Distribution of Halophyte Plants in Relation to Properties of Salt-Affected Soils of District Thatta

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Abstract: The main objective of this study was to survey and collect some halophyte species capable of growing in highly salt affected soils and their distribution in relation to some soil properties of district Thatta. *Sueda fruticosa, Tamarix aphylla, Ceriops candoleana, Cynodon dactylon,* and *Chenopodum album* species were collected form Thatta. Soil samples were collected from the vicinity of each halophyte and were analyzed for pH, organic matter (OM), electrical conductivity (EC), soluble Na^+, Ca^{2+}, Mg^{2+}, HCO_3^-, Cl^-, sodium absorption ratio (SAR), and exchangeable sodium percentage (ESP). Halophytes species collected were analyzed for ion (Na^+, K^+, Ca^{2+}, Mg^{2+} and Cl^-) contents. Data regarding plant ionic composition showed that contents of Na^+ ranged between 3.7-6.9 %, K^+ 0.7-1.9 ,Ca^{+2} 0.4--1.2 %, Mg^{2+} 0.6-2.2 and Cl^- contents between 0.1-0.8 in species collected from Thatta, respectively. Data further revealed that maximum Na^+ (6.9 and %) was recorded in *Sueda fruticosa* and *Salsola indica,* highest K^+ (1.9 %) was noted in *Chenopodium album* species, greatest Ca^{+2} (1.2 %) was documented in *Sueda fruticosa* species, highest Mg^{2+} (2.2 %) was observed in *Sueda fruticosa* whereas, maximum Cl^- (0.8 %) was noted in *Sueda fruticosa* collected from district Thatta, respectively. Data pertaining to soil properties indicated that EC of studied soils ranged between 7.0-18.4dS m^{-1}, pH 7.5-8.0. O.M 0.82-0.94 % , soluble Ca^{2+} 17.3-33.3 meq L^{-1}, Mg^{2+} 15.5-24.6 meq L^{-1}, Na^+ 43.6-83.4 meq L^{-1} , Ka^+ 3.20-4.50 meq L^{-1}, HCO_3^- 2.4-5.3 meq L^{-1}, Cl^- 55.6-145.4 meq L^{-1}, SAR 10.2-17.1 whereas, ESP ranged between 12.2-19.6 % in soil samples collected from Thatta, respectively. It was concluded that halophyte species *Sueda fruticosa, Tamarix aphylla, gallica, Salsola indica, Cyperus irria* accumulate significant amounts of salt (Na^+ and Cl^-)from salt-affected soil and, therefore, may remediate land to the point where native plants could invade and become established, or the site could be returned to agricultural productivity. These halophytes species have an excellent potential for rehabilitation of degraded salt affected soils.

Keywords: Halophytes, Salinity, EC, PH, SAR Organic Matter.

INTRODUCTION

The whole region of unconditioned soils in the world is about 831 m/he which consist of 434 and 397 m/he of sodic and saline soils, respectively [1]. The agricultural field is being reduce continuously because increasing population, green house effects and harsh environmental condition which are being increased day by day and causing global climate change [2, 3]. Soils of high salinity possess two main problems to plants (i) the accumulation of sodium ions can lead to the poisoning of the plant, (ii) high levels of NaCl cause the water potential of the soil to become very negative [4]. Increased salinity level may cause –ve effects on plant growth, rate of germination and production, [5].

According to [6] halophytes plants are defined as those plants which can germinate and reproduce in such an environments where the accumulation of salt enhanced from 200 mM of sodium chloride (~20 dSm^{-1}). Halophytes plants are about 1% of the world's flora. These plants are able to complete its life cycle under highly saline (sodium chloride) conditions [7]. One of the basic differences between halophyte and glycophytes is that halophytes have the ability to survive under a salt shock as for example due to tidal or rainfall events this capacity allows the halophytes to develop a metabolic steady state for growth in a saline environment as compare to glycophytes [8] Halophytes respond to salt stress at three levels i.e. cellular, tissue and whole plant level. A number of halophyte plants have been tested for their possible use as an alternative source of alternative energy. The distribution of halophytic vegetation is related to inter-specific and intra-specific competition, grazing and managemen, [9] Land and water management is critical in order to reclaim saline-sodic soils [10]. Therefore, it is necessary to investigate the plant-soil relationship using the cultivation of halophytic crops. Considerable research has been done on soil-vegetation relationship in saline soils of different parts of the world [11]. A common method for the studying the distribution patterns of halophytes is to select transect of land that passes through the growth zones of several plant types. Sites are chosen along transect and the desired experimental is gathered. When the

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soil salinity at is tested at successive sites, a salinity gradient is often encountered which usually correlates with the growth zones. For example, transect of land is selected for investigation of carbon isotope discrimination among C4 halophytes. Although not the primary focus of the research, a salinity gradient is found to exist along the transect that corresponded with a change of dominant plant types [12, 13] reported that 410 halophytic species are distributed in Pakistan.

