RESEARCH REVIEW JOURNALS
Volume-03
Issue-08
August-2018

ISSN: 2455-3085 (Online)
RESEARCH REVIEW International Journal of Multidisciplinary
www.rrjournals.com [UGC Listed Journal]

Evaluation of the growth sustaining attributes of *Rhizophora mucronata* Lam. for strategic afforestation protocols

[*1]Dr. Neethu G. Pillai & [2]Dr. Harilal C.C.

[*1]*Researcher, Division of Environmental Science, Dept. of Botany, University of Calicut, Malappuram District, Kerala (India)*
[2]*Associate Prof, Division of Environmental Science, Dept. of Botany, University of Calicut, Malappuram District, Kerala (India)*

ARTICLE DETAILS

Article History
Published Online: 07 August 2018

Keywords
Rhizophora mucronata Lam., growth sustaining conditions, water quality, sediment quality, climatology

[*]Corresponding Author
Email: neethupillai9[at]gmail.com

ABSTRACT

Afforestation program on mangroves primarily require reliable information on the growth requirements of the targeted mangrove species. The present investigation was carried out to evaluate the hydrogeochemical, sedimentological and climatological conditions ideal for the growth and establishment of the mangrove species *Rhizophora mucronata* Lam. in pursuit of their afforestation practices.

Estimation of the physicochemical characteristics of water and soil / sediment along with climatological attributes from three heterogeneous habitats falling in the coastal environments of Kerala was monitored monthly for a period of one year for deriving conclusions regarding the growth requirements of R. *mucronata* Lam. Statistical analysis revealed the most vital attributes of water which influence the growth of R. *mucronata* are water pH, TSS, resistivity, alkalinity and potassium and also in sedimentological characteristics such as silt %, organic carbon, nitrogen, potassium and sodium without any significant variation. The study as a whole reported the capability of R. *mucronata* to cope up with different hydrological and sedimentological conditions in terms of tolerance or augmented range, which will form a basis for future afforestation initiatives.

1. Introduction

Restoration or afforestation endeavor on mangroves primarily requires reliable information on ecology, hydrology and sedimentology that control the successful growth of the targeted mangrove species. Among all such vital attributes, water and sediment quality are known to have supreme influence on the growth of mangroves (Thom, 1967). In light of this, the present investigation was carried out with the objective of evaluating the hydrogeochemical, sedimentological and climatological conditions ideal for the growth and establishment of the mangrove species *R. mucronata* in pursuit of their utilization for species specific afforestation practices.

2. Materials and Methods

Rhizophora mucronata is a widespread common mangrove species (along marine and coastal protected areas) found in the intermediate to upstream estuarine zone in the lower to mid-intertidal region and more to the seaward side. Three heterogeneous natural habitats confining to the coastal environments of Kerala (Fig. 1) have been fixed for assessing the growth sustaining conditions of the mangrove species *R. mucronata* (Table 1). Location 1 (Ayiramthengu) was falling in Kollam district. Location 2 (Kumbalam) of Ernakulam District was 102 km far from Location 1 and Location 3 (Thekkumbad) was in Kannur district, which was 294 km from location 2.

Fig. 1. Study Area

Table 1. Study Area

Sl. No	Location	District	Latitude	Longitude
1	Ayiramthengu	Kollam	9º07'28.74"N	76º28'39.44"E
2	Kumbalam	Ernakulam	9º54'22.16"N	76º18'42.21"E
3	Thekkumbad	Kannur	11º58'02.87"N	75º17'45.38"E

The study was carried out during 2013 to 2014. Monthly visits to these habitats were carried out and both water and sediment samples were collected. Estimation of the physicochemical characteristics of water and soil / sediments were worked out for deriving conclusions regarding their growth sustaining conditions along with the range of conditions to which they are adjusted to. Water quality parameters analyzed include pH (Systronics, MK IV), turbidity (Systronics, Model 341), TS, TDS, TSS (Gravimetric method), salinity, resistivity, conductivity (Eutech PCD, 650), acidity, alkalinity, total hardness, calcium, magnesium, chloride (Titrimetric method), sulphate (Turbidimetric method), sodium and potassium (Flame photometric method), total nitrogen (Kjeldahl Method) and phosphorous (Stannous chloride method) outlined in APHA (2005) and Trivedy et al. (1987). Similarly pH, moisture percentage, organic carbon, total nitrogen, total phosphorous, sodium and potassium content of sediment samples were worked out (Subramanyam and Sambamurthy, 2002; Trivedy et al., 1987 and Jackson, 1973). Also the textural percentages of sand, silt and clay associated with soil/sediment samples were worked out following International Pipette Method. The data concerning meteorological characteristics of the study area were obtained from India meteorological department. The results were then analyzed.

