

Demarcation of sites ideal for mangrove afforestation in the Northern part of Kerala

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Abstract

Mangrove afforestation is yet to make a successful leap in the state of Kerala. The present investigation has been carried out to delineate the sites for species specific mangrove afforestation along the northern part of Kerala, include Kozhikode, Kannur and Kasaragod districts based on hydrogeochemical and sedimentological characteristics. The tolerance range of selected mangrove species towards different physico-chemical parameters and textural characterization have been taken in to account for demarcating the most ideal sites for species specific mangrove afforestation. Thus it can be concluded that out of 54 sites studied, 8 sites each for *Avicennia officinalis* and *Sonneratia alba*; 9 sites each for *Bruguiera cylindrica* and *Excoecaria agallocha*; 12 sites for *Rhizophora mucronata* can be treated as the most ideal sites for the afforestation of such species along 3 districts of Kerala.

Key words

Mangrove, Afforestation, Kozhikode, Kannur, Kasaragod, Sediment quality, Water quality.

1. Introduction

Re-establishment of mangroves is often recommended when the ecosystem has been modified to such an extent that it cannot regenerate naturally. Although restoration frequently emphasizes planting as the primary method, mangroves can regenerate naturally if the normal tidal hydrology is restored and the supply of seeds or propagules of mangroves from

adjacent stands reinstated. As physico-chemical attributes of both water and sediment are a major entity towards the growth and proliferation of mangroves, their comprehension with respect to the targeted afforestation area is very much important. Assessment of the feasibility of the area prior to planting practices will reduce the risk of adaptability of species to such habitats and thereby cut short financial mobilizations to a greater extent. In this background, the present study has been undertaken for the demarcation of ideal sites for afforestation of selected mangrove species along the inland shoreline environments of northern part of Kerala.

2. Materials and Methods

The present investigation was an attempt to delineate sites ideal for species specific mangrove afforestation along the heterogeneous coastal environments of Northern Kerala. The afforestation possibilities of the mangrove species *Avicennia officinalis*, *Bruguiera cylindrica*, *Excoecaria agallocha*, *Rhizophora mucronata* and *Sonneratia alba* were assessed based on their range of tolerance to various hydrogeochemical and sedimentological characteristics (Neethu and Harilal, 2018, 2018a, b, c) and the textural characterization (USDA). Similarly, for assessing the supportive nature of habitats, the physico-chemical characteristics of both water and sediments associated with such habitats were assessed using and compared with those of the tolerance range of selected mangrove species. Altogether 18 habitats each in Kozhikode, Kannur and Kasaragod districts of Kerala (Figure 1 to 3) were worked out. Details of districts, together with the specification of sites selected are given below:

