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IRRIGATION OF SPINACH PLANT WITH RO DESALINATED SEA WATER

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ABSTRACT

An approach for recovery of used seawater after reaction of magnesium metal with citric acid for hydrogen gas production and precipitation of magnesium as magnesium gluconate, the water left is desalinated by reverse-osmosis technique. A spiral wound RO commercial membrane module was used in prototype unit. Different concentrations of remediated seawater were mixed to form required water salinities for spinach irrigation to be applied in rural areas where there is no other water supply. Results of irrigation showed that addition of 1000 ppm, 650 ppm, 350 ppm almost gave the best treatments with fresh, dry, weight and NPK as compared with 150 and 200 ml.

Keywords: reverse osmosis, solar stiller, saline irrigation, crop yield.

INTRODUCTION

The present study aims to reuse sea water remained after reaction of magnesium metal with seawater and citric to release hydrogen as green energy. As magnesium is a metal and the citric acid is an acid, hydrogen plus a salt is formed. This results in the chemical equation:

$$C_6H_8O_7 + Mg \longrightarrow H_2 + Mg\,C_6H_6O_7$$

Magnesia combine with both citric acid and gluconic acid and gives magnesium glucono - citrate. Magnesium gluconate ($Mg\,C_{12}H_{22}O_{14}$) is prepared using the US-patent Serial No. 477,186 for citrate solutions [1]

Magnesium gluconate was prepared as a medication product under ordinary conditions and is soluble in water. The dry product mixed with a suitable amount of bicarbonate and heated under 300^{o}C, is the equivalent in strength of magnesia solution and having a therapeutic effect. Further then, remained sea water is subjected to RO treatment and used for irrigation of spinach plants. NPK in dried spinach samples were analyzed and tested for the best salinity irrigation.

Salinity becomes a problem when enough salts accumulate in the root zone to negatively affect plant growth. Excess salts in the root zone hinder plant roots from withdrawing water from surrounding soil. This lowers the amount of water available to the plant, regardless of the amount of water actually in the root zone. For example, when plant growth is compared in two identical soils with the same moisture levels, one soil receiving salty water and the other receiving salt-free water, plants are able to use more water from the soil receiving salt- free water. Although the water is not held tighter to the soil in saline environments, the presence of salt in the water causes plants to exert more energy extracting water from the soil. The main point is that excess salinity in soil water can decrease plant available water and cause plant stress. Salina irrigation water contains dissolved substances known as salts. Most of the salts present in irrigation water are chlorides, sulfates, carbonates, and bicarbonates of calcium magnesium, sodium, and potassium. While salinity can improve soil structure, it can also negatively affect plant growth and crop yields [2] and [3].

Sodality refers specifically to the amount of sodium present in irrigation water. Irrigating with water that has excess amount of sodium can adversely affect soil structure, making plant growth difficult. Highly saline and sodic water qualities can cause problems for irrigation, depending on the type and amount salts present, the soil type being irrigated, the specifies plant species and growth stage, and the amount of water able to pass through the root zone [4] and [5].

Membrane desalination uses membranes technology to separate fresh water from saline feed-water. Feed-water is brought to the surface of a membrane, which selectively passes water and excludes salts. In the Reverse Osmosis (RO), the seawater pressure is increased above the osmotic pressure, thus allowing the desalinated water to pass through the semi-permeable membranes, leaving the solid salt particles behind. The RO plants are very sensitive to the feed-water quality (salinity, turbidity, temperature), while other distillation technologies are not so demanding in this respect. High-salinity and high-temperature feed-water can limit the osmosis process as they affect the osmosis pressure, requiring more energy. High-turbidity feed-water can cause fouling where membrane pores are clogged with suspended solids. Typical seawater salinity which is suited to RO systems is around 35,000 ppm of dissolved solids contents. However, in some regions (i.e. Red Sea, Arabian Gulf), the total dissolved solids content is higher, i.e. 41,000 ppm and 45,000 ppm, respectively. In these regions, seawater has high fouling potential (bio-fouling due to high content of organisms), and high surface temperature [6]. Therefore, an appropriate feed-water pre-treatment is needed prior to RO desalination. RO desalination is also suited to and used for small-scale plants in rural areas or islands where there is no other water supply available. For example, most desalination plants in the Caribbean area use RO systems [7]**.** Thermal and solar desalination**,** such as L-type solar stiller, they are simple, cheap and used solar energy and they doesn`t require high grade energy. They do not produce harmful gases, which will effect earth. Moreover, solar stills are easy to build and operate. Finally, solar stills can be more economical than other desalination technologies for providing water to households and small communities [8] and [9].