MATERIALS AND METHODS

The present study was conducted to study the halophyte distribution in relation to properties of salt-affected soils of district Thatta. For this purpose, a total of five species of halophyte plants were collected from Thatta district. The collected species were chemically analyzed for Na^+, K^+, Ca^{+2}, Mg^{+2} and Cl^- at Laboratory of Soil Sciences, Faculty of Crop Production, Sindh Agriculture University Tandojam.

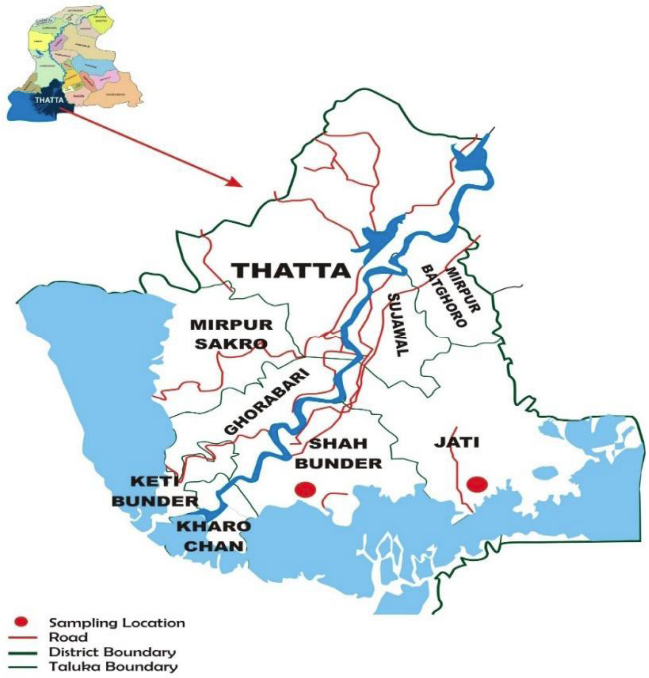

Figure 1: Map of district Thatta, Sindh showing sampling locations.

Soil Analysis

The sample from the salt - affected soil were collected from district Thatta. The soil was analyzed for some basic properties (Texture, EC_e, pH, Organic matter (OM %), Ca, Mg, Na^+, HCO_3, SAR and ESP Of soil were determined.

RESULTS

Halophytes *Sueda fruticosa, Tamarix aphylla, Ceriops candoleana, Cynodon dactylon, Chenopodum album,* growing in salt affected area of Thatta were collected and identified for their species. Plant samples were analyzed for sodium, calcium, magnesium, potassium and chlorine.

Plant Analysis

Classification of plants collected from different locations of Thatta are presented in Table **1**. Halophytes *Sueda fruticosa* (SF), *Tamarix aphylla* (TA), *Ceriops candoleana* (CCT), *Cynodon dactylon* (CD *Chenopodum album* (CA) species were collected form Thatta district.

Sodium (%)

The data regarding sodium (Na^+) concentration in various halophyte plants from district Thatta is present in Table **2**. Sodium concentration ranged between 3.7-6.9% with an average value of 5.6% Na in halophytes collected from Thatta. The results showed that maximum Na^+ concentration of 6.9% was noted in *Sueda fruticosa* species found in Thatta followed by the species *Tamarix aphylla/gallica* (6.3% Na). Whereas, minimum Na^+ concentration (3.7%) was noted in *Chenopodium album* species.

Potassium (%)

The results regarding potassium (K^+) concentration in various halophyte plants collected from district Thatta (Table **3**) showed that it ranged between 0.7-

Table 1: Classification of Plants Collected from Different Locations of Thatta

Local Name	English Name	Technical Name	Family	Season	Class
Larnoo	Shrubby goose foot	*Sueda fruticosa*	*Chenopodiaceae*	Spring/Autumn	Dicot
Lay	Tamarix	*Tamarix aphylla/gallica*	*Coniferae*	Spring	Conifer
Timir	Mangrove tree	*Ceriops candoleana*	*Rhizophoraceae*	Spring/Autumn	Dicot
Chabbar	Bermuda grass	*Cynodon dactylon*	*Gramineae*	Kharif	Monocot
Jhal	Meal weed	*Chenopodium album*	*Chenopodiaceae*	Rabi	Dicot

1.9% being 1.26% K^+ as average in halophytes collected from Thatta and. The results further revealed that maximum K^+ concentration of 1.9% was noted in *Chenopodium album* species found in Thatta followed by the species *Cynodon dactylon* (1.7% K^+). Minimum K^+ concentration (0.7%) was noted in *Sueda fruticosa* species.

