

Breathing Cochin backwaters: Need for conservation

K.K.C. Nair

Regional Centre Kochi, National Institute of Oceanography

If there is a possible threat to the well being of the living resources of EEZ of India, then the coastal waters of southwest coast of India, and in particular, Cochin is one of the prime locations prone to trigger it. Being the second largest city along the West Coast, the coastal circulation of this region is critical because, as compared to the Mumbai coast where the mean tidal height is > 3 m, the southwest coast has only one meter. Because of the low tidal amplitudes, these coastal regions have small inter-tidal expanses, perhaps the smallest among the Indian coasts. This results in incomplete flushing, leaving behind parcels of perennially undulating water. Any substance released in such a waterbody will always have a fraction of it left behind, however small that might be whose residence time will continuously increase with increasing number of oscillations. Therefore, to estimate the carrying capacity or assimilative capacity of any coastal waters, it is imperative to critically examine the residual tidal effect of any eventual pollutant in their waters.

Cochin, the biggest city along the west coast of India after Mumbai, has population of nearly 3 million and 60 % of the chemical industries of Kerala are situated in this area. Cochin backwaters are the largest of its kind on the west coast of India, occupying 256 km². In recent years, great concern has been expressed with regard to deterioration of Cochin backwaters and consequent loss of supportive functions of this wetland system, especially due to urbanization, industrialization and agricultural activities in the downstream zones of the rivers. The 16 major and several minor industries situated in the upstream region of the backwaters discharge nearly 0.104 Mm³.d⁻¹ of effluents, causing large-scale environmental pollution. Apart from this, the backwaters also receive organic wastes (~ 260 td⁻¹ Anon, 1998) from domestic sewage, coconut-husk retting yards, fish processing plants etc. The industrial typology includes fertilizer, pesticides, radioactive mineral processing, chemicals and allied industries, petroleum refining and heavy metal processing and fish processing. The fertilizer consumption in Kuttanad region (the main agricultural field draining to Cochin backwaters) alone is reported to be 20,239 ty⁻¹. The main factors affecting the coastal waters apart from sewage are fish processing, navigational dredging and dumping of dredge spoil and sand mining for filling and construction. In addition, the annual dredge spoil from the harbour area alone come to the tune of 10⁷m³, which are dumped in the coastal seas. To summarize all, as the system has been subjected to irrational economic exploitation during the past five decades, the environmental deterioration has ultimately resulted in ecological degradation. All these factors indicate that the coastal waters of Cochin are prone to receive a significant portion of the wastes arising from the increased developments finding their way to the backwaters.

The approximate residence time of Periyar estuary is 39 days (Hema Naik, 2000), which means that the system is capable of flushing only < 5 % of estuarine waters in a day during lean discharge period. Hence a substantial percentage of the upstream input will be retained after each tidal cycle, which may result in oscillation of such enriched water masses towards the barmouth. Thus, during the neap observation, phosphate levels at the barmouth actually rise in high saline waters as the flood tide peak, and the

concentrations at the surface and bottom levels reach 10 and 8 μM respectively. It must also be noted here that the phosphate concentrations at Cochin barmouth is around 2 μM at any stages of the observation, inferring that in spite of the dilution of estuarine inputs, the barmouth region is also susceptible to enriched nutrient levels quite often.

Physical, chemical and biological processes affect distribution of nutrients in the estuary. It can be seen that there is a very strong negative correlation between salinity and nutrients within the estuary indicating that the nutrient levels within the estuary is controlled by the upstream discharges. The nitrogen fractions seem to have greater fluctuation than other nutrients. A reason for this may be that nitrogen input can increase disproportionately when there is greater fresh water flow (Korner, 1987). The correlation analysis indicates that the nutrients are transported into the estuary through upstream discharges.

