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KERALA AGRICULTURAL UNIVERSITY

COLLEGE OF FISHERIES

Half Yearly Report - 1

(26-2-2001 to 25-8-2001)

of

STUDIES ON CIRCULATION AND MIXING AND THEIR INFLUENCE ON PRODUCTIVITY OF PANANGAD REGION OF VEMBANAD LAKE

Submitted to

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Department of Fishery Hydrography
College of Fisheries
Panangad, Kochi - 662 506.

September 2001

1) Title of the Scheme : Studies on circulation and mixing and their influence on productivity of Panangad Region of Vembanad Lake

2) Sanction No. and Date : F.No.4(14-97-ASR-1 dt 1-9-2000)

3) Total grand sanctioned : 8,97,460/-

4) Amount spent so far : 77,608/-

Research material	Equipments	Salary	Total
22,383	17,612	37,613	77,608

5) Report Period : 26-2-2001 to 25-8-2001

6) Report No. : 1

7) Date of start : 26-2-2001

8) Date of Termination : 25-2-2004

9) Technical Programme as approved for the scheme

Year I

Location inspection, Fixing of station locations, Collection of preliminary data from locations, Fixing new station locations if necessary.

Year II

Monthly data collection from closely spaced stations - to follow tides. About 7 days in a month, seasonal observations on transparency, primary production, plankton biomass and shellfish fauna.

Tidal cycle observations from fixed locations extending over a period of 13 hours for different seasons.

Temperature, salinity and suspended sediment load from different levels will be collected.

Preliminary analysis of data

Year III

Analysis of data, preparation of time sections, vertical and horizontal sections, classification of backwater, determination of flushing characteristics etc. and preparation of report.

10) (a). Name of Institute : College of Fisheries, Panangad

(b). Department : Department of Fishery Hydrography

(c). Location of work : College of Fisheries, Panangad

11) Objectives of Project

Panangad area of Vembanad Lake includes Nettoor Canal, Kumbalam Kayal and adjacent regions. Nettoor Canal connects Kaithapuzha Kayal in south and Kadavanthra in the north.

The objectives of present study are:

a) To understand the spatial variations of temperature, salinity and suspended load in different seasons.

b) To find the tidal variations of these parameters at different locations during different seasons.

c) To know the spatial, tidal and seasonal variations of water current.

d) To understand the variation of transparency and primary production.

e) To study the variation in plankton biomass and bottom fauna in relation to mixing and environmental parameters.

f) To attempt to classify this part of the backwater based on observed mixing pattern.

12) Significant findings, if any. : Nil

13) Progress of Research

- Two research fellows have been appointed.

- Vacuum pressure pump is purchased.
- All glass filter holder apparatus is purchased.
- Supply order for current meter is placed.
- Quotation for Hitech bottle being finalised.
- Essential chemicals and glasswares for the project are purchased.
- A preliminary reconnaissance survey was conducted on board the boat Matsya I along 1 part of study area.
- The Literature survey is being carried out and the brief summary of the Literature survey is presented as Annexure

14) Staff Positions

1 Principal Investigator

Dr. K.K. Varma

2 Research Fellows - 2

1) Prabha Joseph

2).Howlath K.H

15) Difficulty, if any. : Nil

Dr. K.K. Varma

Principal Investigator

"Studies on circulation and mixing and their influence on productivity of Panangad Region of Vembanad Lake"

Introduction

Kerala State has an expansive body of brackish waters, the various sectors of which are variously referred to as backwaters, lakes, lagoons and estuaries, including mangrove and swamps. The different water bodies are named as Veli, Kadinankulam, Paravoor, Ashtamudi, Kayamkulam, Vembanad, Cranganore, Valiyangadi, Korapuzha, Valiyapatnam and Kavvai from south to north in order. This chain of backwaters on the coastal plane is interconnected by an extensive network of canals, which facilitated north-south transport. These backwaters have played a significant role in the socio-economic and cultural history of Kerala. Many rivers debauch the fresh water to Arabian Sea through this backwater system. Hence, lying almost parallel to coastline, many of these backwater bodies exhibit the characteristics of estuaries. It has been realized from the studies carried in different parts of the world that estuaries are one of the most important coastal life support systems and an indispensable medium for the existence of various economically important marine as well as fresh water living resources. This call for the imperative need to protect the backwaters, which have been subjected to continuous man, made alterations.