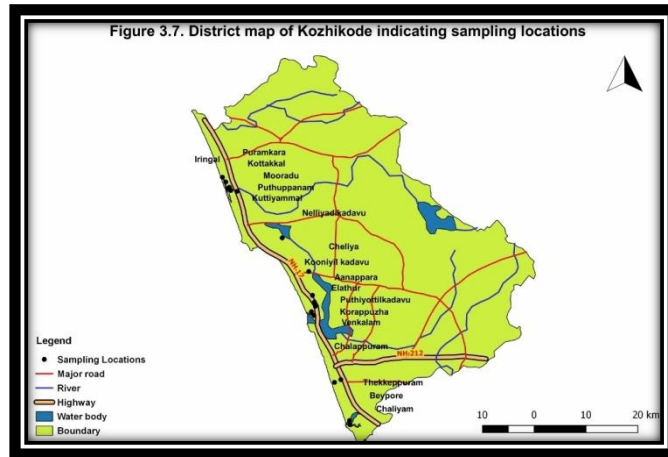


Fig.1. District map of Kozhikode indicating sampling locations

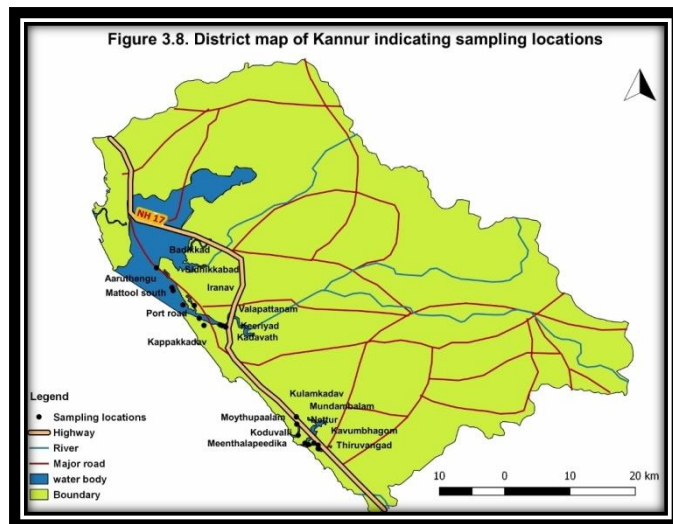


Fig.2. District map of Kannur indicating sampling locations

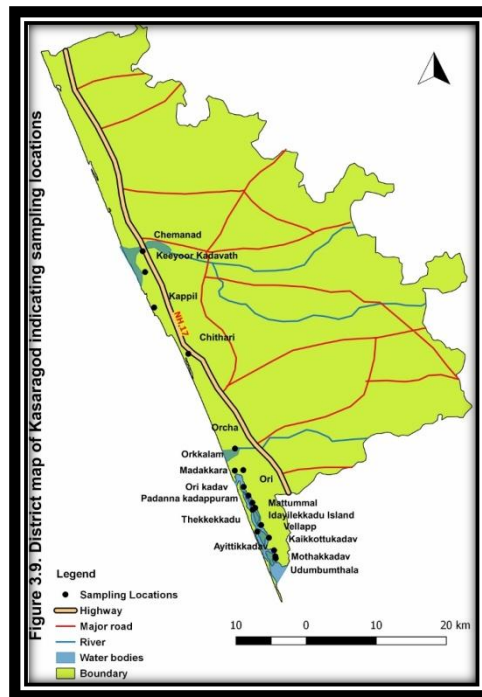


Fig.3. District map of Kasaragod indicating sampling locations

Collection of both water and sediment samples were carried out from all the 54 locations falling in 3 districts. Entire collection was carried out during post monsoon season, which is characteristic in having higher concentration of all elements under target. Also this season is reported to be ideal for the introduction of most of the mangrove species. All the collected samples were subjected to physico-chemical analysis either on spot or in the laboratory, following standard methods (APHA, 2005 and Trivedy et al., 1987). The physico-chemical parameters analyzed for water samples include pH, turbidity, total solids, total dissolved solids, total suspended solids, salinity, resistivity, conductivity, acidity, alkalinity, total hardness, magnesium, calcium, chloride, sulphate, sodium,

total nitrogen, phosphorous and potassium. Similarly, sediment samples were subjected to the analysis of pH, moisture percentage, textural percentage of sand, silt and clay, organic carbon, total nitrogen, phosphorous, potassium and sodium following standard methods (Subramanyam and Sambamurthy, 2002; Trivedy et al., 1987 and Jackson, 1973).

The tolerance range of mangrove species towards different physico-chemical parameters have been taken into account for assessing the most significant growth determinants of each mangrove species. The numbers of sites possessing all these attributes or a share were treated as ideal sites for afforestation of respective mangrove species.

3.Results and Discussion

For assessing the possibilities of mangrove afforestation, physico-chemical analysis of water and sediment samples from 18 sites in Kozhikode district (KKD 1 to KKD 18) has been carried out. The results are depicted in Tables 1 & 2.

Table 1. Results on the physico-chemical characterization of water samples along different locations in Kozhikode district

