# NUTRIENT DYNAMICS CONTROLLED BY GROUND WATER INJECTIONS

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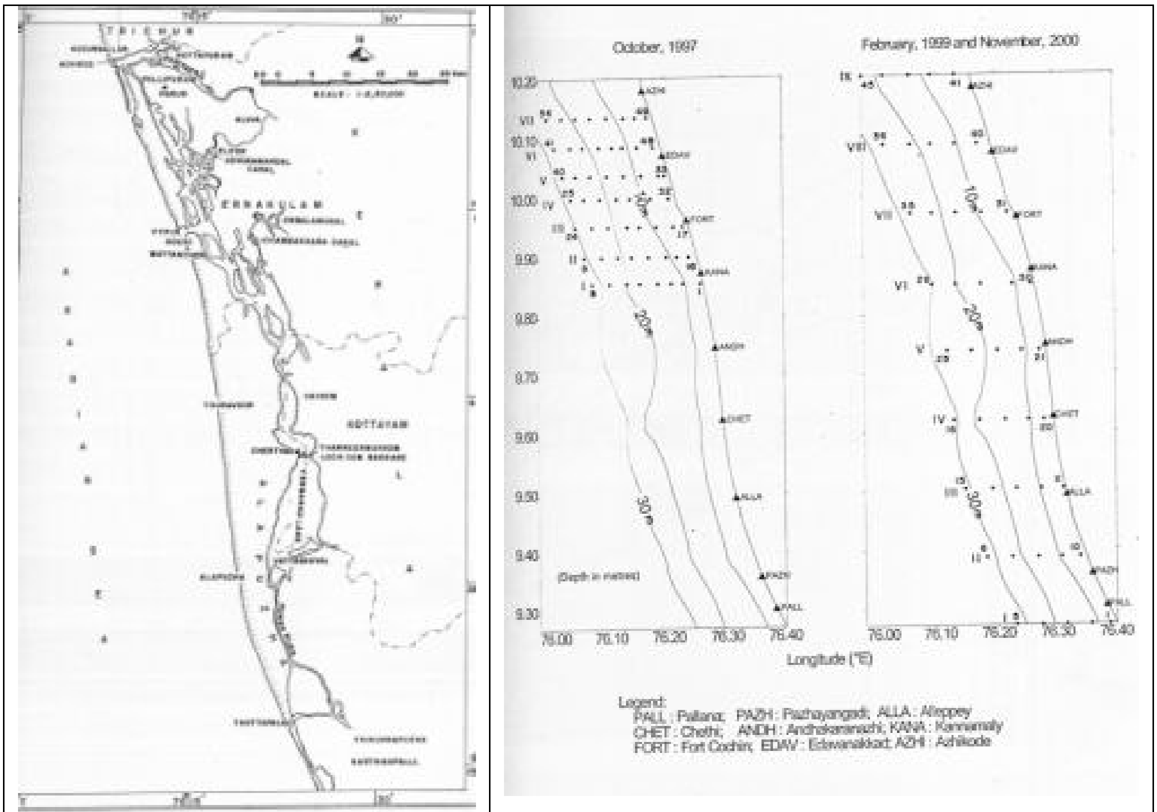
## ABSTRACT

The influence of land-use mosaic among sub-watersheds on coastal processes apply globally to any coastal regions hugged by wetlands and underlain with limestone deposits. The existence of a subterranean flow connecting a tropical backwater to the Arabian Sea through the submerged porous lime shell is indicated from the coastal nutrient distribution. The present investigation represented a non- mud banks period and had fertilization of the coastal water by injection of nutrients by hitherto unknown processes. The high nitrate-N, ammonia concentrations, enriched particulate organic carbon (> 3.5 mg/l) and Chlorophyll *a* (14.8 mg/m$^3$) at a localized coastal region and a band of N/P > 15 funneling out during non-mud bank period gave a clear indication of an 'external source' of nitrogenous compounds to the coastal water. The existence of subterraneous channels as the artifacts of porous nature of the lime shell base of the region transporting the nitrogenous compounds cannot be ruled out in the region. The significance of this study is that subterranean flows could redefine the very concept of formation of mud banks, which are presently recognized only as an oceanographic process. Unlike the existing theories, it is argued that formation of mud banks are not entirely forced by coastal oceanographic processes; instead a remote forcing from the land involving a subterranean flow through the submerged lime beds, appears to be an initiative mechanism. The idea that land-use mosaic among sub-watersheds influence coastal processes may apply globally to any coastal regions hugged by wetlands and underlain with limestone deposits .