A comparative study of the various environmental parameters collected presently as well as the earlier data collected from the estuarine mouth, near Cochin harbour has been chosen for the comparison, as several workers have repeatedly sampled this region since 1965. The reason for taking the barmouth as an index for estimation of these pollution load is because this is the point where the pollutants are brought down to the minimum by dilution before being exported to the coastal waters. The mean surface concentrations of phosphate and nitrate recorded at the barmouth of the non-monsoon months (October to May) from 1965 to 2000 is presented. It can be seen that both nitrate and phosphate were present in very low levels upto mid 70s' from where, due to the combined effect of increased industrial as well as agricultural activities, the levels increased during 80s' and 90s'. During 1965, the surface phosphate and nitrate concentrations were 0.75 and 2.0 μM , which has increased to 2.9 and 6 μM respectively by 2000 eventhough, between the years it show still higher levels. The trend also shows a build up of nitrogen and phosphorus fractions after 1975 and from 1980 onwards, the concentrations remained high. Enrichment of phosphorus with respect to nitrogen is more leading to mesotrophic waters.

The nutrient concentrations reported in the table are only the minimum as it represents the barmouth, but the maximum levels observed by the same workers towards the upstream reaches are quite alarming. For example, in the case of inorganic phosphate, the build up has started after 1973, and subsequent increase in waste discharges have ultimately resulted in extreme levels of ammonia, phosphate and nitrate in the estuarine region. During 1980-81, the backwaters of present study region recorded nitrate and phosphate concentrations upto 40 and 12 μM -upstream peaks are 108 μM for nitrate and 186 μM for phosphate- respectively (Saraladevi, 1986). Sankaranarayanan et al., (1986) have recorded phosphate concentrations upto 88 μM during 1982-83, in the northern upstream stations of Cochin backwaters while during the same period, the present study region was found to contain phosphate from 5 to 40 μM . During 1985-86 Anirudhan (1988) has observed an annual variation of nitrate from 7 to 39 μM and phosphate from 1.63 to 9.69 μM at the barmouth. During 1990, the nutrient maximum reported from this estuarine region was 98.48 μM for nitrate and 15.11 μM for phosphate (Kunjikrishna Pillai, 1991). Recent studies by Sheeba (2000) also **underline** the nutrient enrichment in the Cochin backwaters, as she recorded nitrate upto 451 μM and phosphate upto 33 μM at the barmouth alone.

The analysis of environmental data in previous section signals a general conclusion that over the years, Cochin backwaters has shown deterioration in environmental quality owing to several factors, all related to human interventions. One of the recent estimates show that in spite of receiving $42.4 \times 10^3 \text{ mol.d}^{-1}$ of inorganic phosphate and $37.6 \times 10^3 \text{ mol.d}^{-1}$ of inorganic nitrate from Periyar estuary, the export to the coastal waters is only $28.2 \times 10^3 \text{ mol.d}^{-1}$ of inorganic phosphate and $24 \times 10^3 \text{ mol.d}^{-1}$ of inorganic nitrate (Hema Naik, 2000). Thus, the estuary acts as a sink for the nutrients, flushing out only a portion of the pollutant load that it receives. The enhancement with respect to these nutrients in Cochin backwaters shows the signs of eutrophication.

One of the noticeable changes that has happened to this estuary is that there has been a considerable reduction in the exchange volume of water with coastal waters. The tidal transports during 1950 to 1970 were about 90, 126 and 65 $\text{Mm}^3/\text{tidal cycles}$ (Gopinathan and Qasim, 1971; Wyatt and Qasim, 1973; Rama Raju et al., 1975) respectively. This has been reduced to about 35 $\text{Mm}^3/\text{tidal cycles}$ during 80's (Jomon Joseph, 1989). The reduction in export volume in turn, is the reduction in the flushing characteristics of the backwaters. In 2000 also, during the neap tide, considerable build up of nutrients is observed at the barmouth and at station II (see presentation). The residual currents are found to be towards the estuary at barmouth and non-directional at station II. Flood currents always dominate the ebb currents, as observed earlier (Udaya Varma et al., 1981; Jomon Joseph and Kurup, 1987). All these observations invoke a possible direct relationship between the diminished flushing rate and estuarine build-up of materials. Developments of 'null zones' in estuaries of natural flushing are observed towards the upstream sections where early salinity is experienced (Pattersen et al., 1975). But considerable shrinkage of the Cochin backwaters as a result of human interference (Gopalan et al., 1988) has reduced the tidal expanse of this system and it is probable that the null zones are shifted more towards downstream. The response of such events is complex, as the suspended sediment in the estuarine waters, instead of flushing out into the sea, is pushed upstream and ultimately is retained within the lower estuary itself. The upstream stations of the present study seems to occupy null zones as it is evident that the sediments of this regions are enriched with organic matter and clayey sediments, which may also favor metal accumulation.

