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An ardent chess player and a graceful dancer, Mahalaxmi has represented her state in national level chess competition and also University Blue in chess during her graduation days. Recently, during her training, she secured a bronze medal in chess at the All India Forest Sports Meet 2024. Alongside her active pursuits, Mahalaxmi has a deep-seated interest in research, engaging in research activities even during her on-the-job training. Her love for dance not only enriches her own spirit but also brings joy and vibrance to those around her.

Sediment analysis of mangrove plantation sites at Kali river estuary, Karwar, Karnataka



Mahalaxmi K. K.

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**CENTRAL ACADEMY FOR STATE FOREST SERVICE
COIMBATORE**

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FOREWARD

It is with great pleasure that I introduce **Sediment analysis of mangrove plantation sites of kali river estuary Karwar, Karnataka** - an observation and research work of Mahalaxmi K.K, during her On-The-Job training at Karwar division. This book serves as an informative introduction to the Coastal and Marine Ecosystem Cell of Karnataka in terms of mangrove plantation works and sediment analysis across various mangrove plantation sites in Karwar, Karnataka resulting in significant research outputs.

I am confident that this document will provide a solid foundation for beginners interested in conducting research in coastal ecosystems, encouraging further exploration and conservation efforts in this vital area.

I extend my heartfelt wishes to Mahalaxmi K. K. for her future endeavors, confident that her dedication will continue to enrich the realm of forestry.

Best wishes,



V. Thirunavakarasu, IFS
APCCF &Principal
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PREFACE

The Karavali, coast of Karnataka, renowned for its breathtaking beaches and lush mangrove forests, embodies a remarkable synergy of nature, culture, and history. This region has emerged as a pivotal area for community-based conservation efforts, highlighting the critical need to protect its unique coastal and marine ecosystems.

During my on-the-job training in the Karwar division, I observed firsthand the dedication of the Coastal and Marine Ecosystem Cell in their mission to conserve mangrove forests and enhance coastal biodiversity. My visits to various mangrove plantation sites revealed significant variations in the survival rates of planted mangroves, prompting me to conduct sediment analyses at these locations.

This book emphasizes the importance of sediment analysis in mangrove plantation efforts, advocating for the selection of site-specific mangrove species to improve survival rates. I believe that integrating sediment analysis into the planning stages of plantation activities can profoundly impact the success of conservation initiatives in this vital ecosystem.

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Mahalaxmi K. K.

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CHAPTER 1

Coastal and Marine ecosystem cell and Sediment analysis of the mangrove plantation sites at Kali River estuary in Karwar Karnataka

Karnataka is one of the coastal states of India, sharing its coastline along the Arabian Sea. The length of the coastline is approximately 320 km covering three coastal districts namely Dakshina Kannada, Udupi and Uttara Kannada and eight talukas and 1,044 coastal villages. The coastal region of Karnataka state is popularly known as Karavali. The Karnataka coast has different geomorphological features which include several river mouths, lagoons, bays, creeks, cliffs, spit sand dunes, and long beaches. Depending on the geography and climate, both plant and animal life vary accordingly. The diversity of the animal life in the area is also directly related to the abundance and diversity of the plant life.

For the conservation of Coastal & Marine Eco-system, the Coastal and marine ecosystem cell has been established in Karwar of Karnataka in 2021. RFO will be the head of the cell.

1.1 Duties and Responsibility of Coastal & Marine Ecosystem Cell

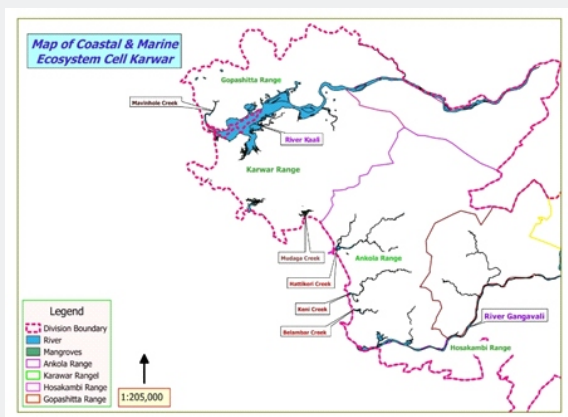
- Identifying flora and fauna species by continuously patrolling the sea and coastal areas. Research, study and taking action for conservation.