MATERIALS AND METHODS

Mediterranean Seawater, from Alexandria, Egypt was collected in a tank of $0.75m^3$and was used as feed water for pilot experiments. In order to observe the effect of desalinated seawater on the quality and growth rates of selected agricultural crops, and evaluate system performance of RO process better, batch experiments with continuous RO system giving $1m^3$/day (40l/h) with a high pressure pump of 70-80 bar with a pressure gauge. Rotameter was fitted with the permeate and concentrate lines to estimate the flow rates together with the feed pressure through a pressure guage. Spiral wound RO commercial membrane module was obtained from AQUA SERVICE Co., Egypt where it was in pilot RO desalination unit. RO permeate was collected in a tank of 0.5 m^3 for required water analysis and quality control tests. This study was carried out at the green house of the National Research Centre, Dokki, Egypt, during the season of 2017, to study the effect of saline water on spinach plant. The experimental trails were conducted in sandy soil.

Table-1. Some physical and chemical properties of soil (Mean of two seasons).

Particle size distribution				**Texture class**		**pH (1:2.5)**		**EC (dSm^{-1})**	**CaCO3 (%)**	**OM (%)**
Sand%	**Silt%**	**Clay%**								
70	12	18		Sandy loam		8.27		1.92	3.78	1.37
Cation and Anion (m/L)										
Na^+	K^+	Ca^{++}	$CO3^-$	$HCO3^-$	CL^-		$SO4^{--}$	N	P	K
5.51	1.41	2.62	---	2.12	7.22		1.72	6.35	0.94	16.65

The experiment treatments were arranged in a factorial experiment and laid out in randomized block design with three replicates Figure-3.

Table-2. Treatment details as follows.

Treatments	**Irrigated ml**
1000	100
	150
	200
650 ppm	100
	150
	200
350 ppm	100
	150
	200

Then, fresh spinach samples were oven dried ground and digested for the determination of N, P and K contents. The analysis of variance was carried out according to using MSTAT computer software [6], after testing the homogeneity of the error according to Bartlett's test [7]. Means of the different treatments were compared using the least significant difference (LSD) test at $P<0.05$.

Experimental tests for Thermal and solar desalination using Solar stiller:

L-type solar stiller consists of a blackened basin filled with brackish (seawater) up to 3cm depth and covered by an inclined glass to facilitate transmission of solar radiation and condensation as shown in Figure-1.

They are simple, cheap and used solar energy and they doesn`t require high grade energy. They do not produce harmful gases which will effect earth. Moreover solar stills are easy to build and operate. Finally solar stills can be more economical than other desalination technologies for providing water to households and small communities.

The design and fabrication of solar still are simple which produces yield of about 4-6L/(m^2 day). Also, solar distillation plant with a capacity less than 200 Kg/day is more economical than other types of desalination plants.

Figure-1. L-type solar stiller during desalination of seawater and recovery of fresh water at the bottom.

The solar radiation entering the basin heated up the water causing evaporation, because of partial pressure difference and temperature difference the water vapor gets condensed along the inclined glass cover and it is collected by suitable provision at the bottom. The obtained water is in its pure form and its analysis is present in Table-3. The stiller needed about 8.5 KW/h solar energy i.e. 8.5*3600= 30, 600 KJ energy required to desalinate 5 liter of sea water in two days of March weather in Cairo. This desalinated water is used for doubling the sea water two – five times before RO desalination.