3. Results

Among the ecological factors, water and sediment quality are known to have supreme influence in the growth and development of mangroves (Thom, 1967; Kjerfve et al., l999). The mean values of water, sediment and climatological parameters together with their standard deviation from habitats containing *R. mucronata* are estimated.

The estimated percentages of sand, silt and clay were used to determine the textural class of the soil. This was achieved through the triangular textural diagram, proposed by the United States Department of Agriculture (USDA). Based on the physical composition, the textural classes of sediments noticed along the habitats of *R. mucronata* were Sand, Sandy Clay Loam and Sandy Clay (Fig. 2).

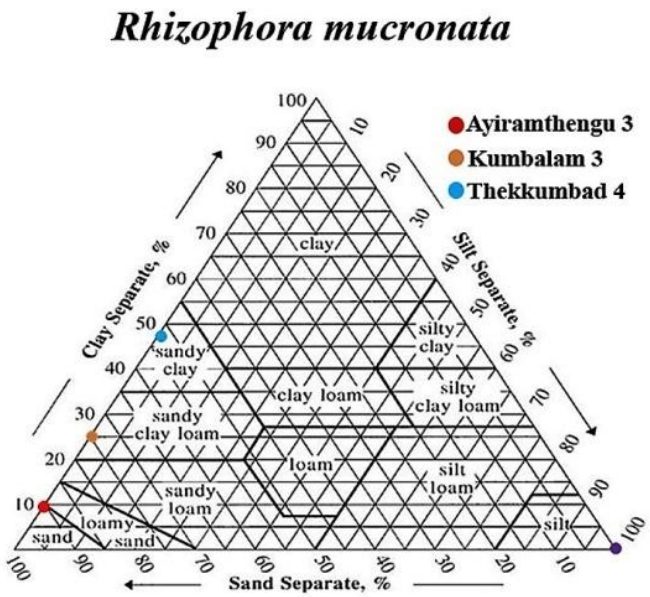

Fig. 2. Sediment class preference of the mangrove species R. mucronata

Data pertaining to climatological attributes like atmospheric maximum – minimum temperature (^{o}C), Total Rainfall (MMS) and Relative Humidity (%) with respect to all the locations under study has been collected and reported.

Upon compiling all the results, it can be stated that, even though the mangroves are growing in a wider range of environmental conditions, each species has its own range of tolerance to different hydrogeochemical, sedimentological and climatological attributes along their natural habitats. In the present investigation, the range of environmental attributes influencing the growth of selected mangrove species has been categorized into tolerance range and augmented range. Tolerance range is the ideal range, at which a particular species can flourish well along their natural environmental settings and the augmented range is the range that is acquired by adapting to an uncertain environmental condition. The ranges of various environmental attributes influencing the growth of *R. mucronata* are depicted in Table 2.

Table 2. Range of environmental attributes influencing the growth of R. mucronata.