Sl No :	Parameters	KKD 1	KKD 2	KKD 3	KKD 4	KKD 5	KKD 6	KKD 7	KKD 8	KKD 9	KKD 10	KKD 11	KKD 12	KKD 13	KKD 14	KKD 15	KKD 16	KKD 17	KKD 18
1	pH	7.91	7.98	7.95	7.86	7.71	8	8.03	7.95	7.9	7.97	7.83	7.24	7.98	7.3	7.97	7.83	8.03	7.8
2	Turbidity (NTU)	1.6	0.9	4	2.1	2.1	2.1	2.0	5.6	6	4.8	3.4	1.2	2.8	8.9	6	2.4	4	1.8
3	T.S (mg/l)	42800	41800	36600	41800	41400	41000	41600	42800	41800	44000	33400	20600	34800	38400	38400	28600	35400	34600
4	T.D.S (ppt)	26.59	26.41	23.51	26.22	26.2	26.56	26.2	26.11	25.55	25.77	21.24	15.41	22.51	25.26	25.11	19.11	23.57	21.9
5	T.S.S (mg/l)	16210	15390	13090	15580	15200	14440	15400	16690	16250	18230	12160	5190	12290	13140	13290	9490	11830	12700
6	Salinity (ppt)	35.45	35.22	30.84	35.09	35.2	35.75	34.79	35.05	34.2	34.36	27.69	19.31	29.5	33.2	33.27	24.5	31.22	28.44
7	Conductivity (mS)	52.13	51.63	45.98	51.34	51.22	51.84	51.21	51.05	50.07	50.38	41.54	30.12	44.01	49.18	49.17	37.36	46	42.8
8	Resistivity (Ω)	18.8	18.94	21.27	19.02	19.0	18.83	19.09	19.14	19.53	19.39	23.53	32.43	22.21	19.86	19.92	26.2	21.19	22.87
9	Acidity (mg/l)	17.6	26.4	26.4	26.4	30.8	17.6	17.6	35.2	22	13.2	22	17.6	22	30.8	30.8	22	17.6	17.6
10	Alkalinity (mg/l)	160	150	250	160	160	170	150	170	150	160	150	90	140	190	200	200	160	120
11	Hardness (mg/l)	570	626	462	600	618	460	526	540	494	564	450	274	480	474	560	588	458	384
12	Calcium (mg/l)	42.453	33.642	32.04	38.448	36.846	28.035	36.045	35.244	25.632	29.637	20.826	16.821	25.632	38.448	34.443	24.03	27.234	26.43
13	Magnesium (mg/l)	112.968	131.958	93.04	122.706	128.063	94.951	106.151	110.046	104.69	119.298	96.9	56.484	101.282	92.03	115.402	128.55	94.951	77.42
14	Chloride (mg/l)	22365	22010	18460	22720	21797	21300	21143.8	22720	21087	21300	17210.4	11473.6	19468.2	20149.8	20206.6	15449.6	19198.4	18048.2
15	Sulphate (mg/l)	170	164	161	161	156	159	170	163	161	163	159	152	156	156	159	156	156	156
16	Sodium (ppt)	21.24	21.34	18.54	20.44	11.72	21.34	21.34	21.24	17.44	17.04	15.48	13.24	17.54	23.14	20.04	15.84	15.24	17.54
17	Potassium (mg/l)	163.985	126.019	103.998	126.019	279.96	133.996	133.996	133.996	879.99	153.999	209.7	819.93	859.97	1519.82	1179.99	660.01	620.01	879.99
18	Total Phosphorus (mg/l)	30.0	10.5	17.5	4.5	8.0	16.0	3.5	35.0	2.5	3.5	0.03	0.04	3.5	120.0	15.5	2.5	1.0	1.0
19	Total Nitrogen (mg/l)	35	35	42	28	28	21	35	42	28	21	28	28	35	42	35	28	28	28

Table 2. Results on the physico-chemical characterization of sediment samples along different locations in Kozhikode district

Sl No :	Parameters	KKD 1	KKD 2	KKD 3	KKD 4	KKD 5	KKD 6	KKD 7	KKD 8	KKD 9	KKD 10	KKD 11	KKD 12	KKD 13	KKD 14	KKD 15	KKD 16	KKD 17	KKD 18
1	pH	7.33	8.15	6.6	6.94	7.55	7.64	7.93	7.4	7.31	7.11	7.21	6.7	7.19	7.65	6.66	7.26	7.89	7.64
2	Moisture %	6.3	5.4	21.36	15.8	6.8	5.4	8.9	7.5	2.5	25.8	6.8	5.7	3.9	11.5	27.3	8.9	5.6	9.5
3	Sand %	93.2	85.9	66.7	80.6	75.4	79.3	67.7	32.4	81.7	62.2	76.0	79.3	76.5	73.1	58.0	50.9	54.8	53.3
4	Silt %	0.2	0.4	0.2	0.2	0.4	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.3	0.1	0.1
5	Clay %	6.6	13.7	33.1	19.2	24.2	20.6	32.2	67.5	18.2	37.7	23.8	20.6	23.4	26.8	41.8	48.8	45.1	46.6
6	Organic carbon (gm/kg)	1.97	3.29	91.58	12.77	22.74	5.31	35.73	48.2	8.68	98.26	26.76	4.41	0.98	12.62	22.36	155.46	111.26	125.96
7	Nitrogen (mg/kg)	560	840	2240	840	840	420	700	2940	840	1401	1470	770	630	910	1820	1540	1401	1680
8	Total Phosphorus (mg/kg)	32.5	42.0	63.5	39.5	60.5	28.0	38.5	70	55.5	69.5	54.5	32.5	35.0	14.5	68.2	74.5	89.5	130.5
9	Potassium (mg/kg)	17.52	24.99	39.99	10.01	22.48	2.50	12.51	149.99	34.99	60.02	60.02	0	2.50	25.02	67.49	52.51	69.99	74.99
10	Sodium (ppt)	0.7125	0.1075	0.4325	0.1425	0.1775	0.025	0.145	1.2325	0.235	0.5725	0.1675	0.1725	0.0625	0.215	0.5375	0.4325	0.6625	0.5225