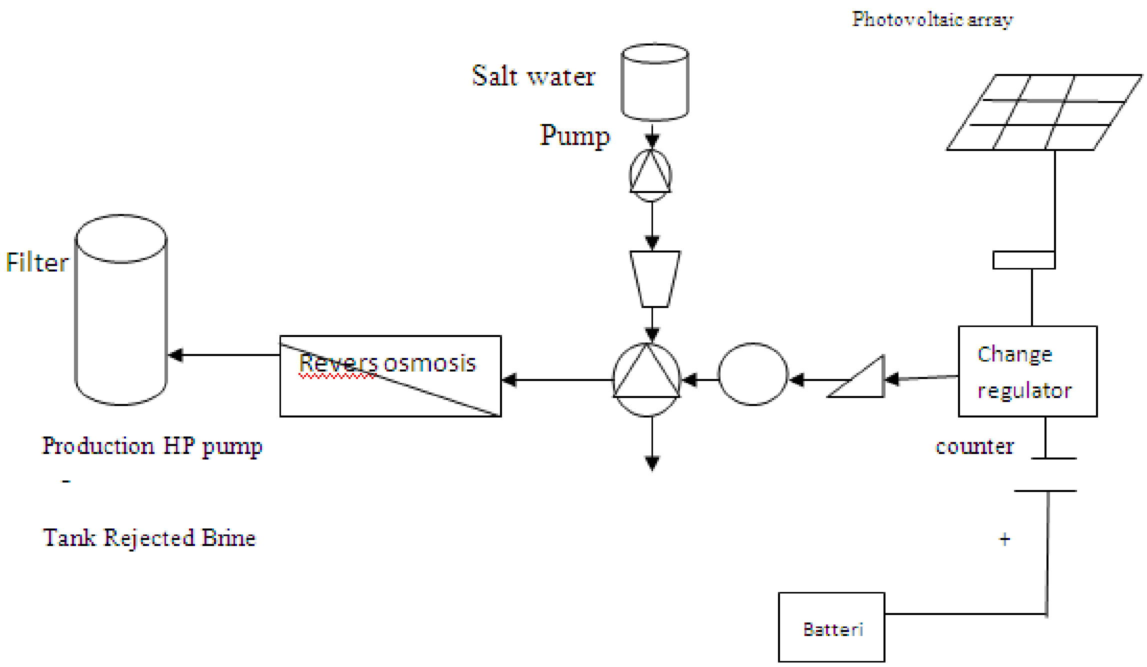

Figure-2. Schematic diagram of the PV powered RO System use.

Because RO plants need less energy, investment coat, space and maintenance than other alternative desalination processes, hence it is preferred desalination technique worldwide successfully used. Energy consumption is commonly fulfilled by renewable energy sources, such as solar, when no renewable sources are available. RO plants are designed to operate at a constant operation point, producing constant flow of drinkable water. By adjusting water production and water consumption.

RESULTS AND DISCUSSIONS

Permeate Water comes out From RO pilot desalination unit (1m^3/day) with 30 ppm. Detailed seawater analysis before introduction to RO treatment is shown in Table-3.

Table-3. Characteristics of seawater compared to tape water and solar still water.

Parameter	Characteristics of Raw seawater	Characteristics of tap water	Characteristics of Solar distilled sea water
Temperature	20°C	20°C	20°C
pH	7.5	6.1	7.8
conductivity	5625-6675µs	420 µs	154 µs
Turbidity	2 FTU	3 FTU	3 FTU
TS	40451.5 mg/L	120 mg/L	160 mg/L
TDS	27550 mg/L	210 mg/L	76 mg/L
Salinity	40 PPT	11340 PPT	0.1 PPT
Ca^{++}	500 mg/L	0.66 mg/L	19 mg/L
Mg^{++}	1548 mg/L	0.38 mg/L	4.8 mg/L
K^{++}	192.157 mg/L	ND	0.911 mg/L
Fe^{t}	0.574 mg/L	ND	0.027 mg/L
Mn++	0.05 mg/L	ND	0.01 mg/L
Cu++	0.26 mg/L	ND	<0.01 mg/L
Cr^{t}	0.128 mg/L	ND	0.075 mg/L
Phosphate	Zero	Zero	Zero
Nitrate	mg/L	0.5 mg/L	0.7 mg/L
Nitrite	mg/L	0.5 mg/L	0.7 mg/L
Magnesium hardness	6450 mg/L	ND	20 mg/L
Calcium hardness	125 mg/L	ND	48 mg/L
Total hardness	7700 mg/L	ND	68 mg/L
Volume of Raw water	1200 mL		5000 ml
Volume of recovered water			3000 ml

The required TDS for water used in planting agriculture crops needs to be of higher salinities which has been found to be 200ppm, 600ppm , 800ppm and 1500 ppm which was formed by mixing permeate water with different concentration of pre treated feed seawater to form the required produced water salinities using RO porotype unit is shown in Figure-2.

