

Palynological evidence of mangrove degradation during mid-late Holocene at Rambha, Chilka Lake, Orissa*

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Khandelwal, Asha & Gupta, H.P. 1993. Palynological evidence of mangrove degradation during mid-late Holocene at Rambha, Chika Lake, Orissa. *Geophytology* **23** (1): 141 — 145.

Palynology of 4.30 m deep soil profile from Rambha has provided clues of two phases of mangrove development since mid-late Holocene. The first phase between 3,800-2,000 years B.P. has revealed the existence of core mangrove forest recording maximum development of rhizophoraceous members. This feature of vegetation mosaic is suggestive of typical deltaic environment with consistency in sea-level rise leading to constant sea water depths in the estuary. Thereafter, in second phase, traumatic decline in Rhizophoraceae, disappearance of *Heritiera*, sporadicity of *Aegialitis*, *Sonneratia*, etc. and overall degradation of core mangroves *vis-a-vis* uprise in the values of hinterland taxa has been recorded. This shift in the vegetation from frontline core mangroves to the peripheral mangrove components has been brought about by the lowering down of sea-level and plentiful fresh water discharge in the estuary since 2,000 years B.P. Another important feature of this study relates to the arrival of *Casuarina* and member of Anacardiaceae in good values around 700 years B.P. which narrates the anthropogenic activities and the woe of mangrove forest.

Key-words—Palynology, Holocene, mangrove degradation, Rambha, Chika Lake, Orissa (India).

INTRODUCTION

RAMBHA (Lat. 19°8', Long 85°1') is a south-eastern flank of Chilka Lake. The salinity effect is more in this area owing to the fact that this end of the lake is in low-ebb zone and also no river or rivulet is directly pouring water at this point. Rambha, particularly in the east-northward, abounds in rocky granitic mounds which are partly inhabited and partly covered with vegetation. In the vicinity about 12 nautical miles east of Rambha, there is a prominent muddy island known as 'birds island'. Until 1989, when the authors surveyed first, there was sufficient spread of swampy margins extending to the south-west of Rambha. Recently embankment has been made and the elongated southern arm of the Chilka Lake has been drained out. Thus, a greater part of the south-western margin of the lake has been dried up and become unsuitable for the operation of manual peat-auger. Therefore, borings were conducted to the north of embankment. For general geology, geomorphology and vegetation in and around Chilka Lake, readers are referred to our previous publications (Gupta & Khandelwal, 1990; Gupta & Yadav, 1990).

MATERIAL AND METHOD

During the survey of Chilka Lake in the year 1990, several trial borings were conducted at Rambha covering, an area of around ten sq km and a 4.30 m deep soil profile was obtained and samples were procured at an interval of ten centimeter each.

Lithostratigraphically the sediments could be broadly classified as sticky grey clay with silt and sand in different denominations having black organic thin streaks upto a depth of 2 m from the surface. Thereafter, sediments become more compressed and composed of blackish organic mud with abundance of shells and fish scales. The details of lithostratigraphy from top to bottom of the profile are given as below.

- 0.0-1.00 m – Grey sticky silty clay with blackish organic streaks at places throughout. Organic matter negligible. Between 0.90-1.0 m medium-sized sand layer is present.
- 1.01-1.50 m – Blackish grey organic mud with silt and medium-sized sand. Grit scatteredly present at places. Animal shells present at 1.10 m depth.

* Paper presented at the Birbal Sahni Birth Centenary Palaeobotanical Conference, Lucknow, November 20-22, 1991.

- 1.51-2.00 m – Black organic mud with silt and fine sand. Rhizomes of *Cyperus rotundus* recovered between 1.90-2.00 m depth.
- 2.01-2.50 m – Greyish black organic mud. Silt, sand, grit and shells interspersed althrough.
- 2.51-3.00 m – Blackish grey clay with abundant sand and shells.
- 3.01-3.50 m – Greyish black organic sticky mud with abundance of shells. Fish scales scatteredly present throughout.
- 3.51-4.30 m – Black humified organic mud with shells and fish scales.

