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# Ecology of Indian Estuaries: Part III—Physico-Chemical Features of Akathumuri-Anchuthengu-Kadinamkulam Backwater Systems, SW Coast of India

N BALAKRISHNAN NAIR, K KRISHNA KUMAR, P K ABDUL AZIS, K DHARMARAJ, M ARUNACHALAM & N K BALASUBRAMANIAN

Department of Aquatic Biology & Fisheries, University of Kerala, Trivandrum 695 007

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As a part of an ecological survey conducted during March 1981 (premonsoon period) at the Akathumuri-Anchuthengu-Kadinamkulam backwaters (lat. 8°35'-8°44'N and long. 76°44'-76°51'E), the physico-chemical conditions were studied at 28 stations. Maximum bottom water temperature was recorded at the river zone (zone A). Comparatively low light penetration and dissolved oxygen content observed at the Anchuthengu backwater (zone C) can be attributed to retting. Salinity distribution was of mixohaline nature and maximum bottom water salinity was recorded at zone A. A distinct stratification in salinity distribution—a surface layer of mixo-oligohaline water and a bottom layer of mixo-mesohaline water—was noticed at zone A. Uniform temperature and salinity distribution observed in the surface and bottom waters at the Akathumuri backwater (zone B) is an indication of its well mixed condition. Nutrient distribution showed comparatively higher concentration at the Kadinamkulam backwater (zone D).

Abundance and diversity of biotic community in backwaters are influenced by the interaction of a series of physico-chemical factors. Though extensive studies on the hydrographic conditions of the Kerala backwaters have been made[1-11], no attempt has hitherto been made to elucidate the hydrographic conditions of the Akathumuri-Anchuthengu-Kadinamkulam backwaters. This paper reports physico-chemical features of these backwater systems during March 1981 (premonsoon period).

## Study Area

The area of study and stations investigated are shown in Fig. 1 and the details of the stations are given in Table 1. The Akathumuri-Anchuthengu-Kadinamkulam backwater system—an interconnected, shallow brackish water tract with depth not more than 5 m—is situated in the southern part of Kerala. The backwater system has no permanent connection with the Arabian sea, but seasonally it gets connected with the sea through the opening of the sandy bar at Perumathura (D5, Table 1). During the present investigation the bar was closed. Generally, the backwater system is free from industrial pollution.

## Materials and Methods

A total of 28 stations were selected for the investigation. Surface and bottom water samples from corresponding depths as shown in Table 1 were collected for the estimation[12,13] of dissolved oxygen, salinity, *p*H, phosphate, nitrate, nitrite and silicate. Light penetration was measured using a Secchi disc. Zonal variations were elucidated by taking the mean of each parameter and student's *t* test was applied to find out the significance of variations at each zone.

## Results and Discussion

Different physico-chemical parameters estimated are given in Table 2.

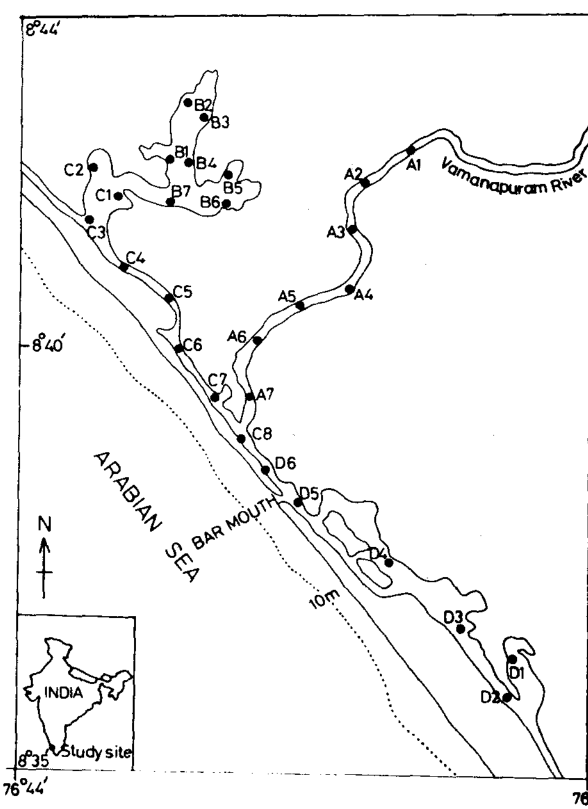


Fig. 1—Akathumuri-Anchuthengu-Kadinamkulam backwater systems and the Vamanapuram river (station details are given in Table 1)