Among the numerous lagoons and estuaries that are present along the Kerala coast (Southwest coast of India), the Vembanad Lake is the largest estuarine system. This system lies parallel to the coastline with several islands and small arms and extends between Thanneermukham at south and Azheekode at north (between 9°30'-10°12'N and 76°10'-76°29'E). According to historians, this typical backwater system has attained its present configuration in the fourth century. It was primarily a marine environment, bounded by an alluvial bar parallel to the coastline and connected to Arabian Sea at the intervals (Anon., 1973).

Cochin backwater is a system of shallow brackish water lagoons occupying about 500 Km^2 along the Kerala coast. It has been subjected to intensive research on several disciplines such as geology, hydrography, organic production, zooplankton production etc. The backwater supports extensive prawn fishery and forms the main nursery ground for commercially important penaeid prawns as well as finfishes.

The Thanneermukham bund plays an important role during all seasons by maintaining the southern parts well mixed. Thanneermukham bund is located at the southern side at about 9°30'N. Two rivers, Periyar and Muvattupuzha discharge into the backwaters, whereas Thanneermukham bund regulates the flow from four rivers namely Meenachil, Manimala, Achankovil and Pampa. Prior to the construction of Thanneermukham barrier in 1976, the entire lake was a single continuous habitat for foraging to the fry of marine prawns and fishes. Also, the southern sector of the lake provided an ideal habitat for heterogeneous assemblage of euryhaline marine fishes, crustaceans and true estuarine fishes which ultimately constituted a diversified and abundant fishery resources (KSSP, 1978). Due to closure of Thanneermukham bund during the pre-monsoon periods, which prevents the salt-water penetration, the area beyond Thanneermukham bund (*ie.* South of bund) has become completely devoid of euryhaline as well as stenohaline marine species. The tidal flow also has been completely arrested and hence the upstream regions can no longer serve as nursery grounds for the post-larvae of prawns (Kurup *et.al,* 1990).The construction of Thanneermukham bund near Vaikom also created severe environmental consequences within and out of adjacent Kuttanad agricultural fields (Balchand, 1983)

Hydrography and Dynamics

Extensive studies have been carried out in Cochin backwater on physical, chemical and biological features (Jos Anto, 1971, Sundaresan, 1989, Lakshmanan *et.al,* 1987, Sankaranarayan and Qasim ,1969). There are three seasonal conditions prevailing in this backwater system- monsoon (Jun-Sep), post-monsoon (Oct-Jan) and pre-monsoon (Feb-May). During the monsoon period, heavy rainfall results in high river discharge in to the backwater causing stratification in the backwater system. In post-monsoon, river discharge gradually diminishes and tidal influence increases changing the estuarine conditions to partially mixed type. In pre-monsoon, the river discharge is minimum and seawater influence is maximum and the backwater becomes well mixed.

The hydrographical conditions of the Cochin backwaters are greatly influenced by seawater intrusion and influx of river water. The studies conducted in Cochin backwater (Lakshmanan *et.al.*, 1982, Anirudhan *et.al.*, 1987) reveal that the northern parts of the backwater are subjected to higher salinity wedging and oscillatory movement than the southern parts. During Oct-Jan, comparatively higher temperatures were observed in the southern parts than in the northern parts. In pre-monsoon (Feb-May) there is no salinity stratification whereas with the onset of monsoon, a rapid build up of stratification is observed.

Ramamirtham and Jayaraman (1963) noticed that in Cochin backwaters, apart from the influence of monsoon rains and the considerable amount of evaporation during hot months, the effect of coastal upwelling and monsoon piling and sinking in the Arabian Sea were considerable. These result in certain characteristic variations in the hydrographical and associated conditions in this area and help to bring about a well-defined seasonal pattern in the backwaters.

The multitudinal features observed in Cochin estuary characterize fresh water and seawater mixing in this area (Lakshmanan *et.al.*, 1987, Balchand *et.al.*, 1990, Balchand and Nair, 1994, Ajith and Balchand, 1996, Joseph and Kurup, 1987, Chandramohan, 1989). Increase in surface salinity during pre-monsoon on the southern arm (extends upto 8-10 kms) is higher than on the northern arm. Fresh water conditions are found at southern most region of the estuary near Thanneermukham bund, throughout the year except for the pre-monsoon increase of salinity (Lakshmanan *et.al.*, 1982, Anirudhan *et.al.*, 1987). They observed that during pre-monsoon, the southern parts of the estuary maintained uniformly higher salinity ($\approx 15^0/_{00}$) at both surface and bottom, which can be attributed to the presence of Thanneermukham bund. This part of the estuary becomes well mixed during this period.