Eventhough these are only approximations; the trend gives a warning by the backwaters in reducing its flushing qualities. This has ultimately resulted in consequent loss of supportive functions of this wetland system, especially due to increased reclamation, deforestation in catchments, inadequate waste treatment and similar other poor management plans. The response of the backwaters was slow initially, but it is now recognized that the deterioration with respect to environmental quality has already taken place and there has been considerable reduction in estuarine fishery.

Coastal waters of Cochin

The long-term changes in the Cochin backwaters give an indication as how anthropogenic influences have dominated the natural process in the estuary. The same analysis is extrapolated for the coastal waters to understand the dominant forces that are controlling the coastal water ecosystem.

The linear trend for dissolved oxygen and nutrients like phosphate, silicate and nitrate for the period 1958 – 2000 are presented (solid circles). In order to visualize the impact

of Cochin backwaters on the coastal waters, the corresponding surface values of phosphate and nitrate for the barmouth region during the same period are also overlaid in the same figure (open circle) (see presentation). The results show that the influence of the anthropogenic inputs through the Cochin backwaters has not significantly affected the coastal waters, as their behavior is more or less consistent when compared to the trends observed at the barmouth. The dissolved oxygen concentrations indicate that over the 41 years, there has been only a very slight reduction in oxygen levels (< 10 %). The trends for the nutrients are however found to be varying. While silicate shows periodic enrichment in the coastal waters after 1990, an increasing trend in the phosphate and nitrate levels seem to be quite surprising.

Phosphate and silicate show a slight build up over the decades. According to the linear regression, surface values of phosphate increased from 0.29 μM to 0.59 μM in 42 years: ie; 2 fold. Corresponding increase at 10m levels is 1.6 fold (0.32 to 0.51 μM). While the surface nitrate decreased from 2.78 μM to 1.67 μM , the levels at 10 m showed an increase from below detectable limit to 1.67 μM . Similar analysis for silicate shows that the surface silicate has almost doubled over the period (4.14 to 8.27 μM) while at 10 m, the increase was 1.8 fold (3.42 to 6.21 μM).

Although the above approximations furnish only the trend observed in the 41 years, limitations are there to assess how much of the variability is due to the different water masses and the adjoining backwaters fertilizing the coastal waters of the study region. Studies conducted by Naqvi and Jayakumar, (2000) show that the surface waters of Arabian Sea did not contain higher nutrient concentrations now than they used to have decades ago. Similar studies conducted elsewhere have successfully delineated the different water masses through systematic water-quality modeling (Gerlach, 1988). As we look into the data more critically, there is a cause for concern in that, a marginal increase in nitrate and phosphate concentrations could be noticed in the coastal waters, though it is not to the level observed at the Cochin barmouth. The period since 1990 is seen with fluctuating levels of phosphate, nitrate and silicate, probably indicating a shift from the natural to anthropogenic dominance of our coastal waters.

Now, are the nutrients transported by freshwater responsible for this ? Though reliable data are scarce, there is enough circumstantial evidence for the statement that rivers from densely populated areas, containing wastewater, sewage and sludge dumping are responsible for transporting substantial amount of nutrients, especially during and immediately after the monsoon months. Progress regarding our understanding of changes over time requires monitoring data in the same way as weather forecasting. Improved modeling and verification of models along our coastal sea circulation is necessary including the modeling of small-scale effects of freshwater discharge. Likewise, there are many questions yet to be answered such as the fate of 19,000 million m^3 of water discharged annually to this coastal environment. A better understanding of the fate of nutrients in the particulate phase is also required. The role of denitrification, remineralisation in the sediment and excretion by grazers has to be identified to get a better estimate. The interactions between nutrients and phytoplankton have to be clarified. Only by improving our understanding on such basic sciences, a proper addressing of coastal eutrophication processes could be made possible. Whether such marginal enrichment in respect of phosphate and silicate, and reduction in nitrate and dissolved oxygen has affected the phytoplankton community over the

years could provide new dimensions to studies related to ecological balance of the coastal waters.