Table 2: Sodium Contents (%) of Halophytes Collected from Salt-Affected Areas of District Thatta

Halophytes	Na^+ (%)
Sueda fruticosa	6.9
Tamarix aphylla/gallica	6.3
Ceriops candoleana	5.5
Cynodon dactylon	5.6
Chenopodium album	3.7
Average	*5.6*
Maximum	*6.9*
Minimum	*3.7*

Table 3: Potassium Contents (%) of Halophytes Collected from Salt-Affected Areas of District Thatta

Halophytes	K^+ (%)
Sueda fruticosa	0.7
Tamarix aphylla/gallica	0.9
Ceriops candoleana	1.1
Cynodon dactylon	1.7
Chenopodium album	1.9
Average	1.26
Maximum	1.9
Minimum	0.7

Calcium (%)

The data regarding calcium (Ca^{+2}) concentration in various halophyte plants collected from District Thatta is shown in Table **2**. Calcium concentration ranged between 0.4-1.2% with an average value of 0.74% Ca^{+2} in halophytes collected from Thatta. The results showed that maximum Ca^{+2} concentration of 1.2% was noted in *Sueda fruticosa* species found in Thatta followed by the species *Tamarix aphylla/gallica* (0.9% Ca^{+2}). Minimum Ca^{+2} concentration of 0.4% was noted in *Chenopodium album* species.

Magnesium (%)

The data regarding Magnesium (Mg^{+2}) concentration in various halophyte plants from district Thatta is present in Table **2**. Magnesium concentration ranged between 0.6-2.2% with an average of 1.34% Mg^{+2} in halophytes collected from Thatta The results showed that maximum Magnesium concentration of 2.2% was noted in *Sueda fruticosa* species found in Thatta followed by the species *Tamarix aphylla/gallica* (1.9% Mg). Minimum Magnesium concentration of 0.6% was noted in *Chenopodium album* species.

Table 4: Calcium Contents (%) of Halophytes Collected from Salt-Affected Areas of District Thatta

Halophytes	Ca^{+2} (%)
Sueda fruticosa	1.2
Tamarix aphylla/gallica	0.9
Ceriops candoleana	0.7
Cynodon dactylon	0.5
Chenopodium album	0.4
Average	0.74
Maximum	1.2
Minimum	0.4

Table 5: Magnesium Contents (%) of Halophytes Collected from Salt-Affected Areas of District Thatta

Halophytes	Mg^{+2} (%)
Sueda fruticosa	2.2
Tamarix aphylla/gallica	1.9
Ceriops candoleana	1.1
Cynodon dactylon	0.9
Chenopodium album	0.6
Average	1.34
Maximum	2.2
Minimum	0.6

Chloride (%)

Chloride (Cl^-) concentration ranged between 0.1-0.8% in all halophyte species collected from Thatta with an average of 0.42% Cl^- .The results showed that maximum Cl^- concentration of 0.8% was noted in *Sueda fruticosa* species found in Thatta followed by the species *Tamarix aphylla/gallica* (0.7% Cl). Minimum Cl^-

concentration of 0.1% was noted in *Chenopodium album* species.

Table 6: Chloride Contents (%) of Halophytes Collected from Salt-Affected Areas of District Thatta

Halophytes	Cl^- (%)
Sueda fruticosa	0.8
Tamarix aphylla/gallica	0.7
Ceriops candoleana	0.2
Cynodon dactylon	0.3
Chenopodium album	0.1
Average	0.42
Maximum	0.8
Minimum	0.1

Soil Properties of Salt-Affected Areas of District Thatta

Soil samples were collected from the same area of each halophyte plants grown in both district of Thatta. Soil samples were analyzed for pH, Organic matter, electrical conductivity (EC), Na^+, Ca^{2+}, Mg^{2+}, K^+, HCO_3^-, sodium absorption ratio (SAR) and exchangeable sodium percentage (ESP). Results are given below:

Electrical Conductivity (dS m^{-1})