**Keywords**: Mud banks, nutrient injection, coastal fertilization

## INTRODUCTION

The west coast of India is environmentally more sensitive than the east coast as it is bordering one of the most sensitive ecosystems, the Arabian Sea. 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 region is the prime location prone to trigger it due to the discharge nearly 0.105 Mm$^3$d$^{-1}$ of effluents. The fertilizer consumption in Kuttanad region (the main agricultural field draining to Cochin backwater) alone is reported to be 20,239 t y$^{-1}$. The backwater receives organic wastes (~ 260t d$^{-1}$ and an annual dredge spoil from the harbor area to the tune of 10$^7$ m$^3$.




A | B

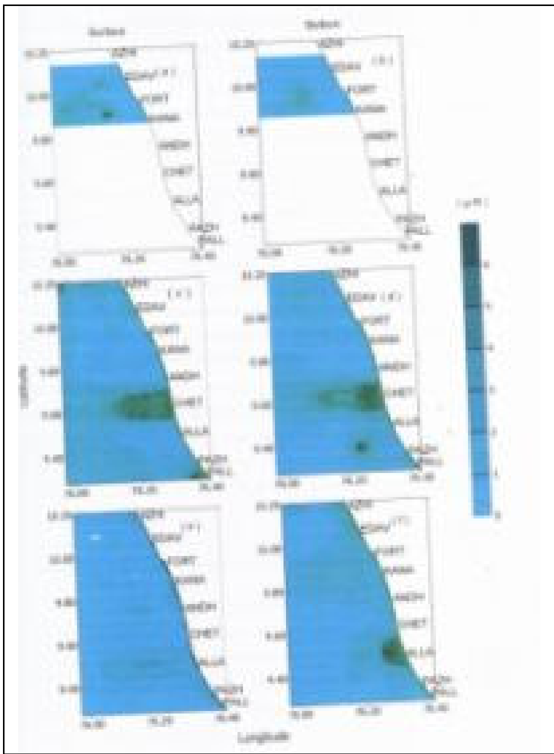
**Figure 1. Map showing the study area (A) and study region with location of stations and bathymetry (B)**

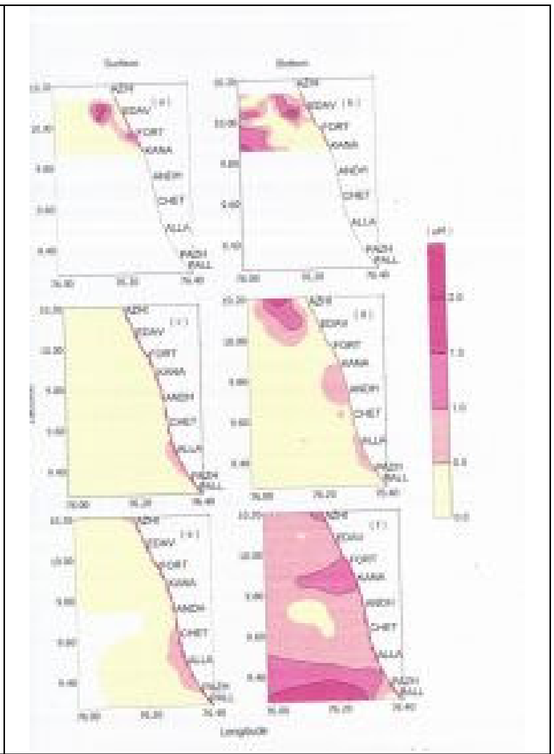
Conventional understanding of coastal waters of southeastern Arabian Sea is that activation of mud banks by monsoon forcing triggers intense geo-chemical processes leading to high productivity. Mud banks, as they appear only during monsoon and disappear with its retrieval, are unique in their formation and functions, and have turned out to be economically important for its rich biological resources. As far as the chemical features are concerned, the general picture so far emerged out is that except during the monsoon periods, the southwest coastal waters remained oligotrophic and surface chlorophyll *a* typically ranges from 0.1 to 5.3 mg.m$^{-3}$, while primary productivity ranges from 100 to 360 mgC.m$^{-2}$.d$^{-1}$. Recent studies as the one discussed here contradict these findings and show that even after the monsoon period, fresh injection of nutrients by hitherto unknown processes fertilize the coastal waters that are either permanent or quasi-permanent in nature. One of the major mudbank regions (Fig. 1 A, B) of southwest coast of India was selected for observation that indicates episodic introduction of nutrients into the coastal waters during periods when mud banks are passive.

