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Influence of Tannery Effluents on Some Morphological Characters of Suaeda Maritima (L.) Dumort. and Sesuvium Portulacastrum L.

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Abstract: Tannery industry is common in many parts of the world and it pollutes groundwater and ecosystems and produce major heavy metals and sodium chloride. Heavy metal pollution due to industrial effluents is gaining worldwide attention. Morphology adaptations to heavy metals in the halophyte population were very specific. The present study aimed at some morphological characters in phytoremediation of heavy metals and ions from tannery effluents by using Suaeda maritima (L.) Dumort. and Sesuvium portulacastrum L. morphological characters were analyzed at an intervals of 30, 60, 90, 120 days. The results indicated that all the morphological characters were increased with an increasing concentration of tannery effluents and no injury symptoms in growth condition. It may be concluded this two halophytic plant species has a potentially suitable for phytoremediation of heavy metal and ions from the tannery effluent contaminated soil.

Keywords: Tannery industry, Heavy metals, Halophytes, Morphology, NaCl.

1. Introduction

Due to industrialization, quantity of solid waste generated from the industrial operations is also increasing day by day, causing pollution of environment. The growth of the industry was spectacular. It was also aided by the fact that many of the developed countries did not wish to dirty their hands any more with the tanning process. The tightening of the environmental legislation in the West also made India a much more attractive production center than the developed countries. Leather tanning industries have cropped up in India over the past three decades. A total number of 2161 tanneries are located in India and spread across the states of Tamil Nadu, West Bengal, Maharashtra, Punjab, Karnataka, Andhra Pradesh, Bihar and Uttar Pradesh. At present more than 568 tanneries are well established in Dindigul, Erode and Vellore districts of Tamil Nadu [1]. The major metals at these sites are lead (Pb), zinc (Zn), copper (Cu) and cadmium (Cd) and chromium (Cr) [2]. In addition, salinity is also common in different parts of the world. Therefore, investigating the survival of salt- tolerant halophytes under heavy metal stress seems pertinent [3].

Generally, the majority of plants used for environmental restoration are typical glycophytes species. Nevertheless, metal-phytoremediation by halophytic plants receives only little attention. Recently, it has been reported that halophytes species would be better adapted to cope with environmental constraints, including heavy metals [4, 5]. A great deal of

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recent studies strongly indicates that halophytic plants could be more suitable for heavy metal extraction mainly from saline soil than glycophytes [6, 7]. Many halophytes often have high metal tolerance that is strongly linked to traits for salt tolerance [8]. The objective of the present study is to analyse the influence of different concentrations of tannery effluents on *Suaeda maritima* and *Sesuvium portulacastrum* to characterize the morphological parameters for phytoremediation of tannery effluent contaminated soil.

2. Materials and Methods

Experimental Plants: Two species of fast growing salt marsh halophytic herbs like *Suaeda maritima* (L.) Dumort. and *Sesuvium portulacastrum* L. were selected for the characterization and screening for phytoremediation of heavy metals and salts from tannery effluents with special reference for morphological studies . The experimental site was located at Panampattu Village, Villupuram District of Tamil Nadu, India.

Experimental Design: The experiment was conducted in an open-air area with natural light, temperature, and humidity. Red soil and sand (3:1 ratio) free from pebbles and stones were filled in polythene bags. The seedlings / cuttings from the selected species of similar size were transplanted from the nursery bed and planted at the polythene bags. The experiment comprised of the following three set of treatments with five replicates and average values are reported. Plants were watered for every 2-3 days, depending on the evaporative demand. Plant samples were harvested for experimental purpose at intervals of 30, 60, 90, 120 days.

S.No	Treatment	Method
1.	Control	Without any treatment (Plants are irrigated with tap water only)
2	Effluent treatment	30%, 60% and 90% of tannery effluents was treated 250 ml for 4 times with a gap of 7 days intervals.

During each and every sampling day, samples were randomly collected, washed thoroughly with tap water followed by distilled water. Shoot length, fresh weight, dry weight, total number of leaves (plant^{-1}) and total leaf area were calculated. Five plants were collected from each concentration and used for studying the morphological parameters.

Shoot Length and Root Length: Plant height was recorded by measuring the height of the plant from the surface of the soil to the tip of the top most leaf. Root length was record by measuring the height of surface soil to tip of the root. This was recorded on 30th, 6th, 90th and 120th days after treatment and expressed in cm plant^{-1}.

Fresh and Dry Weight: For the estimation of fresh weight, leaf, stem and root portions were separated and weighed. They were dried in a hot air oven at 80C for 24 hours. Then, the dry weight was taken by using an electronic balance.

