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Phytoremediation potential of winery effluent on morphological characters of *Suaeda maritime* (L.), *Sesuvium portulacastrum* (L.) and *Ipomoea pescaprae* (Sweet.)

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Abstract
The present study deals with the effect of phytoremediation potential of winery effluent on three halophytic species *Suaeda maritima* (L.), *Sesuvium portulacastrum* (L.) and *Ipomoea pescaprae* (Sweet.) were grown in pot experiment. The results indicated that all the morphological characters were increased with increasing concentrations of 25% of winery effluent and no injury symptoms in grown conditions. It may be concluded this three halophytic species has a potentially suitable for phytoremediation of metals and ions from the winery effluent contaminated soil. To analysis of phytochemical characterization of winery effluent.

Keywords: winery effluent, phytoremedaition, halophytes, heavy metals and salts

Introduction
In India, wine industries have been gradually rising over the last 10 years, because wine is step by becoming a part of urban Indian way of life and quickly increasing its wine economy both in production and consumption and has the potential to turn into an important player on the global wine scene. At present there are 93 wineries in India, which are involved in wine manufacturing (Vikas *et al.*, 2016; Myrto-Panagiota, 2017) [11, 7]. Wineries are major producers of low quality wastewater particularly during the vintage season (harvesting and crushing period) more volume of waste water is generated than the non-vintage season and it varies between wineries depending upon the period of production and methods of wine making (Agustina *et al.*, 2007) [1].
In spite of the fact that reports on the real volume of wastewater generated, the wastewater volume fluctuate extensively among wineries and might be between 1 to 5 mega liter per thousands tons of grapes crushed. It was assessed that medium to big wineries generate in excess of 15,000 m^3 of wastewater every year, though small wineries generate under 15000 m^3 every year. According to Welz (2016) [12] for every liter of wine production, winery generates wastewater up to 4 L and the greater part of the yearly wastewater flow and load is generated during vintage seasons.
There are two possible way to select halophytes for the purpose of phytoremediation. One way is that halophytes can be selected for phytostabilization. Some halophyte have extensive root system and accumulate heavy metals in their tissues. Research findings also suggest that halophytes are ideal for phytoextraction, phytostabilization (or) phytoexcretion of heavy metal polluted saline soil and non-saline soil, while recent findings encourage the use of salt-accumulating halophytes for soil desalinization in arid and semi arid region (Manousaki and Kalogerakis, 2011b) [5].

Materials and Methods
Three species of fast growing salt marsh halophyte herbs like *Suaeda maritima* (L.) Dumort. *Ipomoea percaprae* Sweet and *Sesuvium portulacastrum* L. were selected for the characteristics and screening for phytoremediation of heavy metals and salts from winery effluent with special reference for morphological stdies. The experimental site was located at Botanical Garden, Annamalai University, Cuddalore district, Tamil Nadu, India.

Experimental Design
The experiment was conducted in an open-air area with natural light, temperature and humidity. The 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 five set of treatment with five replicates and average value are reported in table. The plants were watered for every 2-3 days depending on the evaporative demand. The plants samples were harvested for the experimental purpose at bimonthly intervals of 60th and 120th day.
The control plants were maintained without effluent (only maintain tap water). The effluent treatments prepared various concentrations of Control, 10, 25, 50, 75 and 100% 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 with tap water followed by distilled water. The shoot and root length was calculated at bimonthly intervals using scale and expressed in cm plant^{-1}.
For the estimation of fresh weight of leaf stem and root were separated and weighted. They were dried in hot air oven at 80°C for 24 hours. Then the dry weight was taken by using electronic balance and expressed in g plant^{-1}.
The total number of leaves per plant^{-1} counting immediately after harvesting the plant sample. 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 Dhima (1977) [4]. The experimental data were processed statistically by adapting the technique

of analysis the variance of standard deviation (Suedector and Cochran, 1967) [10].

Winery effluent was collected from the Cumbum valley winery located at 9°46′26″N and 77°22′07″E of Uthamapalayam taluk in Theni district, Tamil Nadu, India. After proper collection the collected samples were brought back to laboratory, preserved as per the standard method of APHA (2012) [2] and stored in a refrigerator at 4 - 80°C. The sample were taken out from the refrigerator only at the time of analysis.

In recent years, researchers have undertaken numerous studies on phytoremediation of heavy metal contaminated saline soil using halophytes (Santos *et al.*, 2015b; Christofilopoulosq *et al.*, 2016) [8, 3]. The aim of this work to assess the growth parameters of halophytic species under winery effluent treatment and also analysis the physico-chemical properties of the winery effluent.

Results and Discussion

The physico-chemical characteristics of winery effluent wastewater are presented in Table 1. The pH of the winery waste water was 4.59. The electrical conductivity of the winery waste water was 6.24 dSm^{-1} indicating the presence of high concentration of ionic substance present in the winery wastewater. The total dissolved solids in the winery waste water was high 5028 mg L^{-1}. The contents of cations and anions in the winery waste water were higher making EC value higher. The BOD and COD of the winery wastewater was higher (632 and 1252 mg L^{-1}).

The growth parameters such as shoot and root length, fresh weight and dry weight, number of leaves and leaf area also increased upto extreme level of 25% winery effluent when compared to control plants and thereafter reduced the growth rate drastically on 60^{th} day after treatment of all the three halophytic species. Among these three species the more growth rate was found in *Sesuvium portulacastrum* than compared to other two species (Table 2).