Elathur (KKD 5) and Cheliya (KKD 11) of Kozhikode district were noted to be ideal for the afforestation of *Bruguiera cylindrica*. Also, these two sites were moderately ideal for all the other 4 species. Kooniyil kadavu (KKD 9) and Nellyadikadavu (KKD 12) were moderately ideal for *Avicennia officinalis*. The other moderately ideal sites were Beypore (KKD 2) for all the 5 species under study; Thekkeppuram (KKD 4) and Aanappara (KKD 10) for *A. officinalis*, *B. cylindrica*, *S. alba*, *E. agallocha* and *R. mucronata*; Chaliyam for *Avicennia officinalis* and

B. cylindrica; Venkalam (KKD 8) for *B. cylindrica* and *E. agallocha*; Kuttiyammal (KKD 14) for *A. officinalis* and *E. agallocha*; Puramkara (KKD 15) for *A. officinalis*, *B. cylindrica* and *R. mucronata*; Mooradu (KKD 16) for *B. cylindrica*, *E. agallocha* and *R. mucronata*; Kottakkal (KKD 17) for *B. cylindrica* and *R. mucronata*; Puthiyottilkadavu (KKD 7) for *E. agallocha* and Iringal (KKD 18) for *R. mucronata*.

The results on the physico-chemical characteristics of water / sediment samples from 18 locations of Kannur district are depicted in Tables 3-4.

Table 3. Results on the physico-chemical characterization of water samples along different locations in Kannur district

S l o :	Parameters	KN R 1	KN R 2	KN R 3	KNR 4	KN R 5	KN R 6	KN R 7	KN R 8	KN R 9	KN R 10	KN R 11	KN R 12	KN R 13	KN R 14	KN R 15	KNR 16	KNR 17	KNR 18
1	pH	7.27	7.14	7.41	7.75	7.94	7.69	7.39	7.15	7.08	7.1	7.54	7.5	7.62	7.88	8.04	7.78	7.19	7.54
2	Turbidity(NTU)	0.1	1.2	0.1	0.3	0.3	0.1	1	1.2	0.6	0.5	0.1	1.2	0.1	0	0.2	0.1	0.7	0.2
3	T.S (mg/l)	21000	24600	26600	28400	35800	45600	25400	17400	17400	16600	21200	25400	23000	33400	34400	27600	25800	20200
4	T.D.S (ppt)	14.58	17.19	18.14	18.91	23.66	17.09	15.89	12.34	12.4	11.76	13.78	17.1	15.73	19.55	22.13	17.81	17.59	13.45
5	T.S.S (mg/l)	6420	7410	8460	9490	12140	28510	9510	5060	5000	4840	7420	8300	7270	13850	12270	9790	8210	6750
6	Salinity(ppt)	18.29	21.8	23.28	24.23	31.18	21.76	20.15	15.21	15.29	14.4	17.19	21.82	19.85	25.2	28.88	22.76	22.42	16.68
7	Conductivity (mS)	28.5	33.53	35.43	36.96	46.25	33.42	31.07	24.1	24.25	22.98	26.94	33.43	30.76	38.22	43.27	34.82	34.38	26.3
8	Resistivity (Ω)	34.32	29.14	27.53	26.45	21.14	29.2	31.42	40.58	40.31	42.53	36.29	29.24	31.78	25.57	22.63	28.09	28.45	37.16
9	Acidity (mg/l)	19.8	26.4	17.6	13.2	17.6	17.6	22	13.2	110	13.2	13.2	8.8	13.2	17.6	13.2	13.2	22	17.6
10	Alkalinity (mg/l)	120	130	130	130	170	140	140	110	400	140	130	160	130	120	130	160	160	140
11	Hardness (mg/l)	332	390	427	440	370	388	350	280	272	270	296	386	346	446	526	416	420	307
12	Calcium (mg/l)	22.48	25.632	29.637	34.443	38.448	27.234	24.03	20.826	18.423	18.423	22.428	26.433	24.03	30.438	34.443	28.035	27.234	21.627
13	Magnesium (mg/l)	67.196	79.37	85.943	86.187	66.71	77.91	70.605	55.51	55.023	54.536	58.432	77.91	69.631	90.082	107.125	84.239	85.7	61.6
14	Chloride (mg/l)	11289	12993	13774	14910	18886	14058	12638	9088	9301	8946	10863	13064	13135	15691	18602	20235	13632	10579
15	Sulphate (mg/l)	156	159	157	157	159	155	155	151	145	148	153	156	155	158	160	156	158	153
16	Sodium (ppt)	14.85	16.9	22.3	4	10.92	29.65	12.85	11.17	8.17	10.12	10.07	10.7	13.55	2.1	22.3	15.05	8.07	11.77
17	Potassium (mg/l)	580.987	331.00	333.49	323.50	601.06	336.00	587.986	601.006	603.000	606.011	603.000	328.497	582.981	326.002	316.49	578.0	615.9	596.001
18	Total Phosphorus (mg/l)	7.5	7.5	0.6	3.0	4.5	4.0	11.0	7.0	29.5	5.5	3.5	18.0	4.5	2.5	0.1	5.5	21.0	0.02
19	Total Nitrogen (mg/l)	28	28	28	28	21	21	28	21	42	28	21	28	35	28	28	21	21	21