# RESULTS AND DISCUSSION

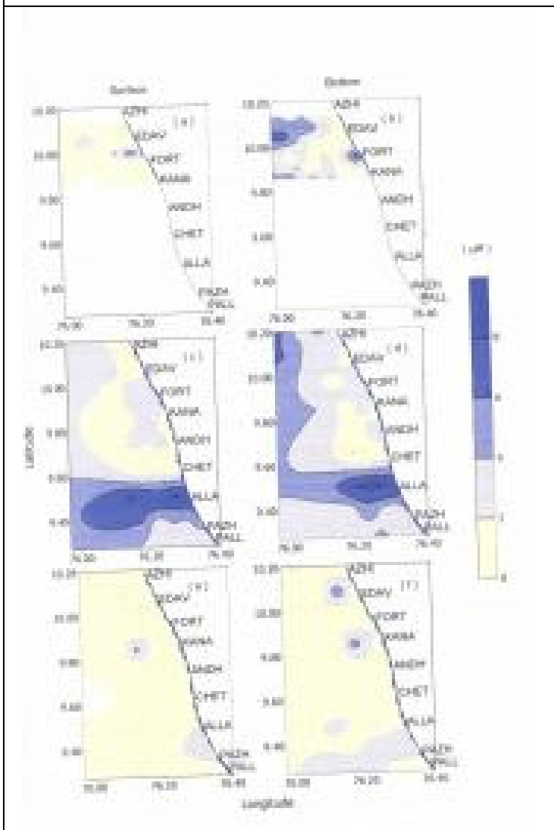
During the typical pre-monsoon (February) months, the nitrogenous nutrients remained low except for the southern transects centered on Chethi and Alleppey. The phosphate concentrations did not show any spatial or vertical variation in the water column, but higher concentrations of ammonia, nitrate and silicate were observed at selected regions starting in the near shore regions and extending offshore (Fig.2 a-d). The Nitrate-N concentrations point towards a clear source between Chethi and Pazhayangadi, where it peaked up to > 8 µM and decreased towards offshore. A similar trend was observed for ammonia-N with the source centered on Chethi (at about 15 m depth). It may be assumed that the ammonia released were either rapidly utilized by phytoplankton or oxidized within the system itself where the waters were saturated with dissolved oxygen. Distribution of silicate-Si was similar to that of nitrate (4 – 10 µM), higher than the corresponding values reported for the waters of Southeastern Arabian Sea. The input of these nutrients supported high primary production up to 14 $mg/m^3$ of chlorophyll *a* (peak column production of 1529 $mgCm^{-2}d^{-1}$), approximately 3 times greater than the peak values reported so far from these waters (Qasim et al. [1]). The peaks in chlorophyll *a* and ammonia showed a preference of ammonia among the nutrients for primary production. It is difficult to point out a definite source to these high nutrients during this period, as the fresh water discharge was at the minimum.

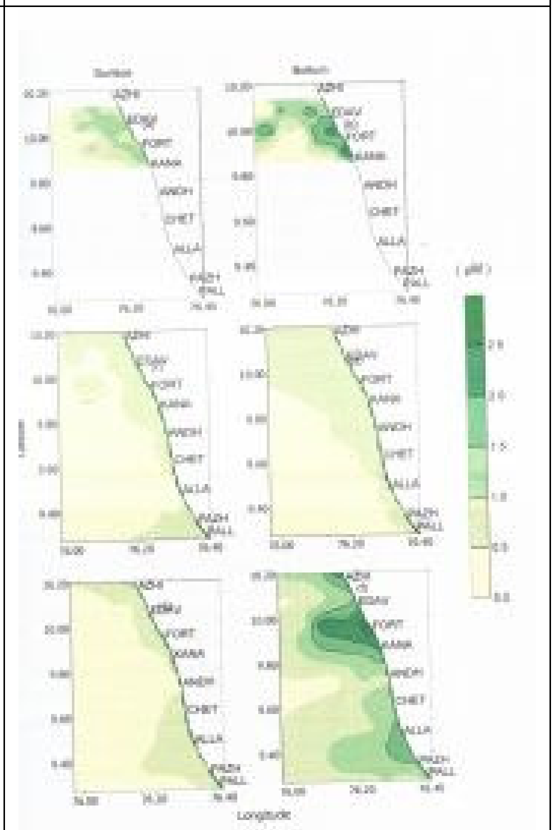
During post monsoon (November), homogenous mixed layer prevailed in the entire region. While the physical characteristics were more or less stable, there was considerable variability in the nutrients and in chlorophyll *a* concentration (Fig.2 a-d). A marked decrease in sub-surface dissolved oxygen (2.8 - 4.8 ml/l) was the characteristic feature of this period, which was concomitant with enriched nitrite (0.5 - 2.0 µM), phosphate (0.4 - 2.8 µM) and silicate (0.5 - 14 µM). The ammonia (1 - 7 µM) and nitrate (1 - 6 µM) were also elevated at some regions along southern transects. The enriched particulate organic carbon (> 3.5 mg/l) and Chlorophyll *a* (14.8 $mg/m^3$) were also the notable features of this period. It is likely that chlorophyll *a* values were proportionate to carbon production indicating a strong positive relationship binding it with nutrient related factors rather than seasonal or diurnal fluctuation. The elevated nitrite and phosphate levels around Cochin may be due to the input from the backwaters. Higher values of nitrite, POC and chlorophyll *a* towards the southern offshore waters off Pallana were conspicuous and the regions with high nitrite had nitrate levels up to 6 µM and the low levels of ammonia had ruled out the nitrification as a significant process responsible for nitrite accumulation. The remarkable co-existence of nitrite with nitrate strongly suggested that the nitrite production should mostly be due to assimilatory reduction. This was further substantiated by the high concentration of chlorophyll *a* (4 - 9.8 $mg/m^3$) on these transects.





