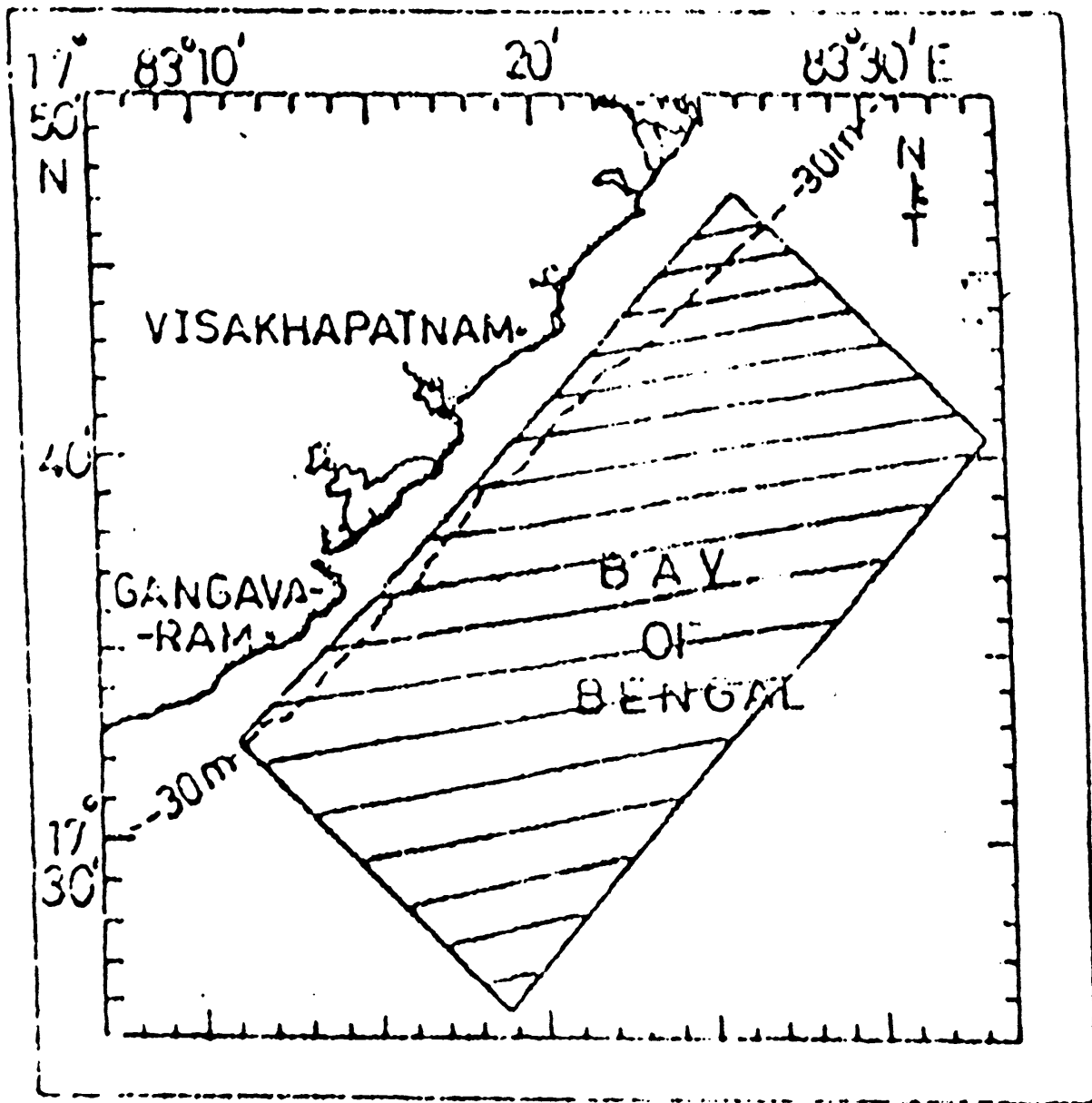


Fig. 3 - Location map (study area is shaded)