Table 1—Study Sites and Their Features in Akathumuri-Anchuthengu-Kadinamkulam Backwater Systems

| St. No. | Station | Depth (cm) | Features |
|---|---|---|---|
| | Zone A (Lower reaches of the Vamanapuram river) | | |
| A1 | Poovampara bridge | 210 | Bathing ghat; a small canal from nearby paddy fields joins the river; bottom hard laterite |
| A2 | Shavamutty kadavu | 405 | Bottom hard laterite |
| A3 | Kollampuzha | 355 | Bathing ghat; banks protected with laterite stone walls; bottom hard laterite |
| A4 | Mannayath kadavu | 435 | Sand collection; coir processing yards on banks; bottom sandy |
| A5 | Karankunnu | 370 | Coir processing yards on right bank; Valia ela thodu joins the river; bottom sandy |
| A6 | Manakandathil kadavu | 415 | Coir processing centres on left bank; bottom sandy |
| A7 | Pulimootu kadavu | 405 | Coir processing units on banks; bottom muddy |
| | Zone B (Akathumuri backwater) | | |
| B1 | Akathumuri | 219 | Shores protected with laterite stone walls; bottom clayey; clam beds noticed |
| B2 | Puthen kadavu | 232 | Extensive retting grounds and coir processing units; active land reclamation; bottom muddy; banks protected with laterite stone walls |
| B3 | Van kadavu | 295 | Retting grounds and coir processing units; bottom muddy; banks protected with laterite stone walls |
| B4 | Kulamuttom kadavu | 217 | Banks protected with laterite stone walls; bottom clayey |
| B5 | Kavalayoor | 195 | Kavalayoor thodu joins backwater; banks protected with laterite stone walls; bottom clayey |
| B6 | Mananakku kadavu | 304 | Retting; coir processing yards on banks; bottom clayey; banks protected with laterite stone walls |
| B7 | Kayal bank | 254 | Retting and coir processing centres; bottom clayey; banks protected with laterite stone walls |
| | Zone C (Anchuthengu backwater) | | |
| C1 | Panayil kadavu | 230 | Mud reclamation very common; intensive retting; bottom clayey |
| C2 | Thuruthy | 165 | Retting; bottom clayey; Varkala canal joins backwater |
| C3 | Kaikkara | 201 | Intensive retting (black turbid water) bottom clayey |
| C4 | Erangu kadavu | 195 | Narrow water tract; thoroughly polluted by retting (black turbid water); bottom clayey; extensive clam bed |
| C5 | Meeran kadavu | 196 | Retting; narrow region; bottom clayey |
| C6 | Anchuthengu church | 207 | Retting (black turbid water); bottom clayey |
| C7 | Poothura | 231 | Retting; coir processing units on banks; bottom muddy |
| C8 | Shinkara thoppu | 205 | Vamanapuram river joins backwater; bottom muddy |
| | Zone D (Kadinamkulam backwater) | | |
| D1 | Panu kayal | 208 | Intensive retting; coir processing unit on banks; clam beds; bottom muddy |
| D2 | Thalamukku | 235 | Retting and coir processing yards; bottom muddy; Parvathiputhenar joins the backwater |
| D3 | Murukumpuzha | 260 | Retting; coir processing centres on banks; bottom muddy |
| D4 | Perunguzhi | 189 | Retting and coir processing units; bottom muddy; intensive land reclamation |
| D5 | Perumathura | 186 | Site of barmouth; region of maximum tidal effect when bar gets opened; bottom sandy; intensive sand collection; oyster beds on the stone wall which is constructed for shore protection |
| D6 | Thazhampally | 190 | Bottom sandy |