Sl. No.	Parameters	Tolerance range	Augmented range
Hydrological attributes			
1.	**pH**	**6.98–7.38**	3.9-7.93
2.	**Turbidity (NTU)**	**7.41–21.336**	0.6-60.3
3.	**TS (mg/l)**	**12050–27,109.09**	400-56,000
4.	**TDS (ppt)**	**11.36–25.546**	0.2-45.8
5.	**TSS (mg/l)**	**683.33–1,563.64**	0-10,200
6.	**Acidity (mg/l)**	**23.46–34.833**	8.8-61.6
7.	**Alkalinity (mg/l)**	**112.08–171.67**	40-280
8.	**Hardness (mg/l)**	**1,852.5–3,660.18**	34-7,660
9.	**Calcium (mg/l)**	**144.12–280.782**	7.21-504.63
10.	**Magnesium (mg/l)**	**363.41–720.47**	1.95-1582.5
11.	**Chloride (mg/l)**	**7931.72–15,323.09**	411.8-25,205
12.	**Sulphate (mg/l)**	**40.29–51.208**	2-129
13.	**Sodium (ppt)**	**7.71–15.33**	0.015-27.4
14.	**Nitrogen (mg/l)**	**56.41–75.273**	19-220
15.	**Phosphorous (mg/l)**	**34–38.7**	0.7-117.5
16.	**Potassium (mg/l)**	**317.08–376.25**	0-1800
17.	**Salinity (ppt)**	**9.82–21.344**	0.247-35.62
18.	**Resistivity (Ω)**	**75.04–499.886**	18.83-1977
19.	**Conductivity**	**15.57–31.826**	0.495-51.76
Sedimentological attributes			
20	**pH**	**6.43–7.51**	5.05-8.08
21	**Moisture %**	**7.58–13.646**	1.06-23.61
22	**Organic carbon (g/kg)**	**17.3–23.03**	0.5-67
23	**Total nitrogen (mg/kg)**	**788.067–1692.89**	630.45-3362.4
24	**Total phosphorous (mg/kg)**	**21.3–57.5**	11.5-76.2
25	**Potassium (mg/kg)**	**47.467–258.92**	8.9-1,400
26	**Sodium (ppt)**	**0.28–0.55**	0.0255-0.947
27	**Sand %**	**52.2–74.72**	25.6-96.8
28	**Silt %**	**0.233–0.433**	0.1-2.2
29	**Clay %**	**9.292–47.367**	2.9-73.8
Climatological attributes			
30.	**Atm.Max.Temp (^oC)**	**32.33–32.95**	28-36.6
31.	**Atm.Min.Temp (^oC)**	**22.13–24.258**	20.4-26.9
32.	**Total rainfall (MMS)**	**223.29–249.533**	0-1131.6
33.	**R.H % at 0830 hrs**	**80.75–86.083**	65-97
34.	**R.H % at 1730 hrs**	**71.833–74.833**	53-94

Physico chemical attributes of both water and sediment along selected habitats were further analyzed statistically to find out the discrepancy among different sites and seasons. Seasonal and site specific mean values of each parameters were subjected to two way ANOVA and found out the variations among the locations as well as the seasons. Such variations in each parameter with respect to sites and seasons were considered towards elucidating each of their influence on the growth of mangrove species. Accordingly, the most vital physico chemical attributes of water and sediment that are likely to influence the growth of each mangrove species can be enumerated. Since a uniform pattern of climatological conditions has been experienced along all the locations under study, statistical analysis for elucidating each of their influence on mangrove growth was not attempted.

The study as a whole revealed that, the heterogeneous habitats of the mangrove species *R. mucronata* showed stability in their water quality attributes such as pH, TSS, resistivity, alkalinity and potassium and also in sedimentological characteristics such as silt %, organic carbon, nitrogen, potassium and sodium without any significant variation (Fig.3).

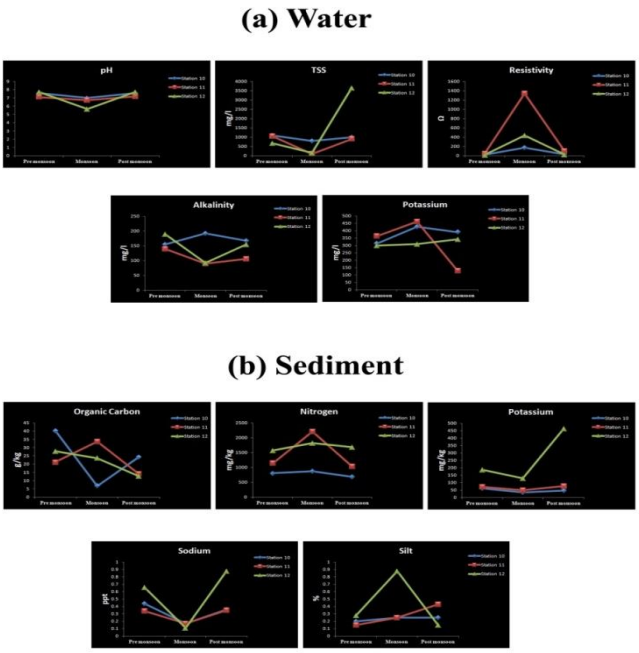

Fig. 3. Physico chemical attributes influencing the growth of *R. mucronata*

The physico-chemical attributes of both water and sediment that showed no significant variations between sites and seasons can be confirmed as the growth promoting factors for the mangrove species under study. Thus, the study as a whole reports the capability of the mangrove species to cope up with different hydrogeochemical and sedimentological conditions in terms of tolerance range or augmented range.