A | B





C | D

**Figure. 2. Distribution of ammonia-N (A) , nitrite-N (B), nitrate-N (C) phosphate-P (D) at the surface and bottom during October (a,b), February (c,d) & November (e,f)**

The N/P ratio in the coastal waters was below 15 during November, possibly due to the disproportionate release of P from mudbank sediment. However, a band of N/P > 15 funneling out from Alleppey region was indicative of an 'external source' of nitrogenous compounds into the coastal waters. A comparison of long-term (decadal) trend in the chlorophyll data of this region showed "greening" of near shore waters (Devassy [2]). This suggests that phytoplankton standing crops had increased historically, possibly in response to watershed nutrient inputs. These sources of nutrients deserve identification as it was traced to a region, far away from any river mouths.

The current observations in general indicated the presence of a nutrient source between Chethi and Pallana. This region has mud banks but the release of nitrogenous compounds cannot be accounted from sediments. The injection of nutrients was in non-monsoon months when mud banks were passive and a new influence of Vembanad Lake on the coastal waters is very clear. One of the recent estimate shows that in spite of receiving 42.4 $x10^3$ $mol.d^{-1}$ of inorganic phosphate and 37.6 x $10^3$ $mol.d^{-1}$ of inorganic nitrate from Periyar side of the estuary, the export to the coastal waters is only 28.2 x $10^3$ $mol.d^{-1}$ of inorganic phosphate and 24 $x10^3$ $mol.d^{-1}$ of inorganic nitrate (Hema Naik [3]) and the lake acts as a sink for the nutrients, flushing out only a portion of the pollution load that it receives.

Increased human population along the coastal belt has also resulted in concomitant increases in widespread use of septic tanks and nutrient inputs to coastal waters, particularly from regions occupying limestone beds. It has been found that domestic wastewater from septic tanks provide more nitrogen than that due to precipitation or use of fertilizers. The situation is exacerbated in the present study region, as more than 70 % of households in these coastal belt and adjacent areas of Vembanad Lake do not have proper sanitation facilities. Significant amounts of nutrients from fertilizer applied in agricultural fields (approx. 94 kg/ha) leach out into waterways, groundwater and to the coastal bays inducing coastal fertilization due to direct discharge into coastal ocean and through ground water seepage.

## 4. CONCLUSIONS

The nutrient fluxes into coastal region were influenced by fluxes from Cochin backwater and by the mud bank formation. The present study isolates a possible link between Vembanad Lake that supplies primary nutrients to the adjacent coastal waters and precondition it for rich primary production during non-monsoon months. The causative factors discussed are indicative of existence of a subterranean flow connecting Vembanad Lake to the adjacent coastal waters through the submerged porous lime shell beds. Continuous nutrient entry through such process is bound to upset coastal water productivity pattern. If the existence of the subterraneous channels linking Vembanad Lake to the adjacent coast is proved, it might even re-construct the historical evidence that the subterraneous flow plays a decisive role in the formation of mud banks along this region. A sub aqueous injection of nutrients into the coastal waters through this region is possible even after the rainy season. This assumption need further study to establish cause and effect mechanisms and quantify actual trends created by increased nutrient loading.

## 5. REFERENCES

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