*Depth*—Depth of the backwater system showed variation from one station to the other (Table 1). The river zone (zone A) was comparatively deeper and recorded maximum depth at st A4 (435 cm). Heavy flow of the river and intense sand collection make this zone deeper. Zone C recorded the lowest mean depth with the minimum at st C2 (165 cm). It was observed that the pith of the coconut—a waste product after the separation of the coir fibre—is dumped into the backwater system. Successive years of dumping of this waste material results in a drastic decrease in the depth giving way to easy reclamation of that part and ultimately in the reduction of the total area of the backwater system. Comparatively low values of depth

Table 2—Physico-Chemical Parameters of the Akathumuri-Anchuthengu-Kadinamkulam Backwaters

[Values are mean ±SD]

| Depth (cm) | Secchi disc depth (cm) | Air temp. (°C) | Nature of water | Water temp. (°C) | Dissolved $O_2$(ml.l$^{-1}$) | Salinity (x 10$^{-3}$) | *pH* | Conc., µg-at l$^{-1}$ Phosphate | Nitrate | Nitrite | Silicate |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Zone A | | | | | | |
| 356.43±81.27 | 112.71±8.08 | 31.14±0.71 | SW* | 31.46±0.95 | 5.70±0.96 | 4.30±2.39 | 7.57±0.14 | 5.59±0.96 | 2.16±0.89 | 0.15±0.04 | 39.00±5.55 |
| | | | BW* | 33.80±0.94 | 5.22±1.78 | 17.15±4.48 | 7.66±0.09 | 6.76±1.03 | 2.47±0.92 | 0.17±0.04 | 34.57±4.82 |
| | | | | | Zone B | | | | | | |
| 245.14±38.16 | 94.99±12.67 | 31.34±0.80 | SW | 31.09±0.51 | 5.35±0.38 | 12.00±0.32 | 7.44±0.09 | 4.09±1.05 | 2.08±0.57 | 0.07±0.05 | 29.86±3.47 |
| | | | BW | 31.23±0.54 | 4.89±0.65 | 12.33±0.28 | 7.64±0.07 | 5.29±1.25 | 2.60±0.74 | 0.06±0.06 | 25.43±0.68 |
| | | | | | Zone C | | | | | | |
| 203.87±19.60 | 87.50±26.16 | 30.95±1.48 | SW | 31.80±0.96 | 3.19±1.67 | 13.42±2.27 | 7.53±0.12 | 4.28±1.10 | 2.88±0.73 | 0.16±0.05 | 36.75±9.97 |
| | | | BW | 32.30±1.20 | 2.51±1.00 | 16.66±2.21 | 7.58±0.07 | 5.20±1.08 | 3.49±0.74 | 0.19±0.07 | 30.44±7.12 |
| | | | | | Zone D | | | | | | |
| 211.33±27.49 | 102.50±11.34 | 31.00±1.04 | SW | 31.97±0.74 | 4.65±0.95 | 10.28±1.18 | 7.18±0.16 | 7.65±1.50 | 5.05±1.11 | 0.29±0.05 | 67.50±9.07 |
| | | | BW | 31.87±0.41 | 4.03±1.25 | 14.20±1.69 | 7.53±0.11 | 9.00±1.85 | 4.18±0.99 | 0.20±0.04 | 41.08±7.64 |

SW* = surface water; BW* = bottom water

recorded at zone C is possibly due to the deposition of silt by the river and the dumping of coconut husk pith from coir industry.

*Temperature*—Atmospheric temperature oscillated between 28 and 32.8°C. The range of surface and bottom water temperature was 30-33°C and 30-34.8°C respectively. Comparison of surface and bottom water temperatures showed that the variation was pronounced at zones A and C where the bottom temperature was higher than the surface resulting in a clearly stratified condition with an upper layer of cold water lying over a bottom layer of warm water. This has been found to be an unusual situation and no special reason could be adduced. Zones B and D showed a homogeneous nature of temperature distribution in surface and bottom waters. As zones B and D are very extensive, mixing of surface and bottom layers by wind is more effective at these zones. The closed condition of the bar and relatively low quantity of freshwater discharge during this period resulted in a total stagnation and the wind seemed to be the major factor influencing the water circulation in the backwater system. Comparison of surface water temperature of different zones showed variation only between zones B and D at 5% level, while the bottom water exhibited significant variation between A and B, and A and D at 1% level and between A and C at 5% level. All these spatial variations observed in bottom water temperature were predominantly due to higher values recorded at zone A.