4. Discussion

The present study evaluated the hydrogeochemical, sedimentological and climatological conditions ideal for the growth and establishment of the mangrove species *R. mucronata* in pursuit of their utilization for species specific afforestation practices. The most vital physico chemical attributes of water and sediment that are likely to influence the growth of the mangrove species can be enumerated using variation analysis. Comparison of the results with earlier reports was carried out to derive strategic conclusions.

The present study reported the tolerance and augmented range of pH of water as 6.981 to 7.383 and 3.9 to7.93 respectively. Paramasivam and Kannan, 2005, in their studies on the Muthupettai mangrove ecosystem, showed the range of hydrological pH in mangrove area as 7.1-8.7 and in 2012, Manju et al., studied the entire mangrove ecosystems of Kerala and reported the pH of water as 7.1 – 8.05. The range of tolerance towards TSS and alkalinity are 683.33 to 1563.64 mg/l and 112.083 to 171.667 mg/l respectively. In 2016, Shilna et al., reported the annual range of acidity and alkalinity of the mangrove area with all the selected mangrove species as 8.24 mg/l and 100.79 mg/l respectively. *R. mucronata* have range of tolerance towards K is 317.083 to 376.25 mg/l. Potassium is a major nutrient in the mangrove sediments studied and reported from various natural mangrove habitats of Kerala and the annual average values reported were 105.38 mg/l (Manju et al., 2012).

With respect to sediments, the study reported a range of tolerance and augmented values towards organic carbon is 1.733 to 2.303 g/kg respectively. Saravanakumar et al. (2008) reported the range of organic carbon from the mangrove ecosystem of Kachchh - Gujarat as 2.9 to 25.6 g/kg. The distribution of total organic carbon closely followed the distribution of sediment type i.e., as sediment is low in clay content, the total organic carbon content is also low and as the clay content increased, the total organic carbon content also increased (Reddy and Hariharan, 1986).

As far as the present study concerned, the tolerance and augmented range of the species to sediment N and K are 788.067 to 1692. 89 and 47.467 to 258.917 mg/kg respectively. A recent study carried out in the mangrove ecosystem of Ayiramthengu, Kerala possessing these mangrove species reported a range of P and K as 29.5 to 57.9 Kg/ha and 231 to 440 Kg/ha respectively. The tolerance range of the species towards sodium is 0.287 to 0.552 ppt and that of silt percentage is 0.233 to 0.433 % respectively. More or less similar results have been reported by Saravanakumar et al. (2008). The study reported ranges of sediment textures in terms of % of sand, clay and silt as 0.26-19.2, 7.6-47 and 47-87.4 % respectively. Studies using textural triangles revealed that the nature of soil / sediment in all the locations studied were Sand, Sandy Clay Loam and Sandy Clay.

In general, mangroves are inimitable intertidal ecosystems with unique features, having own adaptations to cope up with extreme environmental conditions. A prior assessment of the area with respect to the tolerance / augmented range of various growth sustaining conditions of the mangrove species (*R. mucronata*) will help in the futuristic assessment of the feasibility of the area with regard to the introduction of *R. mucronata.*

5. Conclusion

Restoration/ afforestation of mangroves seem to be a promising solution for the restoration of lost coastal ecosystems. Successful restoration/afforestation practices of mangroves require reliable information on their growth sustaining conditions. The present study has been carried out to evaluate the environmental factors (water, soil / sediment and climate) determining the growth of the mangrove species *R. mucronata* along heterogeneous habitats of Kerala.

The results as a whole revealed that between different sites and seasons, no significant variations have been noticed in water quality attributes like water pH, TSS, resistivity, alkalinity and potassium and also in sedimentological characteristics such as silt %, organic carbon, nitrogen, potassium and sodium content of sites having *R. mucronata*.

From the above results, it can be concluded that each mangrove species have their own growth sustaining conditions along different habitats. The physico-chemical attributes of both water and sediments that showed no significant variations between sites and seasons can be confirmed as the growth promoting factors for that species. The study as a whole reports the capability of the mangrove species *R. mucronata* to cope up with different hydrological and sedimentological conditions in terms their **tolerance range** or **augmented range**. Results of the textural characterization of sediments revealed Sand, Sandy Loam and Loamy Sand as ideal environments for the growth of *R. mucronata.*

Thus the study proposed that the ‘tolerance range’ of a species with respect to the site is a mandatory requirement towards including them in afforestation purposes, whereas ‘augmented range’ is not a natural one as it is acquired by the species after acclimatization in the new area. In conclusion, the study emphasized that all the afforestation/ restoration practices of mangroves must be either species or site specific.

