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Evaluation of botanicals for the desalination potential of irrigation water

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Abstract
Agriculture is the largest consumer of water in the world. Over exploitation of water resources is threatening the very sustainability of livelihood and hence use of poor quality water, brackish water and saline water is highly imperative as an adaptation strategy to conserve water resources. Crop selection, application of organic manures and blending with good quality water are the currently available options to manage the use of saline water, which are not always sustainable. The technology which paves way for removal of salts at the source itself can help the farming community to cultivate crops of their preference based on the market demand. Hence in an attempt to explore the desalination potential of botanicals *viz.*, citrus peel, stumps and seeds of *Moringa oleifera*, bark of Indian goose berry (*Phyllanthus emblica)*, Albizia (*Albizia amara)* leaf powder and powdered seeds of Tettamparal (*Strychnos potatorum*) at various reaction time *viz.,* 5, 10, 15, 20, 30, 60 minutes, 2 hours and 24 hours after addition in diverse forms, it was found that seeds of *Strychnos potatorum* was only effective in reducing the salinity of water by 0.01 to 0.25 units than the initial value, whilst the other additives resulted only in increased electrical conductivity. Although plethora of evidences speaks about the biosorption potential of these botanicals for heavy metals, their ability to adsorb sodium and chloride ions in irrigation water needs further exploration.

Keywords: Albizia, desalination, electrical conductivity, irrigation, moringa seeds, *Strychn potatorum*

Introduction
Water is an inevitable input for agricultural production systems and food security. In the era of existential threat of climate change, there is looming crisis of water across the world in all walks of life and more so, agriculture is under pressure to explore viable options to bridge the ever widening gap between demand and supply. Agriculture is, indeed both the cause and victim of water scarcity. Global population is about to cross 9 million by 2050 and the demand for food is expected to surge by more than 50% with the food preferences shifting towards crops with much higher water foot prints. In the resilience of food production systems to feed the burgeoning population, over exploitation of water resources is threatening the very sustainability of livelihood resultantly causing salinization over 20% of the global irrigated land area (FAO, 2020) [9]. Degradation of the quality of groundwater due to salinization process is one of the key issues limiting the global dependence of groundwater in aquifers.
Irrigation with water containing less than 3mM Na and 4 mM Cl, equivalent to an electrical conductivity of less than 0.7 dSm^{-1} is considered harmless to soils and crops (Ayers and Westcot, 1985) [2]. Salinity damage to plants is commonly attributed to an increase in osmotic potential which reduces the ability of plant roots to extract water and reduce photosynthesis and transpiration rates (Russo *et al*., 2009) [17] besides restricting farmers' desire to grow crops of their preference based on the market demand. According to the Report of Ministry of Water Resources (CGWB, 2019) [6], groundwater with salinity more than 3 dSm^{-1} has been observed in 15 states of India including Tamil Nadu and 25 districts across the state. Tailoring the crops to suit the quality of water, scrupulous application of organic manures, blending with good quality water are the technologies available today to mitigate the deleterious effects of poor quality water, which are not viable in the long run. A sustainable long term solution will be to remove the salts at the source itself so that farmers can cultivate crops of their preference. Desalination, the process of reducing the salt content in water (Krishna, 2004) [10] to an appreciable level could be an alternative for improving water quality thereby increasing water

resources and reducing competition among diverse users of water. Presently available desalination techniques are confined only to domestic applications and many available for agricultural purposes are increasingly becoming controversial due to high energy requirements, prohibitively expensive nature, huge capital investments and highly concentrated brine wastes. Biodesalination can be harnessed to tide over the ill effects of the present desalination techniques. Hence an attempt was made to assess the efficacy of commonly available botanicals for their desalination potential.

Material and Methods

Batch experiments were conducted at Coconut Research Station, Tamil Nadu Agricultural University, Aliyarnagar during 2017-18 to evaluate the desalination potential of identified botanicals. Saline water was simulated by adding two grams of NaCl to distilled water to yield an EC of 3.45 dSm^{-1}. The following botanicals were added @ 50 g per litre of saline water. Reaction time was allowed ranging from 5 minutes to 24 hours and the electrical conductivity was measured after every reaction time so as to assess the biosorption potential of the added botanicals.