Total Number of Leaves: The total number of leaves per plant-1 counting immediately after harvested the plant samples.

Total Leaf Area: The leaf area was calculated by measuring the length and breadth and multiplied by a correlation factor (0.69), derived from the method of Kalra and Dhiman [9].

Statistical Analysis: The experimental data were processed statistically by adapting the technique of analysis the variance of Standard Deviation [10].

3. Results and Discussion

In the present investigation, observations of morphological characters (Shoot length, root length, fresh weight, dry weight, total number of leaves and total leaf area) were observed after 30^{th}, 6^{th}, 90^{th} and 120^{th} days of *Suaeda maritima* and *Sesuvium portulacastrum* plants treated with tannery effluents. Table 1 and table 2 represented shoot length and root length of *Suaeda maritima* and *Sesuvium portulacastrum* plants treated with tannery effluents. When compared to control plants the highest shoot length and root length was observed in tannery effluent treated plants. The maxium shoot length and root length (59.6 cm/plant, 10.9 cm/plant) was observed in *Sesuvium portulacastrum* plant treated with tannery effluents after 120 days cultivation period followed by *Suaeda maritima* (40.4 cm/plant, 10.6 cm/plant). The lowest shoot and root length was recorded in *Suaeda maritima* (16.8 cm/plant, 4.1 cm/plant respectively) control plants in 30 days cultivation period.

Fresh weight and dry weight of *Suaeda maritima* and *Sesuvium portulacastrum* plants treated with tannery effluents are represented in the table 3 and table 4. Similar to shoot and root length, when compared to control plants the highest fresh weight and dry weight was observed in tannery effluent treated plants. The maxium fresh weight and dry weight (168.55 g/plant, 66.58 g/plant) was observed in *Sesuvium portulacastrum* plant treated with tannery effluents after 120 days cultivation period followed by *Suaeda maritima* (99.86 g/plant, 36.88 g/plant). The lowest fresh and dry weight was observed in *Suaeda maritima* (10.79 g/plant, 3.98 g/plant respectively) control plants in 30 days cultivation period. Table 5 and table 6 shows total number of leaves and total leaf area of *Suaeda maritima* and *Sesuvium portulacastrum* plants treated with tannery effluents. The maxium total number of leaves and total leaf area (688 number/plant in *Suaeda maritima* and 710.55 cm^2/plant respectively) was observed in plants treated with tannery effluents after 120 days cultivation. The minimum total number of leaves and total leaf area (25 number/plant in *Sesuvium portulacastrum* and 40.81cm^2/plant in *Suaeda maritima* respectively) in control plants after 30 days of cultivation.

In the present study, after 120 days of cultivation of halophytes treated with tannery effluent, showed the maximum growth. All the morphological parameters such as shoot length, root length, fresh weight and dry weight, total number of leaves and total leaf area of both the plants were increased with an increasing concentration of tannery effluents. The highest increase was rocorded in 90% of tannery effeluent treatment. The lowest values are observed in 30% of control plant in both the experimental plants.These results are in coinside with [4, 5] who suggested high potentials of *Sesuvium portulacastrum* to accumulate cadmium in shoots without growth retardation. The ability to tolerate both Cd2+ and Pb2+ accumulation in theshoots without deleterious effects on growth suggests an efficient protection of the cellular biochemical machinery against free metal ions (Cd2+ and Pb2+) and could be of crucial interest for phytomanagement of polluted areas which are frequently contaminated by several heavy metals. [11] tested the effect of artificial pollution with 25 mg kg-1 soil of multiple Zn, Cu and Ni on *Sporobolus virginicus* and *Spartina patens* grown for 8 weeks. They reported that no growth inhibition on shoot biomass was occurred.

Duarte [12] identified the most abundant salt marsh halophytic species *Halimione portulacoides*, considered as suitable for Cr(VI) phytoremediation processes by phytoextraction. [13] observed that, growth of *Spartina alterniflora*, a salt marsh halophyte was not inhibited under Cu stresses (50, 200, 800 mg kg-1) with no chlorotic and brown points on leaves and could be considered to be a promising candidate for phytoremediation of copper contaminated areas. In the present study, the plants cultivated in tannery effluent and salt treated soil stimulated the leaf production and increased the number of leaves throughout the study period when compared to control plants. Along with increase in the leaf number, there was increase in the leaf area. The increase in leaf area might be due to increase in the volume of mesophyll cells with the increase in the water content of the leaves and greater accumulation of heavy metals in the mesophyll tissue with the consequent increase in the leaf thickness.