References

1. APHA (2005):, STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER. 21ST EDITION, AMERICAN PUBLIC HEALTH ASSOCIATION/AMERICAN WATER WORKS ASSOCIATION/WATER ENVIRONMENT FEDERATION, WASHINGTON DC.
2. Clough, B. F. (1984): 'Growth and salt balance of the mangroves Avicennia marina (Forsk.) Vierh. and Rhizophora stylosa Griff. in relation to salinity.' *Functional Plant Biology,* 11, 419-430.
3. Duke, N., Ball, M., Ellison, J. (1998): 'Factors influencing biodiversity and distributional gradients in mangroves.' *Global Ecology & Biogeography Letters*, 7, 27-47.
4. JACKSON, M.L. (1973): SOIL CHEMICAL ANALYSIS. PRENTICE HALL OF INDIA PVT. LTD., NEW DELHI, 498.
5. Kjerfve, B., Lacerda, L.D., Rezende, C.E., Ovalle, A.R.C. (1999): Hydrological and hydrogeochemical variations in mangrove ecosystems. In : Mangrove ecosystems in tropical America: structure, function and management. Yanez-Arancibia, A. and Lara-Dominquez, A.L. (eds.) Mexico), pp. 71-81.
6. Manju, M.N., Resmi, P., Girish Kumar, T.T., Raathesh Kumar, C.S., Rahul, R., Joseph, M.M., Chandramohankumar, N. (2012): 'Assessment of water quality parameters in mangrove ecosystems along Kerala coast: a statistical approach'. *Int. J. Environ. Res*., 6, 893–902.
7. *Paramasivam, S., Kannan, L. (2005): 'Physico-chemical characteristics of Muthupettai mangrove environment, Southeast coast of India'. International Journal of Ecology and Environmental Sciences, 31, 273-278.*
8. REDDY, VENKATASWAMY, H.R., HARIHARAN V (1986): 'DISTRIBUTION OF NUTRIENTS IN THE SEDIMENTS OF THE NETRAVATHI-GURUPUR ESTUARY, MANGALORE'. *IND. J. FISH*., 33, 123-126.
9. Saravanakumar, A., Rajkumar, M., Serebiah, J. S., Thivakaran, G. A (2008): 'Seasonal variations in physico-chemical characteristics of water, sediment and soil texture in arid zone mangroves of Kachchh-Gujarat'. *Journal of environmental Biology*: 29, 725-732.
10. SHILNA E.P., SAJITH U., HARILAL C.C. (2016): **'**SURVEILLANCE ON WATER QUALITY IN PURSUIT OF MANGROVE AFFORESTATION ALONG THE COASTAL AND INLAND AQUATIC ENVIRONMENTS OF MALAPPURAM DISTRICT, KERALA, INDIA'. *INTERNATIONAL RESEARCH JOURNAL OF ENVIRONMENTAL SCIENCES*, 5: 41-50.
11. SUBRAMANYAM N.S., SAMBAMUTHY A.V.S.S. (2002): ECOLOGY, NAROSA PUBLISHING HOUSE, DELHI. 616.
12. Thom, B. G. (1967): 'Mangrove ecology and deltaic geomorphology: Tabasco, Mexico.' *The Journal of Ecology*, 55: 301-343.
13. Tomlinson, P.B. (1986): The Botany of Mangroves, Cambridge University Press, ISBN 0-521- 25567-8, New York, USA.
14. TRIVEDI, R.K., GOEL, P.K., TRISAL, C.L. (1987): PRACTICAL METHODS IN ECOLOGY AND ENVIRONMENTAL SCIENCES. ENVIRON. PUBLIC. KARAD, (INDIA).
15. USDA SOIL SURVEY DIVISION STAFF. (1993): "SOIL SURVEY MANUAL." SOIL CONSERVATION SERVICE. U.S. DEPARTMENT OF AGRICULTURE HANDBOOK 18.
16. Vilarrúbia, T. V. (2000): Zonation pattern of an isolated mangrove community at Playa Medina, Venezuela. Wetlands Ecology and Management, 8: 9-17.
17. Yang, J., Gao, J., Cheung, A., Liu, B., Schwendenmann, L., Costello, M. J. (2013): Vegetation and sediment characteristics in an expanding mangrove forest in New Zealand. Estuarine, Coastal and Shelf Science: 134, 11-18.