The data regarding electrical conductivity (EC) of soil in relation to plant species from district Thatta is present in Table **2**. Electrical conductivity of soil ranged between 7.0-18.4dS m^{-1} with an average value of 12.90 dS m^{-1} in soil samples collected from Thatta. The analytical results further revealed that maximum EC (18.4dS m^{-1}) was noted in soil where *Sueda fruticosa* species was collected in Thatta followed by the soils (17.7 dS m^{-1}) where species *Tamarix aphylla/gallica* was collected. However, minimum EC (7.0 dS m^{-1}) was observed in soils where *Cyndon dactylon* species was collected.

pH

The data regarding pH of soil in relation to plant species from district Thatta is present in Table **2**. Soil pH ranged between 7.5-8.0 with an average of 7.7 pH in soil samples collected from Thatta. The results further revealed that highest pH (8.0) was noted in soils from where *Ceriops candoleana* and *Sueda fruticosa* species found in Thatta. Whereas, minimum pH (7.7) was recorded from soils where *Tamarix aphylla/gallica* and *Chenopodium album* species where grown.

Organic Matter (%)

The analytical results for soil organic matter content showed that in Thatta it ranged between 0.82-0.94% with an average value of 0.88 % in soil samples. According to results maximum organic matter (0.94%) was noted in soils from where *Sueda fruticosa* species found in Thatta. Minimum organic matter (0.82%) was observed in soils of *Ceriops candoleana* species in thatta.

Table 7: EC (dS m^{-1}), pH and Organic Matter (%) of Salt-Affected Areas of District Thatta

Halophytes	EC (dS m^{-1})	pH	OM (%)
Sueda fruticosa	14.0	7.9	0.94
Tamarix aphylla/gallica	16.3	7.7	0.92
Ceriops candoleana	9.8	8.0	0.82
Cynodon dactylon	12.4	7.5	0.89
Chenopodium album	9.0	7.7	0.85
Average	12.3	7.7	0.80
Maximum	16.3	8.0	0.90
Minimum	9.0	7.5	0.80

Soluble Calcium (meq L^{-1})

The data regarding soluble calcium (Ca^{2+}) of soil in relation to plant species found from district Thatta is present in Table **2**. Soluble Ca^{2+} ranged between 17.3-33.3 meq L^{-1} with an average value of 26.4 meq L^{-1} in soil samples collected from Thatta. The results showed that maximum soluble Ca^{2+} (33.3meq L^{-1}) contents were noted in soils where species *Tamarix aphylla/gallica* found in Thatta. However, minimum soluble Ca^{2+} (17.3 meq L^{-1}) was noted in soils where *Chenopodium album* halophyte species was collected.

Soluble Magneium (meq L^{-1})

In Table **2** data showed that soluble magnesium (Mg^{2+}) ranged between 15.5-24.6meq L^{-1} with an average value of 19.6 meq L^{-1} in soil samples collected from salt affected soils of Thatta. The results showed that maximum soluble Mg^{2+} (24.6meq L^{-1}) were noted in soils from where *Tamarix aphylla/gallica* species found in Thatta. Minimum soluble Mg^{2+} (15.5 meq L^{-1}) was noted in soils of *Chenopodium album* species.

Soluble Sodium (meq L^{-1})

The data regarding soluble sodium (Na^+) concentration in relation to plant species found from district Thatta is present in Table **2**. Soluble Na^+ ranged

between 43.6-83.4meq L^{-1} with an average value of 61.2 meq L^{-1} in soil samples collected from Thatta. The results showed that maximum soluble Na^+ (83.4 meq L^{-1}) was noted in soils of *Sueda fruticosa* species found in Thatta followed by the species *Tamarix aphylla/ gallica* (80.4 meq L^{-1}). Minimum soluble Na^+ (43.6 meq L^{-1}) was noted in soils where *Chenopodium album* species collected.

Soluble Potassium (meq L^{-1})

The data for soluble potassium (K^+) concentration in relation to plant species found from district Thatta is presented in Table **2**. In Thatta soluble K^+ ranged between 3.20-4.50meq L^{-1} with an average of 3.89 meq L^{-1} .L^{-1}. The results revealed that maximum soluble K^+ (4.5 meq L^{-1}) was noted in soils where *Cynodon dactylon and Chenopodium album* species found in Thatta. However, minimum soluble K^+ (3.2 meq L^{-1}) concentration was noted in soils where *Sueda fruticosa* species collected.