Table 4. Results on the physico-chemical characterization of sediment samples along different locations in Kannur district

Sl No :	Parameters	KNR 1	KNR 2	KNR 3	KNR 4	KNR 5	KNR 6	KNR 7	KNR 8	KNR 9	KNR 10	KNR 11	KNR 12	KNR 13	KNR 14	KNR 15	KNR 16	KNR 17	KNR 18
1	pH	8.56	5.31	7.53	7.76	8.76	8.53	8.1	7	7.36	7.28	4.99	8.5	8.65	8.51	8.6	7.55	6.83	7.7
2	Moisture %	5.5	16.9	8.6	12.9	8.5	5.7	15.5	19.2	9.56	8.54	5.6	7.9	8.2	18.5	6.35	15.8	21.3	5.25
3	Sand %	82.7	59.7	62.3	47.9	87.0	53.4	61.3	71.3	77.8	94.9	83.4	89.1	91.0	85.6	91.6	83.4	66.6	89.9
4	Silt %	0.3	0.3	0.1	0.2	0.1	0.7	0.2	0.3	0.4	0.1	0.2	0.1	6.8	0.5	0.5	0.6	1.7	0.1
5	Clay %	17.0	40.0	37.6	51.9	12.9	45.9	38.5	28.4	21.8	5.0	16.4	10.8	2.2	13.9	7.9	16.0	31.7	10.0
6	Organic carbon (g/kg)	1.5	299.3	62.3	94.1	55.1	8.14	91.7	151.8	102.8	8.02	9.8	12.2	6.7	31	6.22	51.6	175.7	30.7
7	Nitrogen (mg/kg)	1401	3990	1330	1750	770	560	2310	1750	1960	840	560	630	560	490	700	1680	2450	700
8	Total Phosphorous (mg/kg)	71.5	44.5	46.2	80.0	109.5	51.0	85.5	53.5	72.0	63.0	51.0	41.0	85.0	41.0	38.0	61.0	78.0	41.0
9	Potassium (mg/kg)	32.49	55.01	39.99	20.02	0	5.01	34.99	47.51	7.51	2.50	15.01	15.01	5.01	5.01	10.01	5.01	47.51	5.01
10	Sodium (ppt)	0.2425	0.3	0.16	0.21	0.035	0.06	0.41	0.2225	0.015	0.015	0.2375	0.2175	0.0575	0.06	0.0475	0.375	0.475	0.065