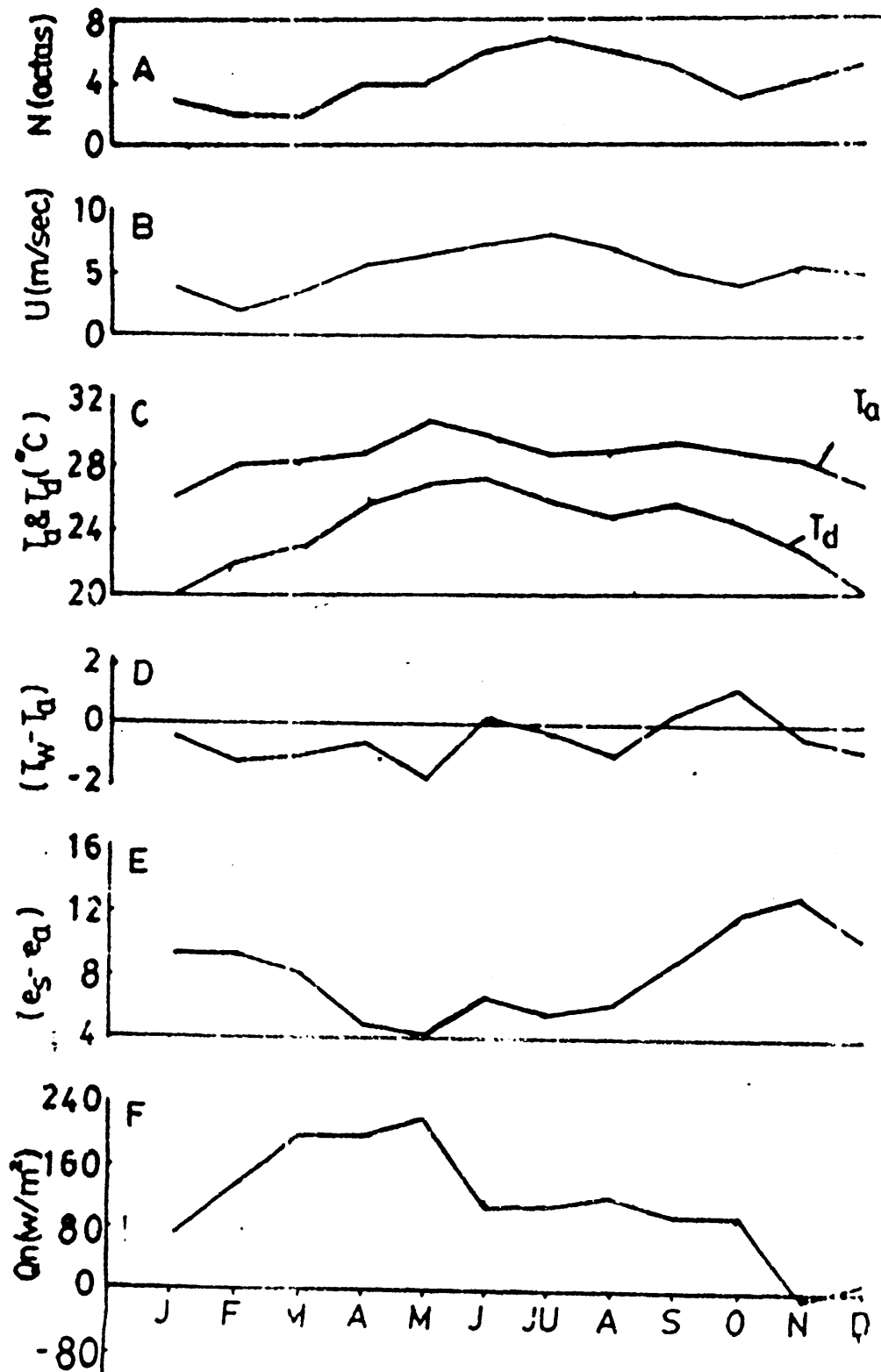


Fig. 4. Mean monthly variation of met parameters and net heat exchange (Q_n)