- To create legal awareness among the coastal people about the Environment Protection Act, 1986 and the Wildlife Protection Act, 1972 with special emphasis on conservation of the species listed in the schedule of the Wildlife Protection Act, 1972.
- Constant liaison and exchange of information with Coastal Security Force, Karnataka University, Department of Marine Biology, National Marine Fisheries Research Institute, Indian National Centre for Ocean Information Services, Fisheries Department, Tourism Departments engaged in coastal and marine ecosystem.
- Coastal ecosystems include sand dune banks, rocky shores, islands, estuaries etc. Work should be focused on their conservation and development.
- Identifying and documenting the extent of the mangrove forest area. Continuous study and recording the biodiversity of flora and fauna. Conservation of mangroves in collaboration with locals and special emphasis on the extending of mangrove forest area through afforestation and promotion of tourism related to mangrove forest.
- To identify the nesting area of Olive ridley turtle, providing them with suitable facilities and take measures for their conservation.
- Emphasis given to the new research and experiments related to Coastal and Marine Eco System.

- The Range Forest Officer shall be fully responsible for the efficient performance of departmental functions under his purview and for the protection of Government property under his charge and for the maintenance of discipline and conduct and performance of subordinate staff.
- The Range Forest Officer is responsible for proper maintenance of revenue accounts in his jurisdiction and regular submission of the report of financial accounts.
- To ensure adequate involvement of the lower-level staff to complete the departmental tasks within the scope of protection of forest resources within its jurisdiction.
- In the case of emergency situations such as forest offences, Encroachment issues, Man-animal conflict, animal protection program, etc., performing duties as supplementary staff with other staff of the sector or department.
- Performing other duties and responsibilities as may be prescribed by senior officers or controlling officers from time to time.

1.2 Mangrove distribution in Karwar Forest Division

Kalinadi Esturies: The Kalinadi is also Called as Kari hole or Sadashivgad river. River Karihole, 3kms from Karwar town is a major river near the northern coastal Karnataka, at latitude 14° 48'N & Longitude 74° 48' E. It has an estuary extending from Kodibag (S) & Devbhag (N) at the river



Map.1 Coastal & Marine Eco-system Cell, Karwar

mouth upto Kumipets & Kadra(S) at a distance of about 30kms.

The Gangavali or Bedti:river forms the boundary of Karwar forest Division along the coast. A narrow range of hills separate Gangavali basis from the Aghanasini farther south. The sea water moves in the Gangavali river for almost a distance of 24km up to the village Gundabala, Mavinhole, Mudaga, Hattikeri, Keni & Shirur creeks.

Table 1. Mangrove afforestation works last three years

Sl.No	Year	Location	Area in ha
1	2021-22	Kadwad & Kinni Creek	10
2	2022-23	Kali estuary, Gangavali estuary & Muduga	171
3	2023-24	Juga, Andle Mogta (Gangavali river bedd), Kinnar , Siddar Kali estuary	22

Mangrove afforestation work (steps involved)

- I. Selection of sites
- II. Collection of Propagule
- III. Transportation of Propagules
- IV. Plantation works

Here, I have taken up a study - sediment analysis of the mangrove plantation sites at Kali River estuary in Karwar division and I have collected the soil samples at four different places of Kali River estuary where plantation work has been taken up by the Coastal and marine ecosystem Karwar.

CHAPTER 2

Abstract

Mangroves around the world settle along coasts and estuaries. The physical-chemical features of sediment in mangrove habitats might be altered by coastal wind, waves, and currents more frequently under the condition of increasing extreme climatic events. These events affect the Survival rate of mangrove plantation sites. To study how sediment texture and organic carbon affect the Survival rate of mangrove plantation, carried out lab analysis of sediments of four mangrove plantation sites, where organic carbon, sand, silt and clay proportion was found out. It has been found that the Survival percentage of mangrove plantation sites at Devbhag and Kadwad is more as compared to Balini and Kinnar. It's because the sand proportion is more in Devbhag and Kadwad as compared to latter as species grown in these sites are more adaptable to sandy texture. In estuaries and coasts featuring various sediment textures, the conservation and restoration of mangroves should consider these conditions to ensure the sustainable development of mangroves.

CHAPTER 3

Introduction

Mangroves mainly occur throughout tropical and sub-tropical coastal areas, usually in sheltered estuaries and bays with lower wind and waves energy (Romañach et al., 2018; Friess et al., 2019). These forests provide numerous ecosystem functions and benefits, such as carbon sequestration, storm and wave damping, and marine and coastal biodiversity conservation (Alongi. 2008).

