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The Optimum Algae Dose in Water Desalination by Algae Ponds

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***Abstract*— *The study aims to determine the best design algae dose for desalination using algae under nature conditions. The experiment was applied on a pilot plant exposed to nature conditions. This pilot consists of three consecutive basins; each basin was divided into two equal parts fed by saline water with constant concentration 30000 ppm. Water depth was 30 cm added by 400 ml/path with adding 100 ml/path of the artificial media BG-11.*

By using varied Algae doses ranged from 150 ml/path, 300ml/path, 500ml/path and compared with previous studies with 400ml/path. The result showed that, when the algae amount increase, the TDS removal efficiency increase, so the relation between the algae amount and TDS removal efficiency is directly proportional which also depend on climatic conditions such as the temperature and sunlight duration. The removal efficiency of algae amount 400 ml is higher than the other efficiencies which means that 400 ml of algae is the optimum algae amount for algae desalination process.

***Keywords*— *Water Desalination, biological Desalination, Desalination by Algae Ponds, Design Parameters*.

I. INTRODUCTION

With the increase of Population and the shortage in fresh water the desalination for sea water became the only choice for future potable water production source. All the existing desalination methods depends on high power consumption that raise the cost of production to 3-7 times the other water resources.

Therefore, several microorganisms are applied to remove salts from water. Some artificial bacteria, which are still under research, were applied for water desalination 3 years ago. Also, some algae spices from 5 years ago started to be applied under research manner to desalinate sea water with successful promising results.

Algae as a group exhibit an extremely wide range of tolerance to salts in their surroundings. Some species can tolerate only millimolar amounts of salt, while others survive in saturated brine. As for the adaptation to salinity, Algae may be roughly divided into halotolerant and halophilic, the later requiring salt for optimum growth and the former having response mechanisms that permit their existence in saline medium [1].

Algae require minor essential elements (Iron (Fe), Zinc (Zn), Silica (Si), Copper (Cu), Molybdenum (Mo), Manganese (Mn), Boron (B) and Bromium (Br)) and major essential elements (Carbon (C), Nitrogen (N), Phosphorus (P), Sulphur (S), Potassium (K), Magnesium (Mg) and Calcium (Ca)) for their maximum growth. Algae can be distinguished than higher plants by their ability of using Na instead of K in case of K-deficiency, while Na can be toxic to higher plants which gives the algae the ability of surviving and growth in saline media. It must be mentioned here that, K is a cofactor for several enzymes involved in protein synthesis and osmotic regulation [2].

Desalination based on the use of algae in the removal of salts from saline water, and water production for use in different purposes is a new concept and it has been used and tested in previous researches in industrial waste water treatment, where using the algae reduced the cost to the minimum while maintained the efficiency with no reduction. The achieved results were promising and good in the desalination of sea water and is successful, continuing to reach the removal efficiency up to 95% till the rates are relatively affordable for possible use in different purposes, opening the door to a new direction may succeed in solving the problem of water desalination with cost reduction to the minimum possible [3].

The application was successfully worked under suitable conditions inside the lab as illustrated by El Nadi [3] [4] [7], El Sergany [3] [4], Saad [5] & Badawy [6]. Also it was success under normal nature conditions as illustrated by El Hosseiny [8, 10] & Nagy [9, 10].

II. MATERIALS AND METHODS

The pilot plant was located on the field pilots environmental engineering laboratory held on the roof of Ain Shams university engineering faculty. It was operated under the nature conditions like temperature, sunlight duration and humidity. The pilot plant consists of three storage tanks, these tanks would feed a basin divided to three parallel equal parts and then two additional basins in series. Figure (1) illustrates the pilot components.

The *Scendesmus* algae species was the choice for operation process, thanks to its natural feature of growing very well in almost any mineral medium. Saline water with constant TDS about 30000 ppm was used in the experiment. *Scendesmus* algae were added using varied Algae doses ranged from 150 ml/path, 300ml/path, 500ml/path and compared with previous studies that used 400ml/path and BG-11 solution was added to give algae enough nutrition with a rate of 100 ml/path. Chemical composition of BG-11 nutrient solutions is as shown in table 1.

TABLE 1. Chemical composition of BG 11 nutrient solutions [11]

Chemical	BG 11(g/l)
$NaNO_3$	1.5
$K_2HPO_4.3H_2O$	0.04
Na_2CO_3	0.02
$MgSO_4.7H_2O$	0.075
$CaCl_2.2H_2O$	0.036
EDTA-Na_2	0.001
Fe(NH3)2Citrate	0.006
Citric acid	0.006

Scendesmus algae were taken 7 days as a retention time to treat the saline water in first basin. Water after separating algae in the first basin was then transferred to the second basin. *Scendesmus* algae in second basin did the second stage of treatment for another 7 days. Then the work repeated in the third basin. Desalinated water was collected in the effluent after the third basin. The added dose of algae was fixed for the the 3 serial basins in the line.

Fig. 1. Components of the Pilot

Samples were taken randomly each day from each part of each basin. The sample volume was 300 ml. Water samples were routinely collected at 9:00 am each morning and analyzed to investigate water quality during the examination period. The measured parameters were: Total dissolved solids (TDS), Temperature, Duration of Sunlight and Humidity.

III. Results & Discussion

The study was applied under similar climatic conditions for 21 days of operation with sampling interval each 24 hours for the three parts of the basins. Three algae doses were applied, 150 ml/path, 300ml/path, 500ml/path. The measurements of different parameters through the experiments are illustrated in table 2 and figure 2.