POLLEN DIAGRAM AND PALAEOFLORESTICS

Based on pollen data of a 4.30 m deep vertical soil profile from Rambha, covering time span of 3,800 years B.P., one pollen diagram (Text-fig.1) has been prepared. Relative values of each spore/pollen, calculated in terms of total land plant pollen, are plotted in the pollen diagram in order to highlight the palaeofloristic development in and around Rambha, the south-eastern flank of Chilka Lake. To achieve the precision in vegetation shifts, two major pollen assemblage zones have been proposed in ascending chronological order and they are prefixed with the site initials, viz., R-I and R-II. This has been chiefly

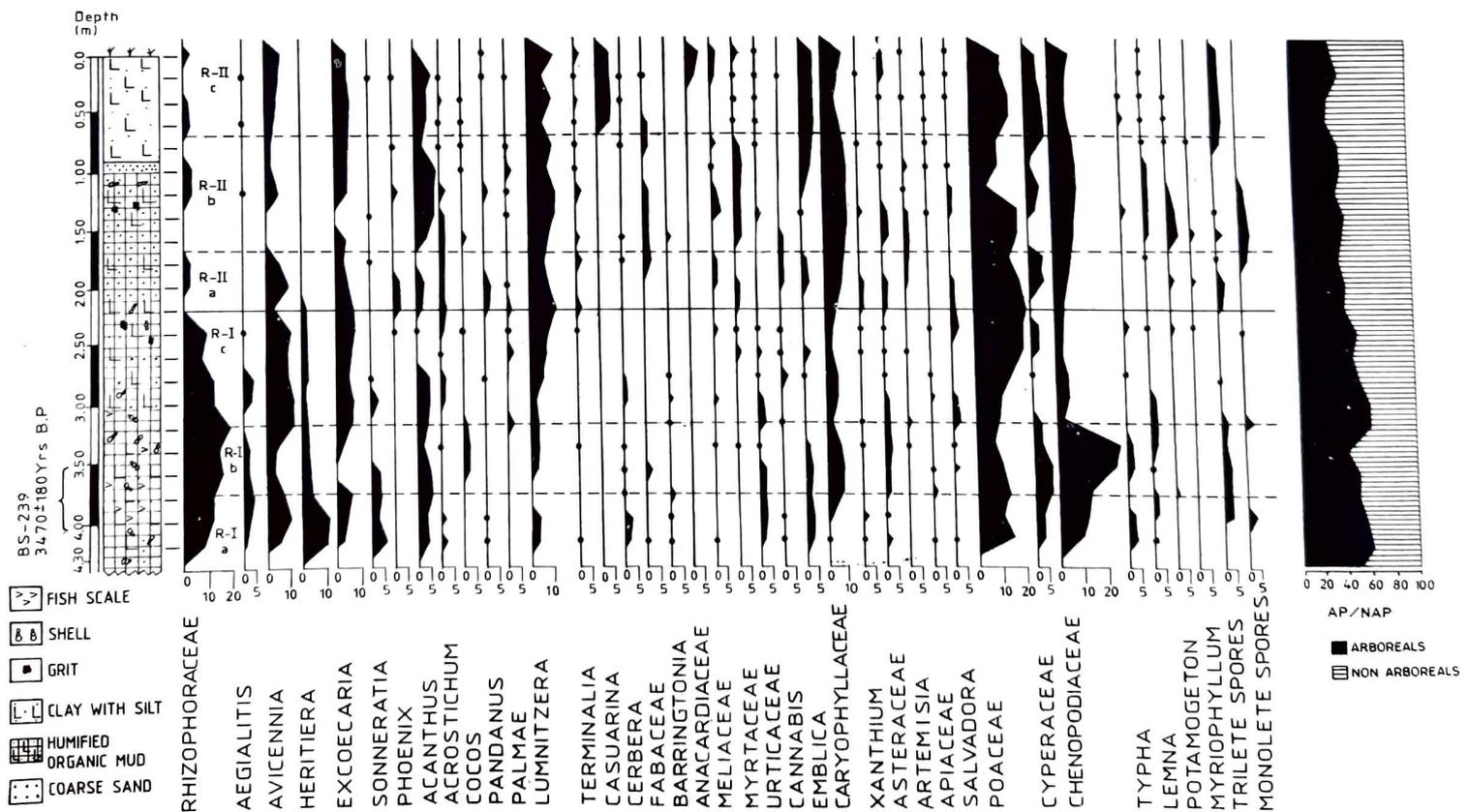
done to express biostratigraphic units in terms of palaeovegetation and to translate them in relation to the significant events and episodes which had occurred within the framework of this study. Each zone has been separately discussed.