The changes in fresh water fraction at the surface, middle and bottom waters of Cochin harbour area during spring and neap tides are studied by Sundaresan (1990). During spring tide, surface waters of the inner channel exhibit gradual changes in fresh water fraction relative to bar mouth. Surface fresh water fraction variation was maximum at south of bar mouth (6.8-68%). Fresh water changes are more in symmetry with the tide and the changes are maximum at Ernakulam channel in spring tide. The incursion of coastal saline water was prominent at mid water levels during neap tide, but at bottom layers, low fresh water fraction was observed during the neap tide.

The distribution of percentage of fresh water in Cochin backwater at the surface and subsurface during different seasons towards northern and southern parts from Cochin barmouth is summarised by Sankaranarayan *et.al.* (1986) and Balchand and Nair (1994). In the southern part of the backwater, where present study area is located, highly saline water intrudes upto around 26 km from barmouth during pre-monsoon period both at surface and subsurface levels. However, in monsoon, saline water extends only upto 5 kms at surface and about 20 km at subsurface levels. In Cochin backwater, salinity variations from surface to bottom were very wide. In pre-monsoon months (Jan-May), when the salinity is about its maximum, practically no change is encountered from surface to bottom (Sankaranarayan and Qasim, 1967,1969). However, during monsoon season, when there is generally a sharp decline in salinity, the bottom salinity remains high and according to them, this wide fluctuation in salinity can be attributed to the influx of fresh water, which is confined to the upper layers.

While comparing the salinity profiles of the Cochin backwater before and after the commissioning of the Thanneermukham bund, Batcha and Damodaran (1987) found that salinity is markedly decreased on the southern side of barrier where, as a result, the water body remains fresh for most of the year. Furthermore, the flow of fresh water towards the north is also interrupted. Notwithstanding this, the salinity in northern part of lake has also decreased. This is because the Idukki hydroelectric project diverted 33.58 m^3 of water per second and this was additionally discharged into Vembanad lake through Muvattupuzha River. Thus, they concluded that both the hydroelectric project and Thanneermukham bund brought about a reduction in salinity of Vembanad Lake, the former causing a reduction at the southern side and latter at the northern side of the bund.

Salinity, temperature and nutrient distribution in the Cochin harbour has been analysed by Balakrishnan and Shynamma (1976). They observed lowest and highest salinity and temperature during monsoon and pre-monsoon periods respectively. According to them concentration of phosphate phosphorous and nitrite nitrogen also were lowest during monsoon and highest during pre-monsoon suggesting that the nutrient concentration be immediately enriched by monsoon rains. Sarala Devi *et.al.* (1991) explained that the fluctuation in nutrient levels might be due to the effect of intermittent discharges of effluents and variation in river flow. Nutrient rich water is observed in the northern part of the backwater compared to southern parts. These low values in the southern parts are attributed to the presence of Thanneermukham bund and influx of large amount of fresh water from Muvattupuzha river.

Seasonal variation in nutrients of Cochin backwaters are analysed by Sankaranarayan and Qasim (1969) and they found that during pre-monsoon when the system is predominantly marine, the nutrient contribution is low and is high during monsoon due to the maximum influx of fresh water. Spatial and seasonal distribution of salinity and silicon in Cochin backwater were explained by Anirudhan *et.al.* (1987). Time series of nitrite, nitrate and phosphate prepared by Lakshmanan *et.al.* (1987), exhibits pronounced seasonal variation and distribution patterns indicating large inputs possibly from industrial units, sewage works and agricultural run off. According to them the northern parts of the Cochin backwater are nutrient rich compared to southern parts.

Sankaranarayan and Panampunnayil (1979) studied the distribution, seasonal changes and ratios of organic carbon (OC), total phosphorous and total nitrogen. According to them the higher OC content may be due to river discharge and high organic production of overlying waters. In addition, the high total phosphorous content may be due to the influence of domestic waste.