Coastal and marine ecosystem cell, Karwar is established in 2021 in Karnataka for conservation of coastal and marine ecosystem. Some of the duties and responsibility of this includes,

- * Identifying and documenting the extent of the Mangrove Forest area.
- * Continuous study and recording the biodiversity of flora and fauna.
- * Conservation of Mangroves in collaboration with locals and special emphasis on the extending of mangrove forest area through afforestation and promotion of tourism related to mangrove forest.
- * Emphasis given to the new research and experiments related to Coastal and Marine Eco System

One of the future research proposals of Coastal and marine ecosystem cell is analysis of Floristic Diversity of Mangroves in Kali Estuary based on Morpho-Physiological Parameters. A scientific work has been carried out to analyze the sediment and correlating it with the plantation Survival percentage.

CHAPTER 4

Past Studies

Many workers have investigated the biogeochemistry of organic and inorganic constituents in sediments and water samples of different seas. Only during the last two decades an increased enthusiasm among the scientists have been found in the investigation on the study of physical parameters and its relation with the biotic components along the Indian coast, in this respect sand, silt, clay proportion becomes an important part of study. Balke et al., (2011) Sediment dynamics are crucial when considering the natural dispersal and colonization of mangrove seedlings. Demaison and Moore (1980) Factors capable of influencing organic matter accumulation in sediments are of biological and physical in nature. It is the interaction of these factors that determine the degree of its preservation quantitatively and qualitatively. Joanna C. Ellison (2009) mangroves flourish on sedimentary shorelines, it is shown here that excess input of sediment to mangroves can cause death of trees owing to root smothering.

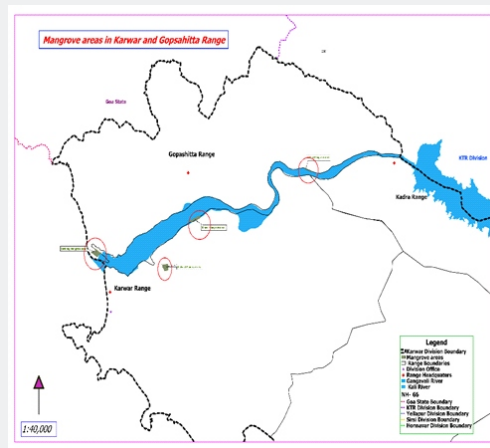
Mangroves have been adversely affected by sediment burial of roots. Wang et al., (2015) The sediment texture may also cause root traits to respond to the inundation of trees. Ziyang He et al., (2022) In estuaries and coasts featuring eutrophication and various sediment textures, the conservation and restoration of mangroves should consider these conditions to ensure the sustainable development of mangroves.

CHAPTER 5

Methodology (Material and Methods)

Sediment Analysis

Sediment of four different mangrove plantation sites (Kadwad, Kinnar, Devbhag and balini) is collected in the month of May 2024 by using soil had probe instrument.