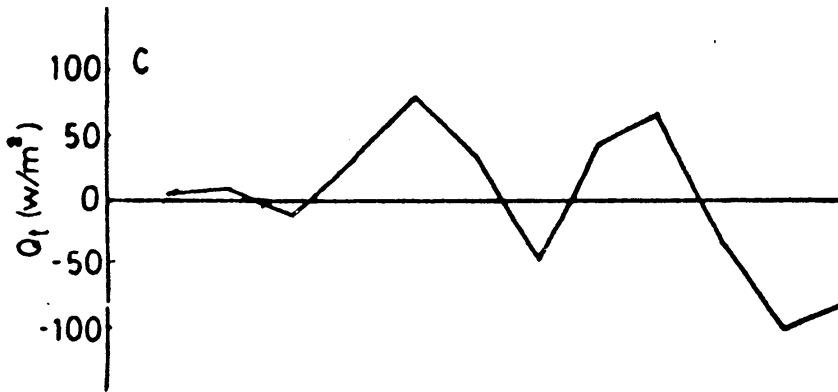
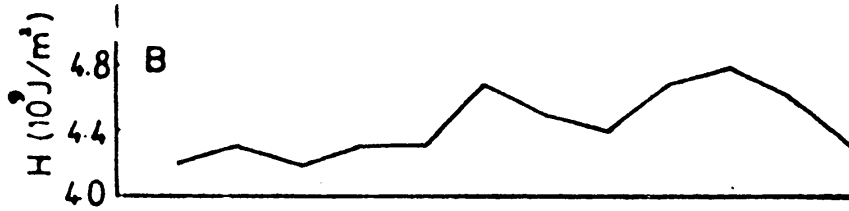
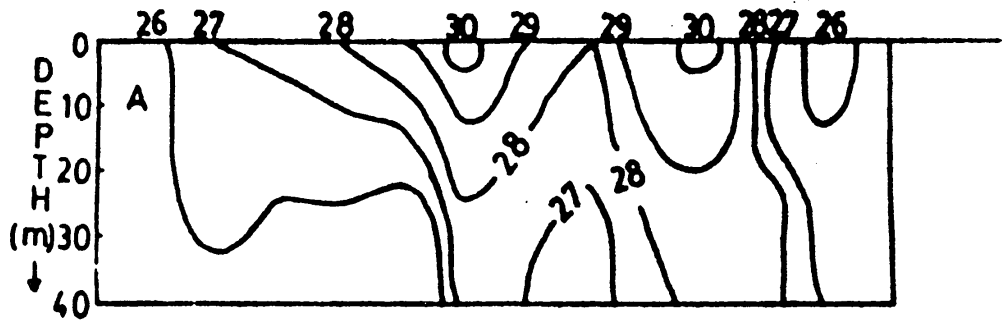