*Light penetration*—Secchi disc visibility depth varied from 54 to 135 cm and recorded minimum at st C5 (54 cm) and maximum at st C2 (135 cm). It showed regional variation between A and B, and A and C at 5% level and was due to higher values recorded at zone A. Light penetration was comparatively low and experienced a wide range of fluctuation at zone C. The ingression of dark turbid ret liquor from the nearby retting enclosures with suspended organic matter, which prevents the light penetration, is the cause of low visibility depth at this zone. Although retting of coconut husk was noticed along the entire coast of the backwater system, the effect of pollution is more intense at zone C. Being too narrow a zone it doesn't provide adequate dilution of the ret liquor. Besides, the bar being closed the normal flushing and dissipation of ret liquor from this zone by tidal action is also prevented. The turbid medium at the retting zone prevents the penetration of light and organic production is virtually inhibited[1].

*Dissolved oxygen*—Lowest values for the surface and bottom waters (1.13 ml.l$^{-1}$ and 0.9 ml.l$^{-1}$ respectively) were recorded at st C4. Highest surface value was recorded at st A1 (6.78 ml.l$^{-1}$) and that of bottom at st A2 and A3 (7.57 ml.l$^{-1}$). Though the oxygen content of the surface and bottom waters showed a homogeneous distribution, it exhibited significant regional variations. A comparison showed that the variations between zones A and C, and B and C, were significant at 1% level in both the surface and bottom waters while the variations between zones C and D were significant at 5% level in the bottom water. All these variations were predominantly due to low values recorded at zone C. There is great depletion of oxygen at zone C owing to the intense retting of coconut husk. Oxygen depletion and consequent anoxic conditions have been reported from the retting zones of Edava-Nadayara backwater during Feb. to late July[1].

*Salinity*—According to the Venice system of classification[14], the salinity distribution in the backwater system is of mixohaline nature. Bottom salinity values were higher than the surface at zones A, C and D. Surface and bottom salinity showed marked variation in zones A and D at 1% level and in zone C at 5% level and followed homogeneous distribution at zone B. Comparison of the surface salinity indicated that the variation between zones A and B, A and C, A and D, and B and D were significant at 1% level and between C and D at 5% level, and was due to the low values recorded at zones A and D. Bottom water salinity variations between B and C were significant at 1% level and A and B, and B and D at 5% level.

As the bar mouth remained closed during the present investigation, the salinity distribution in the backwater system was mainly influenced by the freshwater discharge through the Vamanapuram river. The vertical homogeneity observed in salinity and temperature distribution at zone B is an apparent indication of the well mixed nature of that zone. As zone B is comparatively broader, mixing by means of wind is more effective than at the other zones. Besides, it is less affected by the freshwater discharge as it is away from the river mouth. Salinity distribution showed a distinct stratification at zone A—a surface layer of mixo-oligohaline water ($4.30 \times 10^{-3}$) and a bottom layer of mixo-mesohaline water ($17.15 \times 10^{-3}$). The low saline nature of the surface water at this river zone is due to the dilution resulting from the freshwater flow. Among the backwater zones (zones B, C and D), zone D recorded the low surface salinity and is due to the freshwater influx from the river zone and the water flow from the adjacent Veli lake through the Parvathi Puthenar canal. Bottom water salinity was the maximum at zone A. However, zones A and C exhibited close similarity in bottom salinity distribution. These zones being narrow reduces the chance of mixing by wind. The tongue of high saline bottom water which penetrated into these zones during its exposure to the sea gets trapped when the bar is suddenly closed. This results in a total stagnation and no external factors are at work to alter the salinity distribution at the bottom. Besides this, during premonsoon season the river discharge is meagre. All these have contributed to the comparatively high salinity values for the bottom water at these zones.

*pH*—*p*H fluctuated between 7 and 7.8 at the surface and 7.4 and 7.8 at the bottom. No vertical *p*H gradient was observed at zones A and C. However, zones B and D showed marked variation with high *p*H values at the bottom. *p*H variation between zones A and D, B and D, and C and D in the surface waters were significant at 1% level. Though it showed considerable variation in the surface water, it remained almost uniform at all zones in the bottom. Comparatively low values were recorded in the surface water at zone D.