Zone R-1 (4.30-2.20 m)

Overall picture of this zone signifies the existence of core mangroves. However, based on subtle changes within the mangrove composition, this zone has been subdivided into three zonules, viz., a,b,c, and each zonule has been separately spelled out below.

Zonule R-1a (4.30-3.75 m) - It records high values of frontline core mangroves. The frontline taxa, viz., *Rhizophora*, *Ceriops*, *Bruguiera*, etc. are clubbed together under Rhizophoraceae. Other core mangrove taxa, significant of this zonule, are *Avicennia*, *Heritiera*, *Excoecaria*, *Lumnitzera*, etc. *Acanthus*, a transient between core and peripheral mangroves is also present in good frequency. Peripheral mangrove taxa, such as, *Acrostichum aureum*, *Pandanus*, *Cerbera*, Fabaceae, Meliaceae and *Salvadora* are either present in low values or are sporadic in distribution. Amongst hinterland taxa, *Terminalia* is sporadic and *Emblia* is present in low values.

Chenopodiaceae, inhabitant of salt marshes in the peripheral zone, is present in fairly good values. Nonar-



Text-figure 1. Pollen diagram from Rambha, Chilka Lake, Orissa (Percentages calculated in terms of total land plant pollen).

boreals, mostly with ubiquitous nature in distribution, are predominated by Poaceae followed by Cyperaceae whereas *Xanthium*, Asteraceae, Caryophyllaceae, etc. are sporadic but Urticaceae has consistent low value curve.

In the typical deltaic environment, there is an admixture of fresh water plant taxa also. Amongst them, *Typha* holds low value curve in the middle and *Lemna* remains sporadic with slight improvement at the close of this zonule. Ferns with both trilete and monoete spores, are encountered in good values at the end of this zonule.

Zonule R-1 b (3.74-3.20 m) - Further advancement in the frontline core mangrove taxa under Rhizophoraceae on one hand and overall depression in rest of the core mangrove taxa on the other is the significant feature of this zonule. However, peripheral mangrove taxa exhibit slight improvement than before, and the midland/upland taxa continued to be as before except for *Cocos* which registers slight improvement.

Chenopodiaceae records considerable improvement. Poaceae experiences depression in the upper half but Cyperaceae registers improved values in the lower half and declines in the upper half of this zonule. Rest of the nonarboreal taxa continue in more or less same order as in the preceding zonule.

Likewise, fresh water elements also remain in the same order as before except for *Potamogeton* which makes its appearance in the beginning and then disappears. Ferns, with trilete spores, are present in low value curve throughout.

Zonule R-1c (3.19-2.20 m) - It signifies a shift within the mangroves leading to continuous depression in the frontline core mangroves and an overall improvement in rest of the core mangroves. For instance, Rhizophoraceae declines upward and reaches to the zero point at the close of this zonule. *Avicennia* and *Excoecaria* gain position at the fallout of Rhizophoraceae. *Aegialitis* and *Sonneratia* continue in low values till middle and thereafter disappear at the top of the zonule. *Heritiera* continues in depressed values as in the preceding zonule. *Lumnitzera* remains in low profile till the lower half but improves subsequently. Amongst peripheral mangroves, *Acanthus* and *Acrostichum aureum* remain in good values as before in the lower half and thereafter become sporadic like other associates but regain values at the close of this zonule. *Emblica* and *Terminalia* are sporadic.

Chenopodiaceae and Cyperaceae experience depression and continue to be in low profile throughout the zonule. Poaceae remains as high as in the preceding zonule and attains maximum values at the close of this zonule. Other nonarboreal taxa remain sporadic except for Caryophyllaceae which continues in moderate pollen curve.

Lemna and ferns are present in low values curve

whereas other elements of freshwater origin are negligible.

Zone R-II (2.19-0.0 m)

This zone is marked by steep fall in frontline core mangroves all through. Like preceding zone, it has also been subdivided into three zonules, viz., a,b,c, and each has been defined separately.