Map.2 Red circles showing places of Sediment collection

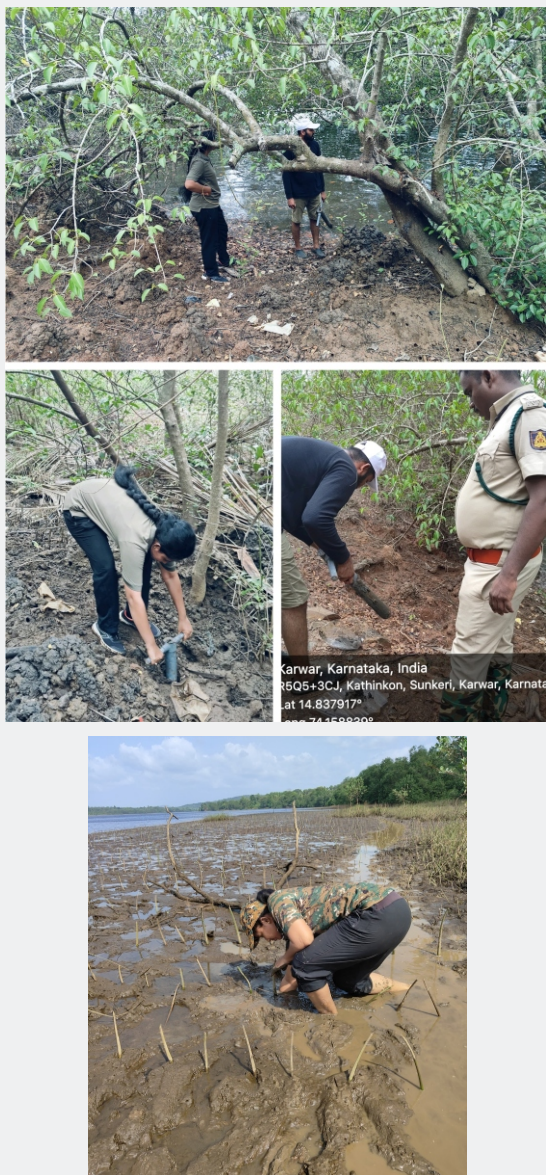


Fig.: 1 Soil sample collection at different places



Fig.: 2 Devbhag Mangrove plantation



Fig.3 Sediment collection at different mangrove plantation sites of Karwar division



Fig.:4 Aerial Photos showing Mangrove plantation sites



Fig.:5 Aerial Photos showing Mangrove plantation sites

5.1 Sand Silt and Clay Proportion.

Sample processing

1. Weigh an appropriate amount (20 to 25 grams) of air-dried or oven-dried sediment.
2. Transfer the sediment to 500 ml beaker. Add about 100 ml of 6% hydrogen peroxide to oxidize the organic matter. Stand overnight. Heat gently on water bath if necessary.
3. Add further small quantities of hydrogen peroxide until there is no further reaction.
4. Wash the contents on to a Whatman no. 50 filter paper in a Buchner funnel.
5. Wash the sediment from the filter paper using around 200 to 300 ml of filtered tap water (filtered through Whatman number 42) into a clean 500 ml beaker.
6. Add 10 ml of sodium hexa metaphosphate solution (6.2 grams in 1000 ml distilled water).
7. Stir the contents for 10- 15 minutes. Leave the sediment soak overnight.

Initial splitting of sand and silt plus clay fraction

1. The soaked sediment along with the water is poured on to a 62-micron sieve taken in a two-liter capacity trough, preferably with a white background.
2. Use another 200 ml of filtered tap water to wash the sediment thoroughly into the trough.
3. Remove the sand fraction from the sieve and dry the content in oven at 60°C.

4. The dried sand is subjected to grain size analysis by using the following log sheet.
5. Dried sand sample is sieved using the above sized sieves using sieve shaker for about 10-15 minutes.
6. Remove the respective sieves from the shaker and weigh the content and enter the data in the above log sheet to get percent weight of each sand fraction and total.

Sediment Analysis

Date:

Station No.:

Sample No.:

Total weight of the sample:

Total weight of the sand:

Sediment lost:

Table 2 Sediment Analysis

Dry Sieving	Weight in grams			
Sieve size in microns	Wt. of F.P.	Wt. of F.P. + Sample Wt	Sample Wt	%
1000				
500				
250				
125				
62				

Pipette Analysis for finding silt and clay fractions

1. The filtrate collected in the trough after initial splitting of the sediment is transferred to a clean and dry measuring cylinder (1 liter).
2. Make up the volume to 1 liter with filtered tap water.
3. Mark the cylinder at 20 and 10 cm from the water level.
4. Stir the sample vigorously and pipette the first sample (20 ml) from 20 cm depth on to a pre-weighed Whatman No. 42 filter paper having 4.7 cm dia and filter the sample through macro filtration unit.
5. Similarly, the next two samples are pipetted out from 10 cm depth at 7' 44" and 2 hours respectively.
6. Dry the samples in oven at 60-70° C for 5 to 6 hours.
7. Enter the data in the following log sheet and find out the percent fractions of silt and clay in the total sediment.
8. Calculate the silt in 1000 ml both at fraction by adding the sample weight instant and 7' 44" pipetting times.
9. The weight of the sample in 1000 ml pipetted out at 2 hours gives the quantity of clay.
10. Calculate the percent fractions of sand, silt and clay in the total sample taken for the analysis. oven-dried.
11. The difference between the weight sample and final weight of the original the sample (sand silt+ clay) gives the amount of organic matter lost in the oxidation of hydrogen peroxide.