Conclusion

The foregoing account, it is evident that Vembanad Lake, including the Cochin backwaters is undergoing man-made shrinkage, at an alarming rate and a rough estimate of similar plans in the future shows that by the turn of this century the area of the backwater will be reduced to about 17%. Lack of proper planning in developmental activities has created an imbalance in the ecosystem, ultimately reducing the carrying capacity of this natural buffering zone.

The time has come now preserve this precious ecosystem for generations to follow. While it is unlikely to restore the system to its pristine glory, we could at least implement strict measures to maintain the lake in good health. This necessitates a multi-disciplinary approach to study the environment in an exhaustive way and generate suitable mathematical models and validate through simulation. Once a model is developed, the estuarine system can be effectively managed by regulating human intervention by all means.

The observations reported recently for Arabian Sea cautions that anthropogenic activities are indirectly being concentrated towards the oxygen minimum zone of the system, disturbing its delicate biogeochemical balance. It has already shown signs of outbursts off Bombay during late monsoon with the development of H₂S along with hypoxic zone. This hypoxic zone was found extended upto 9° N, which included Cochin. The oxygen depleted zone identified in October, 1997 off Cochin also falls under the same late monsoon period underlines the possible adverse effect imparted by anthropogenic activities to the coastal waters in recent years. Hence it is important to consider the fluxes of both nitrogen and phosphorus fractions into the coastal zone because both plays vital role in oceanic nutrient budget.

In view of the response of Arabian Sea to the increased waste discharges, concerted efforts should be made with immediate implementation of regulations to control untreated effluent discharges through Cochin backwaters. All the industrial and domestic sewage should be strictly subjected to proper treatment prior to discharge to the backwaters. Special places should be selected to process the domestic and sanitary wastes, which are presently not taken care of. The increased use of fertilizers in agricultural fields should be optimized, thereby minimizing nutrient losses through leaching and also saving expenditure. Proper management policies should be imparted to minimize sand mining from the upstream sections and sediment transport to the estuary and coastal environment. The catchment's area should be protected from soil erosion by improving natural habitat. While we cannot expect to enlarge the area of Cochin backwaters, we should at least refrain from further reducing its volume by indiscriminate reclamation.

Reclamations in the Vembanad Lake for agriculture and aquaculture

Period	Area (in ha) Reclaimed	% reclaimed	Purpose
1834-1931	2226	6	Agriculture
1912-1931	5253	14.4	Agriculture
1941-1950	1325	3.6	Agriculture
Till 1970s	5100	14	Paddy-cum-shrimp culture
1970-1984	800	2.2	Paddy-cum-shrimp culture
1900-1984	1500	4	Housing, agri., retting yards
1975	6900	18.9	Ecologically severed from back- waters due to bunding
Total	23105	63.3	

Reclamations in the Vembanad Lake for harbour and urban development

Period	Area (in ha) Reclaimed	% reclaimed	Purpose and location
1920-1936	364.4	1	Creation of Wellington Island
1978	10.8	.03	Fishing harbour
1981-1985	141.7	.4	Vallarpadam-Ramanthuruthu-Candle Island complex
1981-1985	141.7	.4	Wellington Island southern extn.
1981-1985	23.9	.07	Foreshore urban development – GCDA & CPT
1981-1985	11.7	.03	For the use of Cochin Shipyard, CIFT, North Tanker berth etc.
Total	694.2	1.9	

Cochin backwaters – Impact of environmental changes

Year	1900	1950	1960-70	1980-1985	% shrinkage
Area (ha)	36500			12700	34.8
Volume (km ³)	2.449			0.559	22.8
Average depth		8 – 9 m		3 – 3.5 m	
Impact of bund (Shrimp production)		1131 kg/ha	600 –700 kg/ha	300-400 kg/ha	
Giant prawn		300-400 t/yr.	Extinct		