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The Potential of Using Plant Extracts as Natural Absorbents for Salinity Reduction in Irrigation Water

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ABSTRACT

Groundwater was polluted mostly by sea water intrusion in coastal areas and it has an adverse effect on crop growth and productivity. Desalination using natural bioabsorbents may be economical and eco-friendly approach. Hence to utilize the organic amendments a study was undertaken to characterize the chemical constituents of various organic amendments and to find out the suitable amendment for reducing the salinity of groundwater. The results of the laboratory experiment revealed that among all the bio adsorbents, Moringa seed powder (T_1) and Amla bark powder (T_5) @ 0.5 per cent concentration showed a better reduction of EC in the water samples from 4.57 dS m^{-1} to 4.12 and 4.06 dS m^{-1}, respectively at 144 hours of incubation. Though the moringa seed powder reduced the salt load of water but caused a foul odour on the fourth day of treatment. The Amla bark powder @ 0.5 per cent concentration were used in water having different concentrations of EC viz., 3.54 (E_1), 4.91 (E_2), 6.50 (E_3), 8.15 (E_4), 10.57 (E_5) and 13.28 (E_6) dS m^{-1}. The EC of the water samples were reduced to 3.46 (E_1), 4.67 (E_2), 6.21 (E_3), 7.69 (E_4), 9.18 (E_5) and 11.31 (E_6) dS m^{-1}. From the study, it is concluded the use of organic amendments also showed better results for the reduction of salt content in the groundwater samples.

Keywords: *Plant Extracts, Natural Absorbents, Salinity, Irrigation water, organic amendments*

INTRODUCTION

Water is a prime requisite among all natural resources. It is a fundamental need for the sustenance of every living organism [1]. Water covers about two-thirds of the earth's surface. The freshwater only contributes about 3 percent which supports all forms of life on earth and the remaining 97 percent of water is saline. Amongst water resources, groundwater is the major source and is widely dispersed in India. It is utilized for all purposes including domestic, agricultural, and industrial purposes. The quality of ground water is degraded with increasing population [2].

Irrigation water quality plays a vital role in sustaining crop productivity and feeding a growing world population [3]. Indian agriculture mainly depends on groundwater for irrigation, and it plays a foremost role in increasing the yield and productivity of crops. The overuse of groundwater and quality deterioration led India towards a serious crisis, in spite of having 30 million groundwater structures. Groundwater is threatened by several factors related to the mismanagement.

Groundwater was polluted mostly by sea water intrusion in coastal areas, and it has an adverse effect on crop growth and productivity. Soil salinity is directly related to groundwater salinity of the coastal region. The increase of salinity level in water affects the plants in numerous ways like drought and oxidative stress, toxicity of ions, nutritional disorders, alteration of metabolic processes and reduction of cell division and expansion. All these factors will ultimately lead to reduction in plant growth, development and yield [4].

Due to the global increase in water demand, the scarcity of water is a major issue in most of countries. One of the feasible solutions for reducing water scarcity is desalination [5]. Desalination refers to the removal of salts and minerals. The ions responsible for salinity include the major cations (Ca^{2+}, Na^{+}, Mg^{2+}, K^{+}) and anions (Cl^{-}, SO_4^{2-}, HCO_3^{-}, CO_3^{2-}). Removing salts from groundwater through the desalination process is beneficial in point of human health, natural resource conservation and betterment of socioeconomic conditions.

Adsorption is one of the significant techniques in which salts and minerals are adsorbed onto a membrane, or a fixed bed packed with resin or other materials [6]. The synthetic materials such as alum and calcium hypochlorite are efficient, because these materials are expensive and is not affordable for most rural population. Hence this study describes the low cost and locally available materials as effective adsorbent for the removal of salts and minerals from water under laboratory conditions, which may be economical and an eco-friendly approach.

MATERIALS AND METHODS

An experiment was conducted with moringa seed, papaya seed, neem leaf, tulasi leaf, lemon peel and amla bark. These bio adsorbents were taken as powder form @ 0.5 per cent concentration and tested against salt reduction. The water used in this study was collected from the coastal areas of Thoothukudi district. The EC of water was tested once in every 24 hours using a Multiparameter analyser kit to know the salt

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reduction potential of each bio adsorbents. The bio adsorbents which exhibit good salt reduction potential were identified for optimization of dosage.

To optimize the dosage of these bio adsorbents, the experiment was conducted with different concentrations of moringa seed and amla bark powder (0.1, 0.3, 0.4, 0.5, 0.6 and 0.7 per cent). The changes in the EC were recorded once in every 24 hours up to 168 hours. Although the moringa seed powder reduced the salt load of water but caused foul odour on the fourth day of treatment. Amla bark powder produced no odour even up to one week and performed better salt reduction. Hence, Amla bark powder was used for further study.

Adsorption study at different levels of salinity

The salt reduction potential of Amla bark powder was good @ 0.5 per cent concentration. Further, a confirmation study was conducted. In this study, water containing different EC's was taken in which Amla bark powder was added @ 0.5 per cent concentration. The changes in EC were recorded upto 168 hours.