Table 3 -Pipette Analysis for Silt & Clay

Pipetting time	F.P Wt	F.P Wt+ Sediment	Sample wt in 20 ml	Sample Wt in 20 ml
Instant				
at 7' 44"				
2 hours				
		Total=		

5.2 Determination of organic carbon in the sediment

Analysis is done as per Walkley and Black method (Holmes and McIntyre, 1984).

Reagents

1. N Potassium dichromate: Dissolve 49.04 gm of reagent grade $K_2Cr_2O_7$ in water and dilute to 1 liter.
2. Sulphuric acid: Not less silver sulphate added for than 96% with 1.25 gms of silver sulphate added for every 100ml of acid.
3. Phosphoric acid at least 85%
4. Diphenylamine Dissolve 0.5 gm of the reagent in 20 ml of water and add 100 ml of Sulphuric acid.
5. 1N Ferrous sulphate: Dissolve 278 gms. of reagent grade of the reagent in water, add 15 ml of conc. Sulphuric acid and dilute to 1 liter.

Procedure

1. Take 1 gm of oven-dried or air-dried sediment (for clayey sample) and powder it in a clean and dried mortar.

2. Transfer the sediment into a 250 ml conical flask. Add 10 ml of normal potassium dichromate followed by 20 ml of conc. Sulphuric acid. Shake by hand for one minute.
3. Place the content in boiling water bath for 30 minutes. Cool, add 200 ml water, 10 ml of Phosphoric acid and 1ml of Diphenylamine indicator solution.
4. Titrate the contents by adding ferrous sulphate, which is taken in a 25 ml burette, drop by drop, until the solution is purple or blue. Continue to add ferrous sulphate in small lots of about 0.5 ml of dichromate. The end point can easily be recognized with a change in color from blue to purple green.



Fig.: 6 Estimation of Organic carbon at laboratory



Fig.: 7 Department of Marine biology where lab analysis has done

Calculation

$$\frac{V1 - V2}{W} \times 0.003 \times 100$$

Where,

V1 is the volume of Potassium dichromate (10.5 ml),

V2 is the volume of ferrous sulphate in ml,

W is the weight of the sample taken.

This gives of the carbon present in the sample.

Organic matter can be calculated by using the values of organic carbon.

$$\text{Organic matter (\%)} = \%C \times 1.724$$

5.3 Hydrology

Collections of water samples were made in all 4 stations during May month for analyzing the various physicochemical parameters.

The physicochemical parameters included under this are temperature, pH, Salinity, Dissolved oxygen, Nutrients like nitrate and Phosphate.

5.4 Temperature

Temperature of water sample was recorded by using centi grade thermometer and represented in degree Celsius (°C).

5.5 Salinity

The salinity of the collected water sample was determined titrimetrically by Mohr's Knudson's method (Strickland and Parson, 1975) and expressed in parts per thousand (ppt).

5.6 pH

Portable pH meter was made use of in the determination of pH at the study stations.

5.7 Dissolved Oxygen

Winkler's method as described by Strickland and Parson (1975), followed for the estimation of dissolved oxygen content in the water sample at different stations and expressed an ml/l of water.

5.8 Nutrients

Nutrient load in the form of nitrate, phosphate in water were measured spectrophotometrically (Strickland and Parson, 1975) and expressed as microgram atom per liter (mg at/L) respectively.

Table 4 Spectrophotometric analysis of Sand

Sand proportion	Kadwad	Kinnar	Devbhag	Balini
Sand	76%	22%	64%	08%
Silt	10%	36%	22%	44%
Clay	14%	42%	14%	48%



Fig.: 8 USDA soil classification chart

Table 5 Organic Carbon ratio

Organic carbon		
Kadwad	0.68	Medium high
Kinnar	0.54	Medium
Devbhag	0.61	Medium high
Balini	0.49	Medium

Table 6. Range of Organic carbon (%) result interpretation

Range in %	Interpretation
<0.20	Very low
0.20-0.40	Low
0.41-0.60	Medium
0.61-0.80	Medium high
0.80	High

Table 7. Survival percentage of Mangrove plantation Sites

Kadwad	70-75%
Kinnar	65-70%
Devbhag	80-85%
Balini	60-65%

Table 8. Water Parameters in the Stations

Station	Temp	Salinity (ppt)	Ph	DO (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)
Kadwad	30	18	7.4	4.6	0.02	0.01
Kinnar	31	06	7.2	5.9	0.01	0.02
Devbhag	31	27	7.4	5.4	0.02	0.01
Balini	30	21	7.5	5.2	0.01	0.01