Fig 5

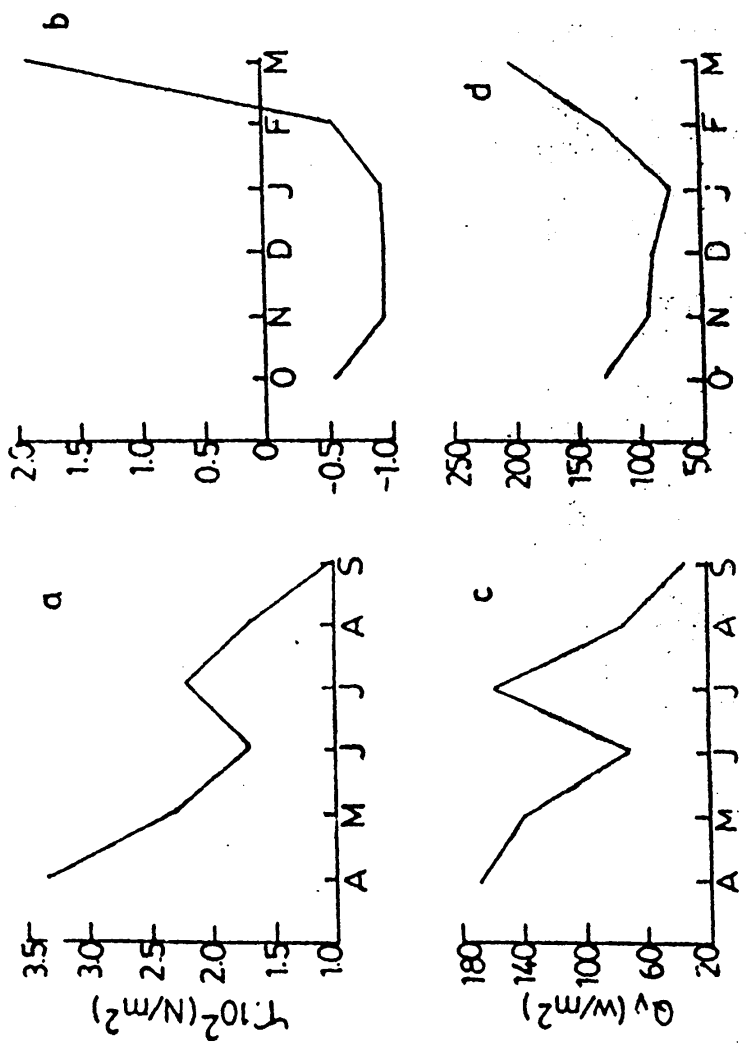


FIG. 6

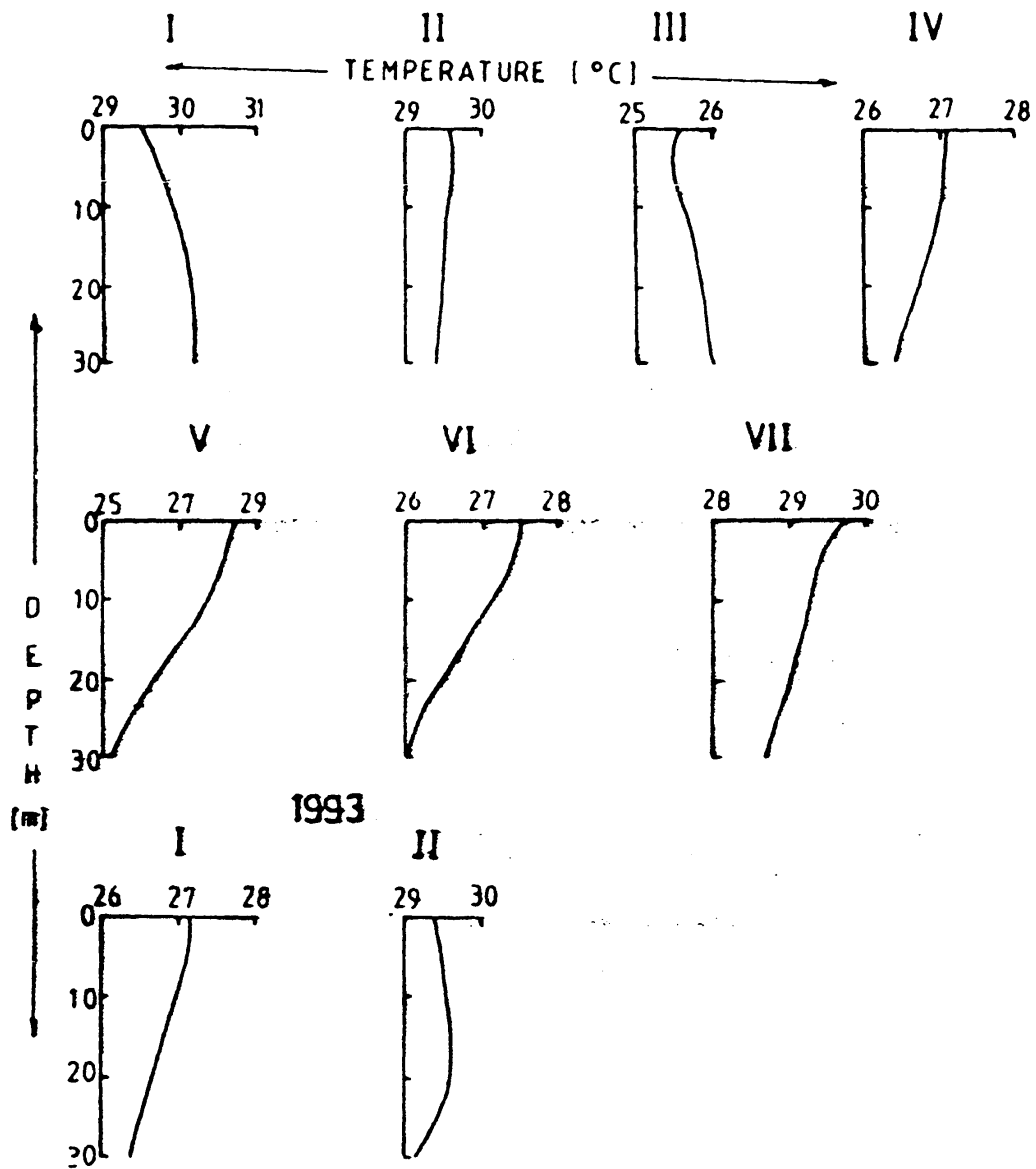


FIG. 3 Thermal