*Inorganic phosphate*—The values varied between 3 and 10.4 $\mu$g-at$\cdot l^{-1}$ for surface and 3.8 and 11.6 $\mu$g-at$\cdot l^{-1}$ for bottom water with a wide range of fluctuation between the stations. Though surface and bottom values showed no significant variation, the bottom mean values were slightly higher than those of the surface. The variations at surface and bottom between zones B and D, and C and D were significant at 1% level and between zones A and B, A and C, and A and D at 5% level. Regional distribution of phosphate showed significant variations but presented a relatively homogeneous nature at zones B and C.

Comparatively low values were reported during premonsoon season at Cochin backwater[3] and at the Mandovi and Zuari river system[15] in contrast to the higher values recorded during the present investigation. As the bar remained closed during the survey normal flushing of nutrients from the backwater to the sea does not take place. Coupled with this, retting causing the death and decay of organisms due to oxygen depletion may also contribute to the replenishment of phosphate. The higher values at zone D is believed to be associated with the influx of water from the Veli lake and from the Vamanapuram river. Comparatively higher bottom values observed at all zones is indicative of an autochthonous source of phosphate. This may either be by regeneration from the bottom sediment or through decomposition of organic matter. Similar trend of higher bottom water phosphate has been reported at the Vizhinjam Bay[16] and Ashtamudi backwater[11]. Subramanian and Venugopalan[17] discussed that the higher particulate organic phosphorus of the bottom water at Vellar estuary might be due to higher concentration of particulate matter and relatively high concentration of phosphorus in the suspended sediments.

*Inorganic nitrate*—Surface water nitrate fluctuated between 1.1 and 6.4 $\mu$g-at$\cdot l^{-1}$ and that of bottom between 1.38 and 6 $\mu$g-at$\cdot l^{-1}$ with wide fluctuations between the zones. Like phosphate, surface and bottom values showed no significant variation. Zones A and B had uniform distribution at both surface and bottom. Regional surface water values exhibited significant variation between zones A and D, B and D, and C and D at 1% level and between B and C at 5% level, while bottom values showed variation between zones A and C, A and D, and B and D at 5% level.

Inorganic nitrogen is present in an aquatic biotope as oxidised nitrite and nitrate, and as reduced ammonia. Though no distinct vertical gradient could be observed, nitrate distribution showed wide regional fluctuation during the present investigation. Similar to phosphate, nitrate concentration was also higher at zone D. Values at zone D are likely to be influenced by the influx of water from the Veli lake and by the freshwater discharge from the Vamanapuram river. However, the higher bottom nitrate mean values at zones A, B and C indicate the possibility of a local nitrate enrichment by means of regeneration from the bottom sediment or through decomposition of organic matter. Higher bottom nitrate values at the Ashtamudi backwater and the possibility of nitrate regeneration from the sediment are reported[11]. At the Cochin backwater nitrate was very low during premonsoon season when the conditions are predominantly marine and explained that the contribution from sea was very little[3].

*Inorganic nitrite*—Nitrite concentration was very low throughout the backwater system and ranged between 0 and 0.38 $\mu$g-at$\cdot$l$^{-1}$ in the surface and 0 and 0.33 $\mu$g-at$\cdot$l$^{-1}$ in the bottom water. Surface and bottom values showed variation only in zone D at 5% level, where as the surface water values were higher than the bottom, while all other zones experienced a vertical homogeneity. It showed uniformity in the surface and bottom waters at zones A and C. Surface values showed variation between zones A and D, B and C, B and D, and C and D at 1% level and between A and B at 5% level. Bottom values exhibited regional variation between zones A and B, B and C, and B and D at 1% level.