Table 9. List of naturally regenerated mangrove species

Devbagh	Kadwad	kinnar	Balini
<i>*Aegiceros corniculatum</i>	<i>*Sonneratia Caseolaris</i>	<i>*Sonneratia caseolaris</i>	<i>*Rhizophora mucranata</i>
<i>*Lumitzera speciosa</i>	<i>*Rhizophora mucranata</i>	<i>*Avicennia officinalis</i>	<i>*Bruguiera cylindrica</i>
<i>*Execoria agallocha</i>	<i>*Kandelia candel</i>		<i>*Avicennia officinalis</i>
<i>*Avicennia officinalis</i>	<i>*Execoria agallocha</i>		
<i>*Bruguiera cylindrica</i>			
<i>*Kandelia candel</i>			

Table 10. List of species planted in plantation sites

- 1) *Rhizophora mucronata*
- 2) *Kandelia candel*
- 3) *Bruguiera cylindrica*
- 4) *Avicennia officinalis*

CHAPTER 6

Discussion and Conclusion

The sites like Kadwad and Devbhag is having higher sand proportion i.e., 76% and 64% respectively and higher organic carbon content 0.68 and 0.61 respectively, which will come in the category of medium high and these two sites contains lower silt and clay content.

The sites Kinnar and Balini is having higher clay content i.e., 42% and 48% respectively and organic carbon content 0.54 and 0.49 respectively which comes under category of medium. These sites showing lower sand content.

When we analyze the water parameters at all the sites it showing nearly similar temperature of water fluctuating between 30-31°C and pH ranging from 7.2-7.5 which is slightly alkaline in nature.

Higher water salinity is shown in Devbhag (27ppt) and lower salinity recorded in Kinnar (6 ppt), this Kinnar site is far away from the sea water.

Dissolved oxygen(DO) content is ranges from 4.6 to 5.9 mg/l and nitrate and phosphate content is ranges from 0.01-0.02 mg/l

Mangrove species planted in the plantation sites are viviparous in nature, for the plantation, matured

propagules are collected from the field itself like as shown in below figure



Coastal and Marine ecosystem cell Karwar will carry out the plantation works at different places.

It's quite difficult for them to carryout nursery activities and raise seedlings and go for plantation activities, so from available propagules they carry out the works.

As we analyze the survival percentage of each plantation sites Devbhag is having higher percentage 80-85%, followed by Kadwad 70-75%, Kinnar 65-70%, Balini 60-65%.

From this we analyze that, the area is having higher sand proportion is having higher survival percentage. Though Kadwad is having more sand proportion its survival percentage is quite less as compared to Devbhag, because former one is more prone to high tidal amplitude.

From the table 10,found out that the species planted are having more adaptive nature to the sites having higher

sand proportions. So, it showing high Survival percentage, wherever sand proportion is more.

The seedling roots of *Kandelia obovate* showed more sensitivity towards sediment texture and nutrient enrichment conditions, suggesting that *Kandelia obovate* needed more suitable conditions for colonization than *Sonneratia apetala*. (Friess et al., 2019).

Sediment texture constructs environmental conditions, such as nutrient availability and oxygen content, affecting the development of roots and colonization by seedlings (Lessen et al., 1999; Krauss et al., 2014). In this experiment, all analyzed features showed a significant difference between mangroves species, and a species-specific adaptive mechanism of mangroves at play.

Compared to *Sonneratia apetala*, in *K. obovata*, the most porous roots occurred in the sediment composed of sand rather than mud, while the root porosity of *K. obovata* was lower than that of *S. apetala*. A higher root porosity rate may indicate higher adaptability to submerged or anoxic conditions by enhancing oxygen exchange (Justin and Armstrong, 1987). It can be inferred that *S. apetala* seedlings can acclimate more seaward in less elevated habitats than *K. obovata* does, which is coincident with their natural occurrence along the coastline of southern China (Ren et al., 2009). (Ziying He et al., 2022)

It has been suggested that the sediment should also be considered when conducting mangrove plantation or restoration work

It's better to go for location specific species plantation, then can be able to get higher survival percentage of plantation rather than collecting the propagules in some other area and planting in different areas.

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