structure under different phases during 1989-90 and 1993 (Feb & Oct/Nov)

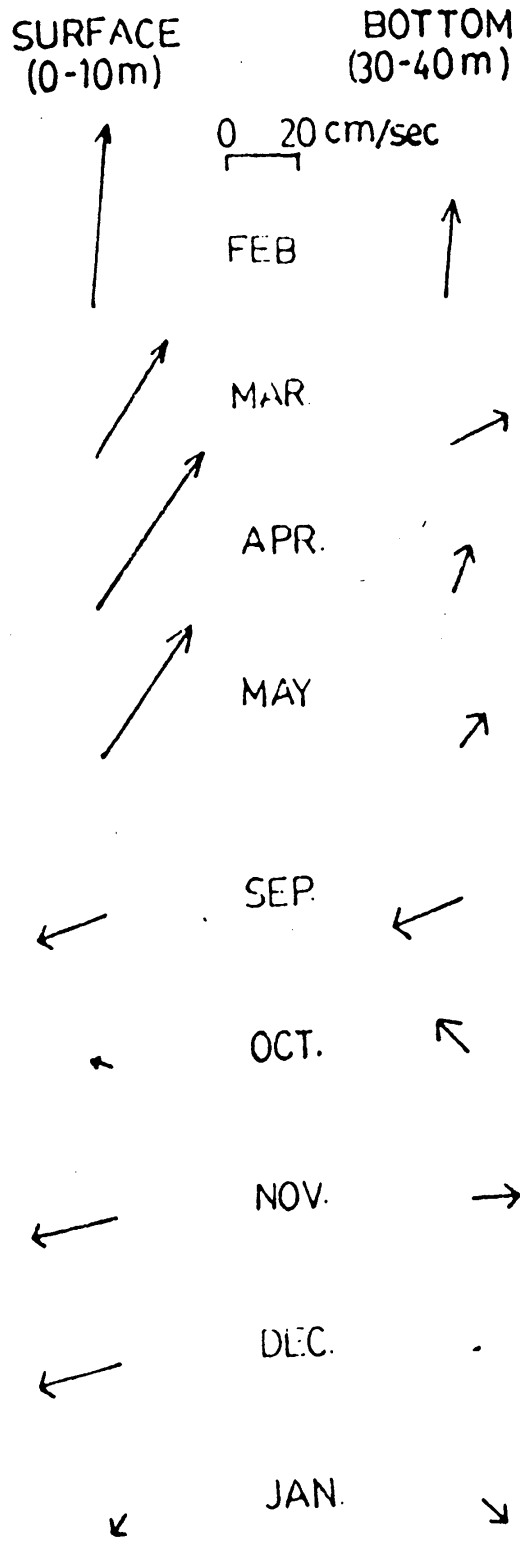


FIG 8