Some halophytes such as *Atriplex nummularia*, *Sesuvium portulacastrum* and *Mesembryanthemum crystallinum* tolerate saline soils and accumulate large amounts of salts in the aerial tissues. Halophytes show high potential to tolerate and accumulate metals in their tissue by triggering mechanisms for toxic metals detoxification with adequate compartmentation in the vacuole or in the cell wall and peptide detoxification with phytochelatins (Sousa *et al.*, 2008) [9]. The increase in biomass in excess of these metals might be due to high protein formation, resulting in the induction of photosynthesis as well as increasing carbohydrate translocation.

Increase in fresh weight in the leaves was mainly due to increase in tissue water content and can be a good reason for tissue succulence. In the present study increase in dry weight may be attributed to the accumulation of inorganic and organic constituents in the plant tissue. Along with increase in the leaf number, there was an increase in the leaf area. The increase in leaf area might be due to increase in the volume of mesophyll cell with 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. The similar findings were observed in many researchers *Acacia holosericea* (Mathan *et al.*, 2019) [6].

The above three halophytic species were cultivated in the polluted and affected soil, for few months to reduce the soil contamination and this soil is used for further crop improvement. These halophytic species were accumulating more heavy metal from the soil.

Table 1: Physico-chemical characteristics of winery wastewater. *All the values are expressed in mg L^{-1} except pH and electrical conductivity (dSm^{-1})

Sl. No.	Parameters	Values*
1	pH	4.59
2	Color	Slightly pink
3	Temperature	30.0
4	Electrical conductivity	6.24
5	Total solids	5934
6	Total dissolved solids	5028
7	Total suspended solids	906
8	Sodium	425
9	Potassium	109
10	Calcium	99
11	Magnesium	32
12	Sulfate	424
13	Chloride	204
14	Phosphate	20
15	Bicarbonate	977
16	Nitrogen	12.8
17	Sodium absorption ratio	9.72
18	Soluble sodium percentage	71.86
19	BOD	632
20	COD	1252
21	Cadmium	0.0164
22	Lead	0.0813
23	Copper	08785
24	Nickel	0.0857
25	Zinc	0.6980

Table 2: Effect of winery effluent on growth parameters of *Suaeda maritima*, *Sesuvium portulacastrum* and *Ipomoea pescaprae* on 60th day after treatment

Treatments	*Suaeda maritima*			*Ipomoea pescaprae*			*Sesuvium portulacastrum*		
	Shoot length (cm plant^{-1})	Root length (cm plant^{-1})	Leaf area (cm^2 plant)	Shoot length (cm plant^{-1})	Root length (cm plant^{-1})	Leaf area (cm^2 plant)	Shoot length (cm plant^{-1})	Root length (cm plant^{-1})	Leaf area (cm^2 plant)
Control	22.0±3.66	21.5±2.68	0.874±0.27	19.8±1.84	25.5±2.94	9.20±1.49	20.6±1.83	15.0±1.06	2.083±0.07
10%	30.4±4.88	28.6±2.17	0.967±0.18	34.1±3.93	25.8±2.02	14.92±1.04	26.6±2.73	18.6±1.83	3.465±0.26
25%	49.1±4.64	43.30±5.84	1.785±0.94	53.0±2.86	37.3±0.98	26.78±1.84	34.2±2.58	23.0±1.04	4.685±0.06
50%	47.5±5.32	39.4±4.85	1.488±0.88	42.3±3.04	36.0±1.95	25.77±2.67	28.4±1.63	22.2±2.95	4.159±0.45
75%	28.5±3.76	38.7±1.56	1.091±0.66	41.5±1.73	32.5±1.07	17.73±1.63	30.0±2.59	21.2±2.64	3.999±0.23
100%	28.3±3.84	30.0±3.73	0.911±0.38	25.3±2.45	28.5±2.74	12.33±2.38	23.3±1.66	17.9±1.32	2.387±0.18

Table 3: Effect of winery effluent on fresh weight and dry weight of *Suaeda maritima*, *Sesuvium portulacastrum* and *Ipomoea pescaprae* on 60th day after treatment

Treatments	*Suaeda maritima*		*Ipomoea pescaprae*		*Sesuvium portulacastrum*	
	Fresh weight (g plant^{-1})	Dry weight (g plant^{-1})	Fresh weight (g plant^{-1})	Dry weight (g plant^{-1})	Fresh weight (g plant^{-1})	Dry weight (g plant^{-1})
Control	27.10±2.74	4.29±0.25	48.5±2.96	2.07±0.74	49.3±2.94	2.56±0.47
10%	35.9±2.85	5.31±0.12	50.4±3.34	3.87±0.39	55.6±3.45	3.29±0.48
25%	50.3±4.74	8.29±0.47	80.10±3.95	5.25±0.72	70.4±3.98	4.53±0.28
50%	45.7±2.85	7.74±0.87	70.12±3.27	2.90±0.06	60.9±3.95	4.16±0.94
75%	40.5±3.89	6.79±0.94	60.2±3.76	2.49±0.27	52.6±2.6	3.15±0.52
100%	37.23±1.74	4.64±0.56	48.8±3.74	2.44±0.55	50.5±3.17	2.87±0.53

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