The results revealed that, Thiruvangad (KNR 2) was the ideal site for afforestation of for *Excoecaria agallocha* and *Rhizophora mucronata*. Aaruthengu (KNR16) and Valapattanam (KNR 9) were noticed to be ideal for *Bruguiera cylindrica* and *Avicennia officinalis* respectively. Kavumbhagom (KNR 1) and Sidhikkabad (KNR 17) were moderately ideal for all the species except *Sonneratia alba*. Mundambalam (KNR 7), Keeriyad (KNR 10) and Aaruthengu were moderately ideal for *A. officinalis*, *E. agallocha* and *R. mucronata*. The other moderately ideal sites were Thiruvangad and Kadavath (KNR 11) for *A. officinalis* and *B. cylindrica*; Nettur (KNR 3) for *B.*

cylindrica, *E. agallocha* and *R. mucronata*; Koduvalli (KNR 4) for *A. officinalis* and *R. mucronata*; Meenthalapeedika (KNR 5) for *B. cylindrica* and *E. agallocha*; Kulamkadav (KNR 8) for *A. officinalis*, *B. cylindrica* and *R. mucronata*; Iranav (KNR 14) for *B. cylindrica*, *E. agallocha* and *Sonneratia alba*; Valapattanam for *B. cylindrica* and *Sonneratia alba*; Port road (KNR 12) for *B. cylindrica* and *E. agallocha* and Badikkad (KNR 18) for *A. officinalis*.

The physico-chemical characteristics of water and sediment samples worked out from Kasaragod district are depicted in Tables 5 – 6.

Table 5. Results on the physico-chemical characterization of water samples along different locations in Kasaragod district

Sl No :	Parameters	KS D 1	KS D 2	KS D 3	KSD 4	KS D 5	KSD 6	KS D 7	KS D 8	KS D 9	KS D 10	KSD 11	KSD 12	KS D 13	KS D 14	KS D 15	KSD 16	KS D 17	KSD 18
1	pH	7.64	7.67	7.36	7.8	7.82	8.1	7.6	7.85	7.68	7.87	8	7.7	7.54	6.96	7.18	6.66	7.37	6.63
2	Turbidity (NTU)	0.1	0.1	0	0	0	0.4	0.1	0.1	0	0.1	0.5	0.1	0.1	0	0	0.1	0.6	0
3	T.S (mg/l)	2400	2420	2420	2620	2660	2840	2840	3400	2880	3260	3580	20200	27600	500	940	200	12600	2600
4	T.D.S (ppt)	17.05	17	16.67	17.89	19.04	19.35	19.62	23.31	20.02	22.11	23.72	14.44	19	3.824	7.201	0.1108	9.326	2.259
5	T.S.S (mg/l)	6950	7200	7530	8310	7560	9050	8780	10690	8780	10490	12080	5760	8600	1176	2199	89.2	3274	341
6	Salinity (ppt)	21.76	21.64	21.24	22.89	24.64	25.04	25.42	30.81	25.99	29.05	31.5	18.15	24.59	4.276	8.471	0.1103	11.1	2.443
7	Conductivity (mS)	33.33	33.24	32.64	34.98	37.19	37.83	38.35	45.6	39.14	43.27	46.38	28.23	37.22	7.475	14.08	0.2158	18.23	4.416
8	Resistivity(Ω)	29.33	29.42	29.97	27.95	26.26	25.87	25.48	21.45	24.98	22.61	21.05	34.64	26.28	130.9	69.48	4689	53.75	221.5

9	Acidity (mg/l)	17.6	22	17.6	15.4	19.8	17.6	26.4	22	35.2	22	17.6	11	22	8.8	13.2	17.6	13.2	17.6
10	Alkalinity (mg/l)	140	130	130	130	150	150	170	140	170	150	210	100	140	50	70	50	100	60
11	Hardness (mg/l)	200	392	336	418	445	260	273	368	480	528	372	324	452	87	166	8	216	54
12	Calcium (mg/l)	36.846	32.04	31.239	29.637	32.841	35.244	32.841	42.453	34.443	38.448	37.647	24.03	32.841	8.01	13.617	0.801	16.02	8.01
13	Magnesium (mg/l)	26.294	75.961	62.814	83.752	88.378	41.876	46.502	63.788	95.925	105.177	67.683	64.275	90.082	16.312	32.137	1.461	42.85	8.278
14	Chloride (mg/l)	13135	13774	12567	13490	14129	15194	15123	17963	14981	19525	17750	11573	14910	3337	6248	994	7810	2769
15	Sulphate (mg/l)	166	160	158	152	152	154	140	155	151	155	155	149	151	114	136	12.5	144	92
16	Sodium (ppt)	14.25	12.57	15.35	5.85	15.55	3.6	11.72	1.4	10.92	12.57	17.3	11.42	0.94	3.46	14.85	9.12	6.08	5.68
17	Potassium (mg/l)	578.015	696.997	575.982	328.49	568.002	323.50	592.991	646.999	601.06	696.97	815.86	592.91	646.988	662.002	575.982	681.982	625.991	672.012
18	Total Phosphorous (mg/l)	1.0	0.02	0.03	2.5	2.5	0.35	5.0	11.0	8.0	5.0	6.5	1.5	3.0	0.05	0.8	0.03	20.0	0.05
19	Total Nitrogen (mg/l)	28	35	21	42	21	28	28	21	28	21	35	21	21	28	28	28	35	28