Several studies also pointed out that the NaCl stimulated the fresh weight, dry weight and leaf area of *Suaeda altissima* [14], *Suaeda monoica* [15] and in *Mesembryanthemum crystallinum* [16]. The growth and survival of plants at high salinities depend on their ability to cope with low water potentials and high concentrations of chloride (or sulphate) and sodium ions and the halophytes showed a range of growth responses to salinity. It would appear that the growth response at moderate salinities might be largely the consequence of an increased uptake of solutes that are required to induce cell expansion, since this maintain the pressure potential in plant tissues [17]. In glycophytes, application of heavy metals generally decreases the overall growth parameters. However, results of [18] reported in *Catharanthus roseus* with 500 $\mu MCdCl_2$ produced stunted growth with reduced leaf area, biomass, chlorophyll total number of leaves and sterility. The reduction in control plants plant height might be mainly due to the reduced root growth and consequent lesser nutrients and water transport to the above parts of the plant. In addition to this, Cr transport to the aerial part of the plant can have a direct impact on cellular metabolism of shoots contributing to the reduction in plant height [19].

4. Conclusion

Finally it was concluded that, when compared *to Suaeda maritima*, *Sesuvium portulacastrum* plants showed a high morphological adaptations and biomass production. It plays a maximum role in phytoremediation of heavy metals and NaCl. So, repeated cultivation of these halophytes is required for high removal of heavy metals and ions from tannery effluent contaminated soil.

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S.NO	Plants	Concentrations (%)	30 DAS	60 DAS	90 DAS	120 DAS
1.	*Suaeda maritima*	Control	16.8 ± 0.841	19.4 ± 0.973	24.9 ± 1.249	27.0 ± 1.350
		30%	18.5 ± 0.927	25.9 ± 1.297	31.5 ± 1.579	36.3 ± 1.810
		60%	20.5 ± 1.027	27.9 ± 1.396	33.6 ± 1.682	38.1 ± 1.900
		90%	22.8 ± 1.142	29.5 ± 1.478	34.1 ± 1.709	40.4 ± 2.020
2.	*Sesuvium portulacastrum*	Control	18.5 ± 0.928	22.3 ± 1.116	27.9 ± 1.398	29.5 ± 1.470
		30%	23.8 ± 1.194	27.8 ± 1.393	36.4 ± 1.820	45.0 ± 2.250
		60%	26.0 ± 1.300	31.8 ± 1.593	40.1 ± 2.005	50.6 ± 2.530
		90%	27.1 ± 1.356	27.1 ± 1.986	49.6 ± 2.480	59.6 ± 2.980

Table 1: Effect of different concentrations of tannery effluents on shoot length (cm/plant) of Suaeda maritima and Sesuvium portulacastrum

S.NO	Plants	Concentrations (%)	30 DAS	60 DAS	90 DAS	120 DAS
1.	*Suaeda maritima*	Control	4.1 ± 0.205	4.8 ± 0.240	5.8 ± 0.290	6.4 ± 0.320
		30%	5.3 ± 0.265	5.6 ± 0.280	6.9 ± 0.345	7.2 ± 0.360
		60%	5.5 ± 0.275	5.9 ± 0.295	7.5 ± 0.375	8.5 ± 0.425
		90%	5.8 ± 0.290	6.4 ± 0.320	8.3 ± 0.415	10.6 ± 0.580
2.	*Sesuvium portulacastrum*	Control	5.3 ± 0.265	5.8 ± 0.290	6.9 ± 0.345	7.3 ± 0.365
		30%	5.8 ± 0.290	6.2 ± 0.310	7.8 ± 0.390	8.5 ± 0.425
		60%	6.5 ± 0.325	6.9 ± 0.345	8.8 ± 0.440	9.2 ± 0.460
		90%	7.1 ± 0.353	8.1 ± 0.405	9.4 ± 0.470	10.9 ± 0.345

Table 2: Effect of different concentrations of tannery effluents root length (cm/plant) of Suaeda maritima and Sesuvium portulacastrum