Zonule R-II a (2.19-1.70 m) - This zonule exhibits tremendous decline in the frontline and other core mangroves. Rhizophoraceae reduced to fraction; *Aegialitis* and *Heritiera* disappear and *Sonneratia* becomes sporadic. However, *Avicennia*, *Excoecaria*, and *Lumnitzera* continue throughout in good values as before. Peripheral mangroves, viz., *Phoenix*, *Acanthus*, *Pandanus*, *Arecaceae* and *Meliaceae* form low profile curve in the lower half and then disappear. *Acrostichum aureum* maintains low pollen curve throughout. There is an overall improvement in the hinterland taxa. *Emblica* shows slight improvement than preceding zonule. *Terminalia* is sporadically high.

Chenopodiaceae and Cyperaceae, though low in the beginning, improve gradually upward. Poaceae, after attaining maximum values in the beginning, declines upward. Other nonarboreal taxa like Urticaceae, *Cannabis*, Caryophyllaceae, *Xanthium*, Asteraceae, etc. are present in higher values than before.

Fresh water taxa such as *Potamogeton* and *Myriophyllum* are sporadically high whereas trilete fern spores reappear in reasonably good values.

Zonule R-IIb (1.69-0.70 m) - All the core mangrove taxa continue in more or less similar frequencies as in the preceding zonule except for *Lumnitzera* which maintains improved values throughout. There is an overall improvement in peripheral mangrove taxa. *Acanthus illicifolius*, Fabaceae, *Meliaceae* and *Myrtaceae* record much higher values than before but *Phoenix*, *Acrostichum aureum*, *Cocos*, *Pandanus* and *Arecaceae* become sporadically low. Amongst hinterland plant taxa, *Emblica* rises and maintains high values in the upper half whereas *Terminalia*, *Anacardiaceae*, etc. are sporadically high.

Poaceae continues to be high till middle of the zonule and subsequently declines. Chenopodiaceae maintains higher values than before. Cyperaceae is fluctuatingly high and retains continuous curve in the upper half. Caryophyllaceae improves considerably and forms high value pollen curve. Other nonarboreals remain either sporadic or present in low discontinuous pollen curves.

Aquatic taxa show improvement than before. *Lemna* and *Potamogeton* form good pollen curves whereas *Typha* and *Myriophyllum* remain sporadically high. Monoete spores improve and trilete spores lose their values as compared to the preceding phase.

Zonule R-II c (0.69 m-0.0 m) - The overall picture of vegetation composition remains more or less similar to the preceding phase. However, Rhizophoraceae further reduces while *Avicennia* and *Excoecaria* maintain slight improvement. *Lumnitzera* is fluctuatingly high. *Casuarina* suddenly appears right in the beginning and continues throughout the zonule maintaining consistency in its values. Anacardiaceae appears in the middle of this zonule and abruptly improves upward. Amongst peripheral mangroves, *Barringtonia* suddenly appears in the upper half and forms high pollen curve. Another notable feature of this zonule is that *Emblica* and trilete spores improve adequately whereas herbage and aquatic taxa experience setback in their values.

DISCUSSION AND CONCLUSION

Rambha pollen diagram is phased into two broad zones in ascending chronological order which can be subdivided into three zonules each. The total 4.30 m thick sediments were laid down in a span of about 3,800 years. While translating the pollen diagram in terms of palaeofloristics, we have categorized the whole vegetation into different groups, viz., core mangroves, peripheral mangroves, hinterland, ubiquitous and aquatic taxa. While doing so, we could get the insight knowledge of shifts in vegetation and their impact on depositional environment which is being presented below under each zone separately. The nature and texture of the sediments in this profile is almost alike throughout and there is no evident change in the lithology. Therefore, it is being presumed that the rate of sedimentation throughout was almost uniform and could be estimated roughly at the rate of 1 centimeter per 10 years.

Zone R-I records splendid growth of core mangroves and thereby enjoyed typical deltaic environment. Nevertheless, some minor changes and shifts in vegetation within the mangrove complexes have been highlighted under each zonule.