Table-4. Effect of treatment with different saline levels with water of irrigation and NPK% in spinach plant growth.

treatments	Irrigated ml	Fresh weight	Dry weight	N %	P%	K %
1000	100	22.6	4.6	1.4	0.9	1.6
	150	20.2	3.9	1.2	0.7	1.4
	200	17.0	3.0	0.9	0.6	1.3
650 ppm	100	28.7	6.0	1.8	1.0	1.9
	150	23.0	4.8	1.5	0.9	1.5
	200	19.5	4.2	1.3	0.7	1.4
350 ppm	100	37.0	7.8	2.2	1.1	2.1
	150	35.5	5.8	2.1	1.1	2.0
	200	35.5	5.7	2.0	1.1	2.0

It was observed from Table-4 that the irrigation water of 350ppm gave the highest of fresh, dry weight and NPK of spinach plants as compared with the irrigated water as 650 and 1000 ppm. It was noticed that the addition of 200ml water as 350ppm gave the highest fresh weight, dry weight and NPK of spinach plants. However the addition of 1000ppm of water salinity with 200ml gave the lowest fresh weight, dry weight and NPK as compared with all treatments.

The addition of 100ml water with 1000,650 and 350ppm almost gave the best treatments with fresh, dry weight and NPK as compared with 150 and 200 ml.

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Figure-3. Illustrating three replicates of spinach plant irrigation with different saline water prepared by RO system.

Figure-4. Illustrating three replicates of spinach plant irrigated with low salinity and High salinity.

CONCLUSIONS

The availability to reuse seawater after reaction with magnesium metal and citric acid was successfully done with plantation of spinach. Different saline water concentrations achieved good yield. Solar stills and RO technology helped for good water characteristics and the addition of 1000ppm of water salinity with 200ml gave the lowest fresh weight, dry weight and NPK as compared with all treatments. While the addition of 100ml water with 1000,650 and 350ppm almost gave the best treatments with fresh, dry weight and NPK as compared with 150 and 200 ml.

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REFERENCES

[1] Patent Nov. 21, 19331, 936, 364, CITRATE SOLUTIONS Richard Pasternack and Clinton I. Ammo 1 Brooklyn, N.Y., assi gnors to Chales Pfizer and Company, Brooklyn, N.Y., a corporation of New Jercy No Drawing. Application August 22, 1930 Serial No. 477, 186.

[2] Bauder J. W. and T. A. Brock. 2001. Irrigation water quality, soil amendment, and crop effects on sodium leaching. Arid Land Research and Management. 15: 101-113.

[3] Abu-Sharar T. M., F. T. Bingham and J. D. Rhoades. 1987. Stability of soil aggregates as affected by electrolyte concentration and composition. Soil Science Society of America Journal. 51: 309-314.

[4] Bauder J. W. and T. A. Brock. 1992. Crops species, amendment and water quality effects on selected soil physical properties. Soil Science Society of America Journal. 56: 1292-1298.

[5] Ayers R. S. and D. W. westcot. 1976. Water quality for agriculture. FAO irrigation and drainage paper No, 29 (Rev 1), Food and Agriculture Organization of the United Nations.

[6] Abd El Aleem, F. A., *et al*. 1997. Biofouling problems in membrane processes for water desalination and reuse in Saudi Arabia. International Bio deterioration & Biodegradation. 41(1998): 19-23.

[7] Caribbean Environmental Health Institute (CEHI). 2006. The Evaluation of the Use of Desalination Plants in the Caribbean, United Nations Educational, Scientific and Cultural Organization (UNESCO).

[8] S. A. Nada, H. H. El-Ghetany and H. M. S. Hussein. 2004. Performance of a two-phase closed thermosyphon flat-plate solar collector with a shell and tubes heat exchanger. Applied Thermal Engineering. 24: 1959-1968.

[9] H. H. El Ghetany, A. Abdel Dayem. 2010. Numerical simulation and experimental validation of a controlled flow solar water disinfection system, Desalination and Water Treatment. 20: 11-21.