Treatments

T_1: Control
T_2: Citrus peel @ 50 g per litre of water
T_3: Moringa stumps @ 50 g per litre of water
T_4: Albizia leaf powder @ 50 g per litre of water
T_5: Moringa seeds @ 50 g per litre of water
T_6: Bark of Indian goose berry @ 50 g per litre of water
T_7: Powdered seeds of Tettamparal @ 5 g per litre of water

The experiment was laid out in Completely Randomized Design with each treatment replicated thrice. Experimental results were analysed using Panse and Sukhatme (1985) [15].

Results and Discussion

Electrical conductivity of the untreated water was 3.45 dSm^{-1} and most of the added botanicals failed to drop the electrical conductivity of the saline water at various reaction time (Table 1). Addition of citrus peel @ 50 g per litre of water resulted in an increase in electrical conductivity over control and the increase was steady with the extension of the reaction time. However a slight dip in EC was observed after 24 hours of treatment although it was not lesser than the control. Plethora of evidences states that citrus peel possess biosorption nature and the advantages of biosorption include high adsorption rate, cost effectiveness and lesser by-product at the end of adsorption (Marina Fomina and Ghadd, 2014) [12]. Bhatti *et al.* (2010) [4] employed biosorbent derived from *Citrus reticulata* waste biomass (CWB) for the removal of heavy metals Pb^{2+} and Co^{2+} from aqueous solutions. Biosorbent from *Citrus limetta* biomass waste at 500 °C temperature was synthesized to remove As(III) and As(V) from aqueous solutions and groundwater samples (Lata *et al.*, 2019). Citrus waste derived active carbon biochar is documented widely to provide cost effective and efficient biosorbent material which can be employed for eliminating poisonous heavy metals and dyes from the effluents. Although citrus peel derived biochar is noted to have potential application in removal of heavy metals from effluents and waste water, its desalination potential needs investigation.

Table 1: Impact of botanicals on electrical conductivity (dSm^{-1}) of saline water at various reaction time

S. No	Treatments	5 min.	10 min.	15 min.	20 min.	30 min.	60 min.	2 hrs	24 hrs
1.	T_1 – Control	3.45	3.45	3.45	3.45	3.45	3.45	3.45	3.45
2.	T_2 – Citrus peel @ 50 g per litre water	3.48	3.59	3.87	3.92	4.12	4.12	4.24	3.98
3.	T_3 – Moringa stumps @ 50 g per litre of water	3.56	3.83	3.97	4.19	4.22	4.31	4.24	4.24
4.	T_4 – *Albizia* powder @ 50 g per litre of water	3.78	3.42	3.78	4.12	3.98	4.36	5.12	4.12
5.	T_5 – Moringa seeds @ 50 g per litre of water	3.78	3.82	3.96	4.34	4.72	3.94	3.88	3.72
6.	T_6 –Bark of Indian goose berry @ 50 g per litre of water	3.86	3.88	3.92	4.10	4.27	4.22	4.14	3.98
7.	T_7 – Powdered seeds of Tettamparal @ 5 g per litre of water	3.50	3.78	3.86	3.41	3.20	3.44	3.51	3.64

Addition of moringa stumps @ 50 g per litre of water or an equal concentration of moringa seeds and Albizia powder also did not help in reduction of electrical conductivity of the saline water. Muyibi and Alfugura (2013) [13] recorded the combined potential of *Moringa oleifera* and alum towards reduction in turbidity of water, the mechanism being combination of partial-charge neutralization and micro-bridging or an electrostatic patch mechanism based on zeta potential measurements. As per Fayos *et al*. (2016) [8], the seeds of *Moringa oleifera* contain a coagulant protein that can be used in clarification of drinking water and in waste water treatment. Efficacy of the purified seeds of *Moringa oleifera* in removing suspended material and in softening hard water was well documented (Bina *et al*., 2010; Ali *et al*., 2010) [5, 1]. Bark of Indian goose berry also failed to register its positive impact in desalination of water. In an attempt to investigate the relative efficacy of botanicals like bark of Indian goose berry, lemon peel, peanut husk and vettiver roots in reducing the total dissolved solids (TDS) of hard water, the superiority of Vettiver in reduction of TDS by 56% followed by bark of goose berry and citrus peel to the tune of 42.14% was observed by Ebrahim *et al*. (2011) [7].