The effect of changes of directionality of currents and mixing in Cochin backwater are analysed by Rama Raju *et.al.*(1979). According to them the highly stratified conditions that exist during the monsoon gradually changes to partially mixed and homogeneous conditions of the post and pre-monsoon periods apparently due to decreasing river inflow and increasing tidal influence. They observed that the velocity of current is maximum (174 cm/sec) during ebb currents of spring tide of post-monsoon season. The tidal prism values at Cochin inlet at different seasons at spring are also studied by them. Tidal prism in the pre-monsoon season during which time the fresh water addition to backwater is least, is found to be $31.5x10^6$ m^3. During other seasons, the values of tidal prism vary between $9.5x10^6$ m^3 and $132x10^6$ m^3.

Water circulation is an important integral aspect to be investigated in the study of a backwater system. In estuaries circulation is controlled by fresh water flow, friction and tidal mixing. The presence of tidally regulated flow of sea water through the bottom and constant fresh water flow along surface results in a mechanical mixing of water between the two layers which necessitates a net landward flow of shelf water to make good loss from surface layers (Pond and Pickard, 1986). Sundaresan (1994) studied the intensity of water current and the nature of mixing at the surface, middle and bottom layers in Cochin harbour.

The salinity distribution in estuaries are controlled by tide, but George and Krishna Kartha (1963) found that the tidal influence on surface salinity is practically nill in Ernakulam channel which may be due to the high water level in the channel and low tidal amplitude off Cochin. During monsoon, at Mattancherry and Ernakulam channels and Cochin harbour mouth, salinity varies from $5^0/_{00}$ at surface to $25^0/_{00}$ at the bottom in flood tide (Udayavarma *et.a l*, 1981). Study on fresh water fraction and dilution factor (inverse of fresh water fraction) at different stations reveals that fresh water content is slightly higher in Ernakulam channel than in Mattancherry channel and is large during southwest monsoon indicating the greater influence of fresh water discharge on the Ernakulam channel (Joseph and Kurup, 1989).

Joseph and Kurup (1990) have studied stratification and distribution of salinity in relation to tides and fresh water discharges in Cochin backwater. According to them diurnal variations of salinity are in phase with the tides. Monthly synoptic field observations of vertical profiles of velocity, temperature and salinity were made at different stations by Pylee *et.al.* (1990) to study the circulation and mixing in lower reaches of estuary towards the northern side of Cochin barmouth.

To evaluate the extent of salinity intrusion and to evaluate the effect of the release of fresh water from upstream in reducing the salinity intrusion in estuarine rivers of Kerala, a mathematical model was developed by Veerankutty and Rebeccamma (1987).

Long-term temperature and salinity data collected from Madavana region of Vembanad Lake have been studied using spectral anlysis by Varma *et.al* (manuscript).

The two dominant frequency bands observed correspond to the lunar periodicity of 15 days and longer periods ranging between 25-43 days. The observed low frequency variability appeared to be linked to the coastal dynamics, which includes coastally trapped Kelvin waves also.

Plankton

Qualitative and quantitative studies on phytoplankton of Cochin backwaters showed that about 120 species of phytoplankters (excluding nanoplankton) commonly occur in the backwater (Gopinathan, 1974). Of the 88 species of diatoms, 74 occur regularly and the rest are rare. Two peaks of abundance were observed, one during monsoon months (May-July) and the other during post monsoon (October-December). Enrichment of backwater seems to be the most important feature for the quantitative abundance. The influence of various physical chemical parameters on the occurrence, seasonal fluctuation and distribution of estuarine diatoms are discussed by Gopinathan (1975).

Growth characteristics of estuarine phytoplankton (Joseph and Ramachandran Nair, 1975), seasonal and spatial distribution of phytoplankton (Joseph and Kunjukrishna Pillai, 1975, Kümaran and Rao, 1975, Gopinathan, 1974), quantitative ecology of phytoplankton (Gopinathan *et.al.*, 1984), influence of salinity on the rate of photosynthesis and abundance of phytoplankton (Qasim *et. al.*, 1972) *etc*, are some of the important works in the Cochin backwater.