Table 6. Results on the physico-chemical characterization of sediment samples along different locations in Kasaragod district

Sl No:	Parameters	KSD 1	KS D 2	KS D 3	KSD 4	KSD 5	KS D 6	KS D 7	KS D 8	KSD 9	KSD 10	KS D 11	KSD 12	KS D 13	KS D 14	KS D 15	KS D 16	KS D 17	KSD 18
1	pH	5.1	4.47	6.32	5.52	8.35	7.58	2.84	8.34	8.08	8.83	8.48	8.66	7.5	3.87	6.73	5.82	7.78	6.93
2	Moisture %	7.75	5.25	8.35	4.8	9.6	24.8	6.8	9.25	6.39	25.8	12.6	18.2	12.5	8.9	6.4	7.5	8.45	6.5
3	Sand %	92.6	93.6	90.8	85.4	86.0	80.9	89.5	95.0	83.1	9.4	93.4	79.0	37.7	73.9	47.5	83.2	79.3	84.2
4	Silt %	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.6	0.1	0.3	0.1	0.2	0.1
5	Clay %	7.2	6.3	9.1	14.5	13.9	18.9	10.4	4.9	16.8	8.5	6.5	20.9	61.7	2.0	52.2	16.7	20.5	15.7
6	Organic carbon (g/kg)	13.3	5.3	8.1	9.0	11.0	4.3	26.44	12.66	13.88	5.3	11.79	6.23	41.61	11.33	31.72	25.22	9.0	19.2
7	Nitrogen (mg/kg)	630	560	700	560	700	420	770	1540	1120	420	560	560	1540	700	1470	910	700	1401
8	Total Phosphorous (mg/kg)	15.5	12.8	12.5	8.5	18.0	13.0	28.0	64.0	42.0	14.5	23.5	36.5	105.5	32.0	48.0	41.0	37.8	37.5
9	Potassium (mg/kg)	12.51	7.51	10.01	15.01	2.50	12.51	22.48	7.51	20.02	2.50	5.01	2.50	64.98	2.50	22.48	0	5.01	15.01
10	Sodium (ppt)	0.2975	0.19	0.22	0.3175	0.1325	0.27	0.225	0.08	0.1275	0.0275	0.045	0.0425	0.45	0.235	0.47	0.235	0.29	0.3925

The results revealed that sites Chithari (KSD 15) and Keeyoor Kadavath (KSD 17) were ideal for *Excoecaria agallocha* and *Avicennia officinalis* respectively whereas, Chemanad (KSD 18) was ideal for *Bruguiera cylindrica* and *Excoecaria agallocha*. Udumbumthala (KSD 1) and Keeyoor Kadavath were moderately ideal for *Rhizophora mucronata*. The other moderately ideal sites noticed were Kaikkottukadav (KSD 3) for *E. agallocha*; Idayilekkadu Island (KSD 5), Thekkekkadu (KSD 7) and Mattummal (KSD 9) for *Avicennia officinalis*, *B. cylindrica* and *E. agallocha*; Madakkara (KSD 13) for *R.*

mucronata; Vellapp (KSD 4) for *B. cylindrica*, *E. agallocha*, *R. mucronata* and *S. alba*; Ayittikkadav (KSD 6) for *A. officinalis*, *B. cylindrica*, *R. mucronata* and *S. alba*; Orcha (KSD 14) for *A. officinalis*, *E. agallocha* and *R. mucronata*; Chithari for *A. officinalis* and *R. mucronata*; Kappil (KSD 16) for *B. cylindrica* and *E. agallocha* and Chemanad for *A. officinalis*, *R. mucronata* and *S. alba*.