A notable feature was its low concentration compared to other nutrients throughout the backwater system. Like phosphate and nitrate, nitrite also showed higher values at zone D. This interesting coincidence was another noticeable feature of the nitrite distribution. The nitrite concentration remained very low at zone B and recorded zero values in both the surface and bottom waters at st B3 and B4. The lower surface water nitrite values observed at the river zone (zone A) and the higher values at the backwater zones (zone C and D) clearly suggest that nitrite input does not entirely depend on the freshwater discharge during premonsoon and indicates possibilities of local replenishment. Since it is an unstable form, rapid oxidation into nitrate can be considered as the main reason for the observed low nitrite content. At the Cochin backwater the values of nitrite-N were much lower than those of nitrate-N and the conversion of nitrite-N into nitrate-N, explains reason for the low nitrite content[3].

*Inorganic silicate*—It varied in surface water between 25 and 82 $\mu$g-at$\cdot$l$^{-1}$ and that of the bottom water between 23 and 54 $\mu$g-at$\cdot$l$^{-1}$ and exhibited a wide range of fluctuations between the zones. A notable feature observed was its invariably higher concentration in the surface water at all zones. Vertical variation was more pronounced in zone D where it was significant at 1% level and in zone B it was at 5% level. Surface and bottom concentrations between zones A and C, and B and C were somewhat similar. Regional surface silicate comparison showed variation at 1% level between zones A and B, A and D, B and D, and C and D, while that of bottom showed variation at 1% level between A and B, and B and D and at 5% level between C and D. Similar to the other nutrients silicate concentration was also higher at zone D. Comparatively higher values observed at zone D might be due to the freshwater influence from the riverine zone and the water flow from the Veli lake lying adjacent to this ecosystem. Low values at zone B can be attributed to its highly secluded position in the backwater system, free from any land drainage and water flow. Rao and George[8] recorded a range of 20 to 220 $\mu$g-at$\cdot$l$^{-1}$ of silicate in the river mouth at the Korapuzha estuary and attributed this to the laterite of the drainage area.

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**References**

1 Abdul Azis P K & Balakrishnan Nair N, *Aqua Biol*, **3** (1978) 41.
2 Ramamirtham C P & Jayaraman R, *J Mar Biol Ass India*, **5** (1963) 170.
3 Sankaranarayanan V N & Qasim S Z, *Mar Biol*, **2** (1969) 236.
4 Wellershaus S, *On the hydrography of the Cochin backwater (a South Indian estuary)*, paper presented at the Symposium on Indian Ocean and adjacent seas—their origin, science and resources, Cochin (1971).
5 Joseph P S, *Indian J Mar Sci*, 3 (1974) 28.
6 Manikoth S & Salih K Y M, *Indian J Mar Sci*, **3** (1974) 125.
7 Sarala Devi K, Venugopal P, Remani K N, Lalitha S & Unnithan R V, *Indian J Mar Sci*, **8** (1979) 141.
8 Suryanarayana Rao S V & George P C, *J Mar Biol Ass India*, **1** (1959) 212.
9 Nair G S, *Bull Dept Mar Biol Oceanogr Univ Cochin*, **5** (1971) 87.

10 Mary John C, *Bull Cent Res Inst*, University of Kerala (Series C, Natural Science) **6** (1958) 97.

11 Dharmaraj K & Balakrishnan Nair N, *The nature of distribution of major inorganic nutrients in the Ashtamudi backwaters in relation to environmental factors*, paper presented at the All India seminar on the status of environmental studies in India, Trivandrum (1981) Abst 27.

12 Martin D F, *Marine chemistry*, Vol 1 (Marcel Dekker, Inc, New York) 1968.

13 Strickland J D H & Parsons T R, *A practical handbook of sea water analysis*, (*J Fish Res Bd Canada*, *Bull* 167) 1972, 311 p.

14 Venice System, *Symposium on the classification of brackish waters*; *Arch Oceanog Limnol*, **2** (1959) Suppl 1-248.

15 De Sousa S N, Sen Gupta R, Sanzgiri S & Rajagopal M D, *Indian J Mar Sci*, **10** (1981) 314.

16 Dharmaraj K, Balakrishnan Nair N & Padmanabham K G, *Studies on the hydrographical features of Vizhinjam Bay*, paper presented at the Symposium on Coastal Aquaculture, Cochin (1980) Abst No 30.

17 Subramanian B R & Venugopalan V K, *Indian J Mar Sci*, **9** (1980) 246.