The average concentration of phytoplankton in the Cochin backwater varies from 22200-299700 cells/l (Devassy and Bhattathiri, 1974). They followed a fortnightly observation schedule from four stations. The methodology was to collect one-liter sample and to preserve in 2-3% formalin. After shaking the bottles thoroughly, a 50 ml sample from each was transferred into a sedimentation chamber and allowed to settle for 2 days. The supernatant removed and the organisms counted under inverted microscope. Diatoms, dinoflagellates and other algae had their maximum concentration during post-monsoon, pre-monsoon and monsoon periods respectively. On few occasions diatoms and dinoflagellates were found to bloom. The maximum concentration observed during a bloom is two million cells/l.

Benthos

Bottom fauna of Cochin backwater was studied by Kurian *et.al*, (1975), Desai and Krishnankutty (1968), Jayasree (1971), Kurian (1967 and 1971), Ansari (1974) *etc.*

The microbenthic algae also play an important role in the productivity of Cochin backwater. Sivadasan and Joseph (1998a) assessed the productivity potential of microbenthic algae in terms of chlorophyll-a. The studies concentrated at 5 representative stations for a period of one year. The average potential productivity has been found to be 57.81 $mgC/m^2/hr$. Based on the ratio of biomass and productivity, the annual potential productivity of benthic microalgae with an effective shallow area of 22.5 Km^2 in the backwater is estimated to be 400,000t of carbon.

Benthic microalgal biomass showed significant seasonal and spatial variation, but unaffected by the changes in the bottom water chemistry (Sivadasan and Joseph, 1997). The seasonal variation of biomass may be due to grazing or due to the recruitment of the flora from adjoining marine and fresh water environment. Their average contribution is 50.8 mg/m^2, which is indicative of its substantial contribution to the total microalgal biomass in the backwater.

Sivadasan and Joseph (1998b) studied the community structure of microalgal benthos viz. indices of diversity (H'), richness (R1), evenness (E2), similarity and Hill's diversity factor (N1) in the Cochin backwater. Pearson's coefficient of correlation (r-value) was calculated to study inter relationship of hydrographic parameters on distribution of diversity indices.

Primary Production

The plankton production in the Vembanad Lake and adjacent waters in relation to the environmental parameters was studied extensively by Kunjukrishna Pillai *et al.* (1975). The area of study includes the backwaters running almost parallel to the Arabian

Sea from Alleppey in the south to Azheecode in the north (90 km S-N). The depth varies from 1.5 to 10 m and total area of water spread is about 300 sq.kms. Data on temperature, salinity, dissolved oxygen, nutrients, primary production and zooplankton were collected once in a month, from Feb.1971 to Jan.1972, from seven stations, and analysed according to standard methods. Primary production estimation based on C-14 technique showed considerable seasonal variation with peak production in post-monsoon period. This is in contrast with the observations in the inshore environment off the West Coast of India where high production occurs during the monsoon months (Ramachandran Nair, *et.al.*, 1973). Post-monsoon months are characterised by high rates of primary production, the maximum value being 125 mgC/m^2/hr. The higher values may be due to the optimum light intensities and effective utilization of nutrients. In the backwater, since there is less mixing of bottom waters with the surface waters, almost until the end of October, there is no effective utilization of nutrients. This accounts for the lower rate of production during the monsoon period and progressively increasing rates during the subsequent period (Ramachandran Nair *et. al.*, 1975).

The annual organic production in the Cochin backwater by periphyton has been estimated to be 92000 tones of carbon, the rate being 1.4 gC/m^2/day (Sreekumar and Joseph, 1997). This almost equals to the planktonic production. Qasim (1973) estimated the gross production in the backwater to be 0.35 to 1.5 gC/m^2/day. In the Vembanad Lake, Ramachandran Nair, *et. al.,* (1975) has recorded an average production rate of 1.2 gC/m^2/day. Qasim and Wyatt (1973) have used a model to explain the variation of ecosystem of Vembanad Lake.

In the Cochin backwaters, nanoplankters also contributed to the total production. The contribution of nanoplankton to the total productivity was studied for 9 months in coastal waters of Cochin and its average production accounts for 66.40%of total productivity (Sumitra Vijayaraghavan *et.al,* 1974). From January to March the contribution of net plankton photosynthesis was greater while during April - Dec the contribution of nanoplankton photosynthesis was more than 60% of the total. This indicates there is seasonal variation in the photosynthesis of nanoplankton.

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