Characterization of chemical constituents of organic amendments

Moringa seed and amla bark was collected, dried and powdered. One gram of the powdered samples were taken in 95 per cent ethanol and kept in shaker for 24 hrs. Then the samples were centrifuged at 3000 rpm for 15 min and the supernatant was collected and stored at 4^0 C for further analysis.

GC-MS analysis

The analysis was done on a GC-MS QP. The following conditions were employed:

Column R_{xi}- 5 MS silica column with 30 m length, 0.25 mm diameter and 0.25 μm thicknesses. Helium was used as a carrier gas with a flow rate of 1 ml min^{-1} and an injection volume of 0.5 μl was employed with split ratio of 1:10, interface temperature 270^0 C, ion source temperature 200^0C. The oven temperature was set at 70^0 C with an increase of 5^0 C min^{-1} to 120^0 C ending with a 5 min isothermal at 280^0 C. In Gas chromatography, the total running time was 40 min. The compounds were identified by comparing with the spectra library.

RESULTS AND DISCUSSION

Among all the bio adsorbents, Moringa seed powder (T_1) and Amla bark powder (T_5) @ 0.5 per cent concentration showed a better reduction of EC in the water samples from 4.57 dS m^{-1} to 4.12 and 4.06 dS m^{-1}, respectively at 144 hours of incubation (Table 1). *Moringa oleifera* reduced the conductivity of ground water up to 53 per cent @ 100 mg L^{-1}. The addition of coagulant *M. oleifera* may result in the dispersion of some mineral ions and inorganic compounds into a floc which will then be precipitated and separated from the solution. This caused the reduction of EC. The salinity removal efficiency of *Phyllanthusemblica* was found to be 55 per cent for a dosage of 1g and at a time period of 240 minutes [7][8][9].

Table 1. Influence of different bio adsorbents on the changes in EC of irrigation water

Treatments	Changes in EC dS m^{-1}					
	Initial	24 hrs	48 hrs	72 hrs	96 hrs	144 hrs
T_1 – Moringa seed powder	4.57	4.77	4.62	4.33	4.14	4.12
T_2– Tulsi leaf powder	4.57	4.79	4.61	4.47	4.39	4.35
T_3 – Neem leaf powder	4.57	4.69	4.64	4.56	4.55	4.48
T_4 – Lemon peel powder	4.57	5.07	4.98	4.83	4.71	4.68
T_5 – Amla seed powder	4.57	4.65	4.56	4.49	4.25	4.06
T_6 – Papaya seed powder	4.57	4.71	4.69	4.63	4.57	4.55

The moringa seed powder and amla bark powder exhibited good salt reduction potential @ 0.5 per cent concentration and to optimize the dosage of these bio adsorbents, the experiment was conducted with different concentrations of moringa seed and amla bark powder (0.1, 0.3, 0.4, 0.5, 0.6 and 0.7 per cent) (Table 2). The Moringa seed powder (T_1) showed a reduction of EC from the water having an initial EC of 3.43 dS m^{-1} to 3.18 dS m^{-1} and similarly, Amla bark powder (T_2) also reduced the EC from 3.43 dS m^{-1} to 3.18 dS m^{-1} at 168 hours of incubation. The Moringa seed powder (T_1) and Amla bark powder (T_2) @ 0.5 per-cent concentration would be ideal for salt reduction in irrigation water. The seeds of *Moringa oleifera* contain coagulating proteins which are water soluble and act as effective coagulants for water treatment [10][11][12][13]. Amla stem and leaves were efficient in reducing the salt load of irrigation waters [14].

Table 2. Influence of bio adsorbents at different doses on the changes in EC of irrigation water

Treatment details	Initial	24 hrs	48 hrs	72 hrs	168 hrs
T_1D_1 – Moringa seed powder @ 0.1%	3.43	3.41	3.35	3.31	3.26
T_1D_2 – Moringa seed powder @ 0.3%	3.43	3.42	3.36	3.32	3.22
T_1D_3 – Moringa seed powder @ 0.4%	3.43	3.43	3.37	3.3	3.23
T_1D_4 – Moringa seed powder @ 0.5%	3.43	3.4	3.36	3.28	3.18
T_1D_5 – Moringa seed powder @ 0.6%	3.43	3.45	3.42	3.37	3.31
T_1D_6 – Moringa seed powder @ 0.7%	3.43	3.46	3.41	3.36	3.33
T_2D_1– Amla bark powder @ 0.1%	3.43	3.29	3.26	3.21	3.19
T_2D_2– Amla bark powder @ 0.3%	3.43	3.31	3.28	3.26	3.21
T_2D_3– Amla bark powder @ 0.4%	3.43	3.34	3.29	3.28	3.17
T_2D_4– Amla bark powder @ 0.5%	3.43	3.37	3.26	3.21	3.02
T_2D_5– Amla bark powder @ 0.6%	3.43	3.43	3.34	3.33	3.29
T_2D_6– Amla bark powder @ 0.7%	3.43	3.42	3.38	3.35	3.31

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The Amla bark powder @ 0.5 per cent concentration were used in water having different concentrations of EC *viz*., 3.54 (E_1), 4.91 (E_2), 6.50 (E_3), 8.15 (E_4), 10.57 (E_5) and 13.28 (E_6) dS m^{-1} and the changes in EC were recorded up to 168 hours (Table 3). The EC of the water samples were reduced to 3.46 (E_1), 4.67 (E_2), 6.21 (E_3), 7.69 (E_4), 9.18 (E_5) and 11.31 (E_6) dS m^{-1}. Similar results were reported by [15] [16].