Unlike other botanicals, powdered seeds of Tettamparal (*Strychnos potatorum*) @ 5 g per litre was effective in reducing the electrical conductivity of water by 0.01 to 0.25 units (Fig. 1).

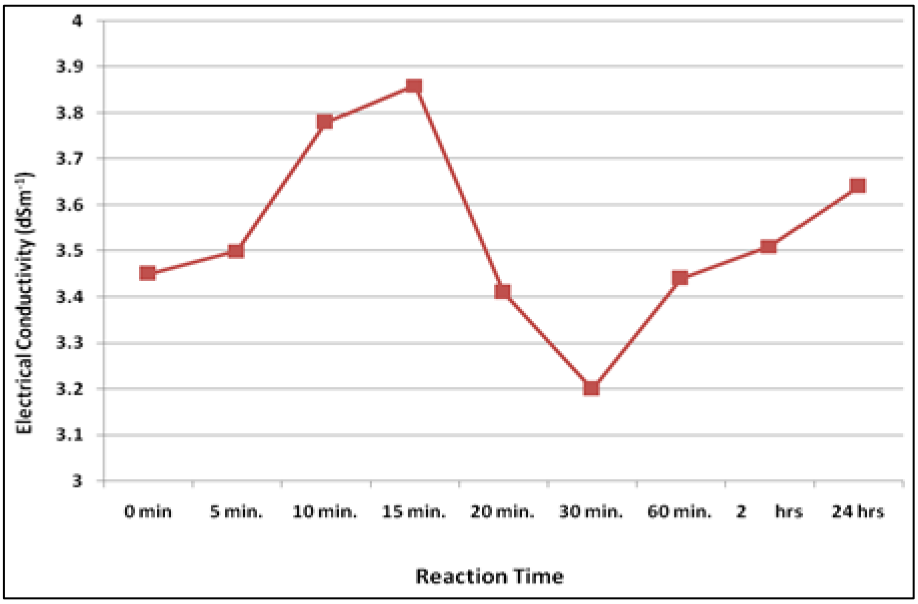

Fig 1: Electrical conductivity of saline water as influenced by *Strychnos potatorum*

In a batch mode coagulation study employing *Strychnos potatorum*, a protein responsible for coagulation and removal of pollutant from sewage water was confirmed by sodium dodecyl sulfate polyacrylamide gel electrophoresis by Vishali *et al*. (2019) [18]. Seeds of the plant *species Strychnos potatorum* and *Moringa oleifera* contain natural polyelectrolytes which can be used as coagulants to clarify turbid waters (Raveendra Babu and Chaudari, 2005) [16]. Thus in the present study also *Strychnos potatrum* offered a ray of hope in desalination of saline water.

Conclusion
Exploitation of botanicals in desalination of irrigation water is a non-chemical initiative. In the batch experiment conducted to evaluate the desalination potential of diverse botanicals *viz.*, Citrus peel, Moringa seeds and stump, Albizia powder, bark of Indian goose berry and powdered seeds of *Strychnos potatorum*, only *Strychnos potatorum* was effective in reducing the electrical conductivity of saline water whilst all the other additives registered an increase in the electrical conductivity at various reaction time. Advanced imaging techniques like Scanning Electron Microscopy can be employed to characterize the adsorption potential of botanicals for specific ions associated with water salinity. Exploring the biosorption potential of the active isolates of the identified botanicals may go a long way towards hinting strategies for bio-desalination of irrigation water.

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