Table 8: Cationic (Ca^{2+}, Mg^{2+}, Na^+, K^+) Concentration of Salt-Affected Soils of District Thatta

Halophytes	Ca^{2+}	Mg^{2+}	Na^+	K^+
	Meq L^{-1}			
Sueda fruticosa	28.5	19.4	98.6	3.2
Tamarix aphylla/gallica	33.3	24.6	94.6	2.8
Ceriops candoleana	25.5	18.3	60.4	1.3
Cynodon dactylon	27.7	20.5	67.5	1.5
Chenopodium album	17.3	15.5	55.5	0.9
Average	26.4	19.6	75.32	1.9
Maximum	33.3	24.6	98.6	3.2
Minimum	17.3	15.5	55.5	0.9

HCO_3^- (meq L^{-1})

The data regarding bicarbonates (HCO_3^-) contents of soil in relation to plant species from district Thatta (Table 2) indicates that it ranged between 2.4-5.3 meq L^{-1} with an average value of 3.7 meq L^{-1} in soil samples collected from Thatta. The results showed that maximum HCO_3^- (5.3meq L^{-1}) was noted in soils where *Sueda fruticosa* species found in Thatta followed by the species *Tamarix aphylla/gallica* (5.0 meq L^{-1}). However, minimum HCO_3^- (2.4 meq L^{-1}) was noted in soils of *Chenopodium album* species.

Chloride (meq L^{-1})

The data regarding Chloride of soil in relation to plant species from district Badin and Thatta is present in Table **2**. Chloride of soil ranged between 55.6-145.4meq L^{-1} with an average value of 108.5 meq L^{-1} in soil samples collected from Thatta. The results showed that maximum Chloride of soil 145.4 meq L^{-1} was noted in *Sueda fruticosa* species found in Thatta followed by the species *Tamarix aphylla/gallica* 139.4 (meq L^{-1}). Minimum Chloride of soil 55.5 meq L^{-1} was noted in *Chenopodium album* species.

Table 9: Bicarbonates and Chloride Concentration of Salt-Affected Soils of District Thatta

Halophytes	HCO_3^-	Cl^-
	MeqL^{-1}	
Sueda fruticosa	5.3	109.5
Tamarix aphylla/gallica	5.0	99.5
Ceriops candoleana	3.2	61.3
Cynodon dactylon	2.7	65.6
Chenopodium album	2.4	51.2
Average	3.7	77.42
Maximum	5.3	109.5
Minimum	2.4	51.2

Sodium Adsorption Ratio (SAR)

Sodium Adsorption Ratio (SAR) is a widely accepted index for characterizing soil sodicity, which describes the proportion of sodium to calcium and magnesium in soil solution. The SAR ranged between 10.2-17.1 with an average value of 12.7 in soil samples collected from Thatta. The results showed that maximum SAR of 17.1 was noted in soils of *Sueda fruticosa* species found in Thatta followed by the species *Tamarix aphylla/gallica* (15.0). Minimum SAR (10.2) was noted in soils from where *Ceriops candoleana* species was collected.

Exchangeable Sodium Percentage (%)

Another index that characterizes soil sodicity. As noted above, excess sodium causes poor water movement and poor aeration. By definition, sodic soil has an ESP greater than 15 (US Salinity Lab Staff, 1954). ESP is the sodium adsorbed on soil particles as a percentage of the Cation Exchange Capacity. The data regarding ESP of soil in relation to plant species sampled from district Thatta (Table **2**) revealed that ESP of soil ranged between 12.2-19.6% with an average value of 14.9% in soil samples collected from Thatta. The results showed that maximum ESP (19.6%) was noted in soils where *Sueda fruticosa*

species found in Thatta followed by the species *Tamarix aphylla/gallica* (17.5%). Minimum ESP (12.2%) was noted in soils where *Ceriops candoleana* species found.

Table 10: Sodium Adsorption Ratio and ESP of Salt-Affected Soils of District Thatta

Halophytes	SAR	ESP
Sueda fruticosa	17.1	19.6
Tamarix aphylla/gallica	15.0	17.5
Ceriops candoleana	10.2	12.2
Cynodon dactylon	10.5	12.6
Chenopodium album	10.7	12.9
Average	12.7	14.9
Maximum	17.1	19.6
Minimum	10.2	12.2

CONCLUSION

Soil salinization is considered one of the most important factors in land degradation. The results of this study indicated that halophyte species accumulated significant amounts of salt (Na^+ and Cl^-) from salt-affected soil and therefore, may remediate land to the point where native plants could invade and become established, or the site could be returned to agricultural productivity. These halophytes species have an excellent potential for improvements of salt affected soils.

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