Table 3. Influence of Amla bark powder @ 0.5% concentration on different levels of salinity

Levels of EC	Initial	24 hrs	48 hrs	72 hrs	168 hrs
3.54 -E_1	3.54	3.53	3.53	3.51	3.46
4.91 -E_2	4.91	4.88	4.83	4.7	4.67
6.50 -E_3	6.5	6.47	6.35	6.26	6.21
8.15 -E_4	8.15	8.12	7.56	7.42	7.39
10.57- E_5	10.57	10.41	9.38	9.22	9.18
13.28 -E_6	13.28	13.13	11.8	11.32	11.31

In the GC-MS analysis of moringa seed powder and amla bark powder (Fig. 1 & 2). The major compounds found in the moringa seed powder are Ethyl 1-thio-. alpha. -1arabinofuranoside (51.04%), 9-Octadecenoic acid (14.12%), 9-Octadecene,1-[3(octadecyloxy) propoxy]- (6.54%), 1,3-Propanediol, 2-(hydroxymethyl)-2-nitro- (4.16%), Octadecanoic acid (2.67%) and Squalene (2.46%). The major compounds found in the amla bark powder analyzed using GC-MS are Spirosat-8-en-11-one,3-hydroxy-,(3.beta.,5.alpha.,14.beta,22.beta, 25R)- (14.30%), Diisooctyl phthalate (13.68%), 2-Propenoic acid, pentadecyl ester (10.57%), Dibutyl phthalate (7.42%), 1,5,9,9-Tetramethyl-2-oxatricyclo[6.4.0.0(4,8)] dodecane (6.22%) and 10-t-Butyl-10hydroxytricyclo [4.2.1.1(2,5)]de (5.00%). Similar results were reported by [17].

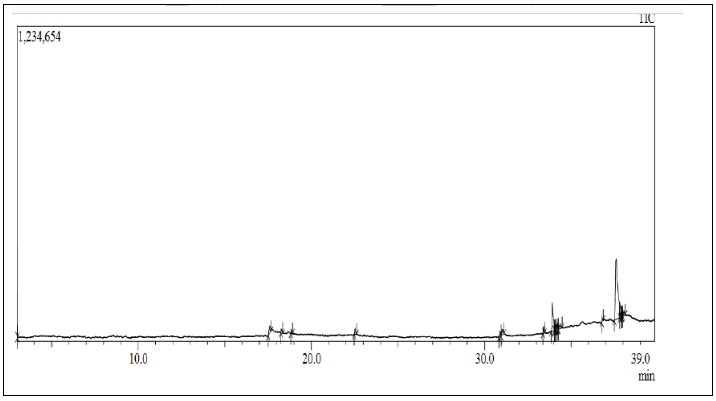

Fig. 1. GC-MS profile of Moringa seed powder

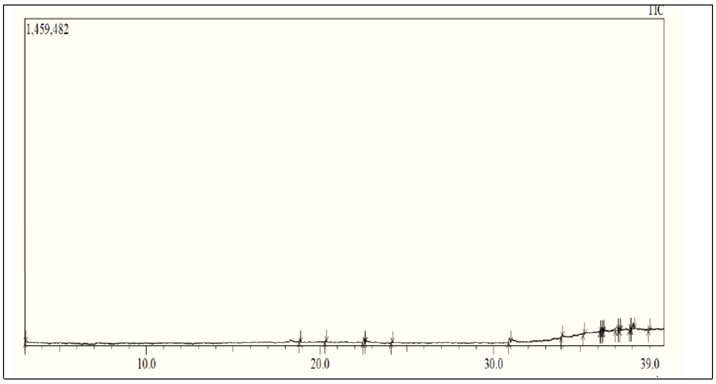

Fig. 2. GC-MS profile of Amla bark powder

CONCLUSION

The EC of salt water can be reduced by using amla bark powder @ 0.5 per cent concentration and it can be used for agricultural purposes. Replacement of chemical coagulants by organic amendments is an effective management option for poor-quality water and it may also bring about significant results. It is an eco-friendly and cost-effective technology for water treatment. Although they produce significant results, no effort has been made for the commercialization of these low-cost technologies. The study will be useful to use the amendments and find a viable solution for its commercialization.

Future scope of Study

Desalination is the feasible solution for removing salts from groundwater. The study will support for developing low cost and locally available materials as effective adsorbent for the removal of salts from water, which may be economical and an eco-friendly approach.

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Conflict of Interest

There is no conflict of interest. The authors had full access to all set of data and table complete responsibility for the accuracy of the data analysis.

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