S.NO	Plants	Concentrations (%)	30 DAS	60 DAS	90 DAS	120 DAS
1.	*Suaeda maritima*	Control	10.79 ± 0.539	18.56 ± 0.928	25.73 ± 1.286	28.98 ± 1.449
		30%	16.99 ± 0.849	26.58 ± 1.329	39.76 ± 1.988	48.19 ± 2.409
		60%	20.58 ± 1.029	39.00 ± 1.950	50.58 ± 2.529	78.66 ± 3.933
		90%	28.59 ± 1.429	49.63 ± 2.481	76.88 ± 3.844	99.86 ± 4.993
2.	*Sesuvium portulacastrum*	Control	14.99 ± 0.749	28.56 ± 1.428	39.52 ± 1.976	48.58 ± 2.429
		30%	20.56 ± 1.028	40.58 ± 2.029	59.56 ± 2.978	70.88 ± 3.544
		60%	38.56 ± 1.928	68.99 ± 3.449	98.57 ± 4.928	120.88 ± 6.044
		90%	56.53 ± 2.826	106.88 ± 5.344	134.59 ± 6.729	168.55 ± 8.427

Table 3: Effect of different concentrations of tannery effluents fresh weight (g/plant) of Suaeda maritima and Sesuvium portulacastrum

S.NO	Plants	Concentrations (%)	30 DAS	60 DAS	90 DAS	120 DAS
1.	*Suaeda maritima*	Control	3.98 ± 0.199	6.78± 0.339	8.56 ± 0.428	10.56 ± 0.528
		30%	5.96 ± 0.298	9.57 ± 0.478	10.86 ± 0.543	18.44 ± 0.922
		60%	7.00 ± 0.350	13.85 ± 0.690	17.00 ± 0.850	25.88 ± 1.294
		90%	9.88 ± 0.494	16.88 ± 0.844	28.55 ± 1.427	36.88 ± 1.844
2.	*Sesuvium portulacastrum*	Control	5.86 ± 0.293	10.11 ± 0.505	15.88 ± 0.794	18.96 ± 0.944
		30%	7.00 ± 0.350	13.86 ± 0.693	18.88 ± 0.944	25.55 ± 1.277
		60%	12.88 ± 0.644	23.88 ± 1.194	31.65 ± 1.582	40.56 ± 2.028
		90%	16.85 ± 0.842	36.88 ± 1.844	50.55 ± 2.527	66.58 ± 3.329

Table 4: Effect of different concentrations of tannery effluents dry weight (g/plant) of Suaeda maritima and Sesuvium portulacastrum

S.NO	Plants	Concentrations (%)	30 DAS	60 DAS	90 DAS	120 DAS
1.	*Suaeda maritima*	Control	69 ± 3.45	89 ± 4.45	109 ± 5.45	148 ± 7.40
		30%	88 ± 4.40	115 ± 5.25	189 ± 9.45	294 ± 29.45
		60%	110 ± 5.50	189 ± 9.45	268 ± 1.340	468 ± 23.40
		90%	139 ± 6.95	225 ± 11.25	419 ± 20.956	688 ± 34.40
2.	*Sesuvium portulacastrum*	Control	25 ± 1.25	39 ± 1.95	58 ± 2.90	80 ± 4.00
		30%	32 ± 1.60	48 ± 2.40	80 ± 4.00	102 ± 5.10
		60%	42 ± 2.10	59 ± 2.95	112 ± 5.60	136 ± 6.80
		90%	56 ± 2.80	70 ± 3.50	139 ± 6.95	188 ± 9.40

Table 5: Effect of different concentrations of tannery effluents total numbers of leaves (number/plant) of Suaeda maritima and Sesuvium portulacastrum

S.NO	Plants	Conc. (%)	30 DAS	60 DAS	90 DAS	120 DAS
1.	*Suaeda maritima*	Control	40.81 ± 2.040	56.90 ± 2.845	80.80 ± 4.040	99.55 ± 4.977
		30%	43.52 ± 2.176	80.56 ± 4.028	115.99 ± 5.799	199.86 ± 9.993
		60%	55.22 ± 2.761	129.85 ± 6.475	260.56 ± 13.028	388.56 ± 19.428
		90%	88.55 ± 4.427	290.56 ± 14.528	419.88 ± 20.944	590.65 ± 29.532
2.	*Sesuvium portulacastrum*	Control	60.56 ± 3.028	90.88 ± 4.544	188.55 ± 9.427	290.52 ± 14.526
		30%	80.33 ± 4.016	188.56 ± 9.428	244.99 ± 12.249	388.55 ± 19.427
		60%	88.53 ± 4.426	212.56 ± 10.633	588.55 ± 19.425	499.55 ± 24.977
		90%	112.56 ± 5.628	288.55 ± 14.427	580.00 ± 29.00	710.55 ± 35.527

Table 6: Effect of different concentrations of tannery effluents total leaf area (cm^2/plant) of Suaeda maritima and Sesuvium portulacastrum