From all the results, it can be concluded that, one site each in Kannur and Kasaragod districts were ideal for the afforestation of *Avicennia officinalis*.

Bruguiera cylindrica was noticed to be ideal for afforestation in two sites of Kozhikode and one site each in Kannur and Kasaragod districts. The species *Excoecaria agallocha* was found to be ideal for afforestation in two sites of Kasaragod and one site in Kannur district. With respect to *Rhizophora*

mucronata, one site in Kannur district was found ideal for afforestation.

Upon comparing the present result with standard textural class preferred by each mangrove species, the sites ideal for their afforestation have been demarcated (Table 7).

Table 7. Ideal Sites for species specific mangrove afforestation from the district of Kozhikode, Kannur and Kasaragod.

Sl. No:	Ideal Places for Afforestation	District	Mangrove Species
1.	Thekkeppuram	Kozhikode	<i>Avicennia officinalis</i> and <i>Sonneratia alba</i>
2.	Kavumbhagom	Kannur	
3.	Kadavath,		
4.	Aaruthengu		
5.	Ayittikkadav	Kasaragod	
6.	Mattummal		
7.	Kappil		
8.	Chemanad		
9.	Beypore	Kozhikode	<i>Bruguiera cylindrica</i> and <i>Excoecaria agallocha</i>
10.	Meenthalapeedikka,	Kannur	
11.	Port road		
12.	Iranav		
13.	Badikkad		
14.	Vellapp	Kasaragod	
15.	Idayilekkadu Island		
16.	Thekkekkadu		
17.	Orcha		
18.	Chalappuram	Kozhikode	<i>Rhizophora mucronata</i>
19.	Elathur		
20.	Korappuzha		
21.	Cheliya		
22.	Nellyadikadavu		
23.	Puthuppanam		
24.	Kuttiyammal		
25.	Kulamkadav	Kannur	
26.	Valapattanam		
27.	Sidhikkabad		
28.	Orkkalam	Kasaragod	
29.	Keeyoor Kadavath		

The results were comparable with that elucidated on the basis of hydrological and sedimentological aspects. All these sites possessed significant share of growth determining attributes of different mangrove species.

Thus it can be concluded that out of 54 sites studied, 1 site for *Avicennia officinalis* and *Sonneratia alba*; 1 site each for *Bruguiera cylindrica* and *Excoecaria agallocha*; 7 sites for *Rhizophora mucronata* can be treated as the most ideal sites for the afforestation of such species

4. Conclusion

Assessment of the feasibility of an area prior to planting practices will reduce the risk of

along Kozhikode district of Kerala. 3 site for *Avicennia officinalis* and *Sonneratia alba*; 4 sites each for *Bruguiera cylindrica* and *Excoecaria agallocha*; 3 sites for *Rhizophora mucronata* can be treated as the most ideal sites for the afforestation of such species along Kannur district of Kerala. In Kasaragod district, 4 site for *Avicennia officinalis* and *Sonneratia alba*; 4 sites each for *Bruguiera cylindrica* and *Excoecaria agallocha*; 2 sites for *Rhizophora mucronata* can be treated as the most ideal sites for the afforestation of such species.

adaptability of species to such habitats and thereby cut short financial mobilizations to a greater extent. In this background, the present study has been undertaken for the demarcation of ideal sites for

afforestation of selected mangrove species along the inland shoreline environments of Kerala.

The afforestation possibilities of mangrove species were assessed based on their range of tolerance to various hydrogeochemical and sedimentological characteristics. Collection of both water and sediment samples were carried out from 55 locations falling in 3 districts of Kerala such as Kozhikode, Kannur and Kasaragod. Entire collection was carried out during post monsoon season, which is characteristic in having higher concentration of all elements under target.

The tolerance range of mangrove species towards different physico-chemical parameters have been taken into account for assessing the most significant growth determinants of each mangrove species. Based on the textural classes of soil/sediment preferred by various mangrove species, attempt has also been carried out to demarcate ideal sites for mangrove afforestation. The results were comparable with that elucidated on the basis of hydrogeochemical and sedimentological aspects.

Thus it can be concluded that out of 54 sites studied, 8 sites each for *Avicennia officinalis* and *Sonneratia alba*; 9 sites each for *Bruguiera cylindrica* and *Excoecaria agallocha*; 12 sites for *Rhizophora mucronata* can be treated as the most ideal sites for the afforestation of such species along 3 districts of Kerala.

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