Zonule R-I a, encompasses the vegetation picture of 500 years between 3,800-3,300 years B.P. wherein Rhizophoraceae, *Avicennia*, *Heritiera*, *Excoecaria*, *Lumnitzera* and *Acanthus* association thrived. *Avicennia* and *Lumnitzera* are more resistant and can withstand hypersalinity. Species of *Avicennia* and *Lumnitzera racemosa* characteristically colonize the lagoons with fluctuating water levels in association with *Cerlops*. While species of *Rhizophora* prefers constant depth of saline water. *Excoecaria* is also an associate of mangrove community but prefers to colonize either open sites or sandy beaches in estuarine complex but certainly not regarded as an exclusively mangrove component for the want of specialized adaptations to mangals. *Aegialitis* requires open rocky shores to colonize but at the same

time, owing to high adaptability, it can establish in highly saline soil also. *Heritiera* and *Sonneratia*, although characteristic mangrove taxa, prefer the sites where there is more fresh water discharge. *Acanthus ilicifolius*, being vegetatively propagated, forms dense bushy crown bordering the lagoons. It has the adaptations to shift landward and seaward depending upon the spread of seawater in the estuary. High values of Chenopodiaceae is indicative of the fact that besides being salt marsh plants, it can colonize the shallows and even flourish in the freshwater influenced zone.

All the combinations and permutations of vegetation mosaic have envisaged that during this period lagoonal environment with fluctuating water levels prevailed.

Zonule R-I b, covering a time span of subsequent 500 years, has recorded the preponderance of Rhizophoraceae and Chenopodiaceae whereas other core mangroves and mangrove associates declined drastically. *Heritiera* marked sharp decline and *Sonneratia* disappeared from the upper half of this zonule. Chenopodiaceae spread is remarkable that it attained exceedingly high values throughout.

The overall vegetation mosaic of this zonule has suggested the advancement in the sea level as a result of constant depth of sea water developed. This encouraged the frontline mangroves under Rhizophoraceae to flourish and spread in aerial extent. With this phenomenon of advancement of sea water level, shallows and salt marshes developed which were colonized by Chenopodiaceae.

Zonule R-I c, encompassing a period of about 900 years, is marked by consistent decline in the overall values of Rhizophoraceae and corresponding improvement in *Avicennia*, *Excoecaria*, *Lumnitzera*, etc. *Heritiera* continued in depressed values and rest of the core mangrove taxa vanished from the upper half. Chenopodiaceae is dotted by steep fall in its values. Peripheral mangroves, in general, have tended to improve.

Thus, the vegetation picture obtained during this zonule has deduced that the sea spread was ceased considerably leading to the lowering down of sea level. This feature in the prevailing environment has led the overall depression in the frontline core mangroves and spurt in peripheral mangroves and hinterland taxa.

Zone R-II, a period of evident shift in vegetation, has recorded sporadicity in the frontline core mangroves under Rhizophoraceae. At the same time spurt in the mangrove taxa having preference for low salinity and high degree of adaptations, to the changing scenario, has been recorded. However, on the basis of some imminent segregation in the vegetation development, this zone has been defined under the following three different phases.

Zonule R-II a, covering a time period of about 400 years, has recorded very meagre and insignificant occurrence of Rhizophoraceae, Other mangrove taxa along-

with hinterland taxa have recorded improvement. Chenopodiaceae also improved.

This set up of vegetation mosaic has revealed that there was more fresh water discharge in this estuarine complex which led to the feeble growth of frontline core mangroves and subsequently encouraged the spread of freshwater salt tolerant plant taxa.

Zonule R-II b, dwelt for a period of about 300 years and recorded high spurt in the values of *Acanthus*, *Excoecaria*, *Lumnitzera*, etc. Besides, freshwater taxa, both arboreals and nonarboreals improved adequately. Important amongst them are Myrtaceae and Caryophyllaceae.

Thus, information permeated from vegetational development in this zonule has reflected that the discharge of fresh water continued more and more leading to the establishment of freshwater loving and salt tolerant plant community.

Zonule R-II c, covering a period of 700 years B.P., displays the arrival of *Casuarina* and Anacardiaceae (*Anacardium occidentale*). Both the taxa have been recently introduced all along the coast and have now been naturalized in the area. Their occurrence is a testimony of human interference in the mangrove forest which has

led to a considerable damage to the indigenous vegetation.

On comparison of Rambha pollen data with the already worked out profiles one each from Balugaon (Gupta & Khandelwal, 1990) and Paradip island (Gupta & Yadav, 1990) a common feature was found that both at Balugaon and Rambha, Rhizophoraceae ceased to occur around 2,000 years B.P. Thereafter, an anomalous feature was observed between the two. At Balugaon, Rhizophoraceae re-emerged and flourished between 1,600-1,000 years B.P., and then continued in degraded mosaic, whereas at Rambha, it did not re-establish till date.

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