The data in Table 2 and figure 2 show that the use of algae amount equal to 150 ml/path was not working for desalination this may be for the huge load on the algae that prevent its activity and maximum TDS removal efficiency did not exceed 0.00 % while the maximum TDS removal efficiency using algae amount equal to 300 ml/path reached to 62.67 %, the maximum TDS removal efficiency using algae amount equal to 400 ml/path in previous study [12] reached to 87.67 % and the maximum TDS removal efficiency using algae amount equal to 500 ml reached to 82.00 %.

Also the data show that from the 16th day till the end of the run there was very small change in TDS value and as well the TDS removal efficiency this may be due to the decrease of the TDS with the saturation of algae cells by salts.

Finally when the algae amount increase, the TDS removal efficiency increase, so the relation between the algae amount and TDS removal efficiency is directly proportional which also depend on climatic conditions such as the temperature and sunlight duration.

TABLE 2. TDS Removal Efficiency with different algae amount

Time (days)	Left Part (150ml/path)		Middle Part (300ml/path)		Right Part (500ml/path)		Previous study[12] (400ml/path)	
	TDS (ppm	R.Eff. (%)	TDS (ppm	R.Eff. (%)	TDS (ppm	R.Eff. (%)	TDS (ppm)	R.Eff. (%)
1	30000	0.00	30000	0.00	30000	0.00	30000	0.00
2	30000	0.00	28900	3.67	28400	5.33	28600	4.67
3	30000	0.00	27500	8.33	26500	11.67	26900	10.33
4	30000	0.00	25700	14.33	23700	21.00	24400	18.67
5	30000	0.00	22100	26.33	18600	38.00	19700	34.33
6	30000	0.00	19500	35.00	15600	48.00	16600	44.67
7	**30000**	**0.00**	**18600**	**38.00**	**14400**	**52.00**	**15400**	**48.67**
8	30000	0.00	18400	38.67	14200	52.67	15200	49.33
9	30000	0.00	17200	42.67	13300	55.67	14500	51.67
10	30000	0.00	16100	46.33	11900	60.33	13300	55.68
11	30000	0.00	15300	49.00	10100	66.33	11700	61.00
12	30000	0.00	14400	52.00	8600	71.33	9800	67.33
13	30000	0.00	13200	56.00	7300	75.67	8400	72.00
14	30000	0.00	12100	59.67	6400	78.67	7300	75.67
15	30000	0.00	11900	60.33	6200	79.33	7100	76.33
16	30000	0.00	11200	62.67	5400	82.00	6300	79.00
17	30000	0.00	10900	63.67	5100	83.00	5600	81.33
18	30000	0.00	10700	64.37	4800	84.00	4800	84.00
19	30000	0.00	10500	65.00	4500	85.00	4200	86.00
20	30000	0.00	10300	65.67	4300	85.67	3900	87.00
21	30000	0.00	10200	66.00	4200	86.00	3700	87.67

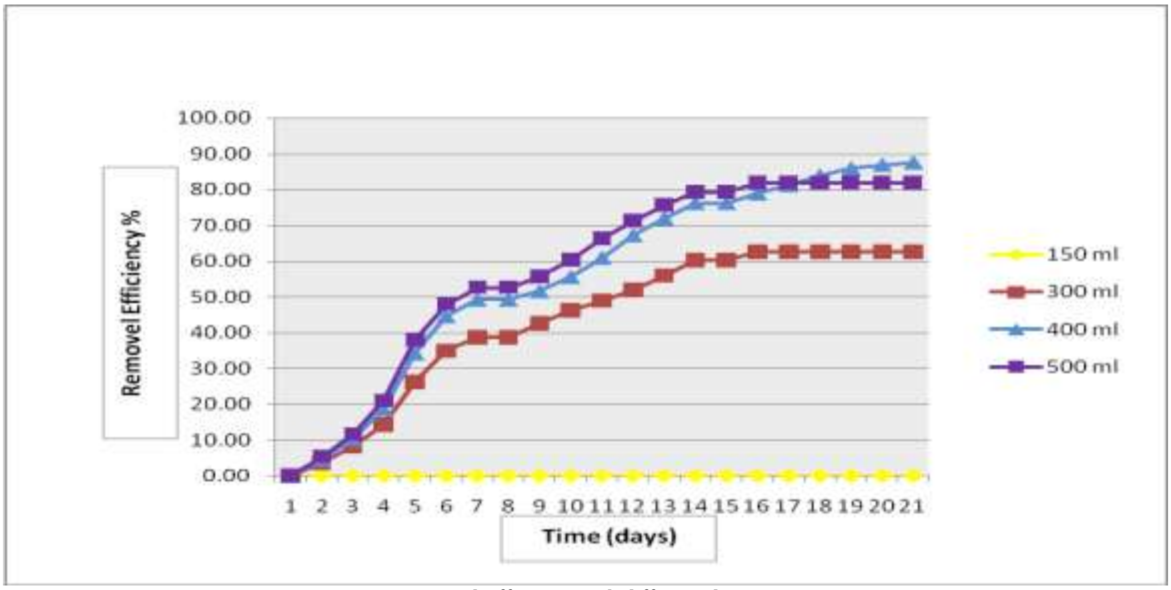

Fig. 2. TDS Removal Efficiency with different algae amount

The TDS removal efficiency with algae amount 400 ml is higher than the other efficiencies which means that 400 ml of algae is the optimum algae amount for algae desalination process.

IV. Conclusion

Generally, the results of this study had shown the following specific conclusions:-

1. The suitability of the biological desalination to be applied in the in Egyptian weather with all types of this weather.
2. *Scendesmus species* uptakes salt and make use of them in its metabolism.
3. The maximum TDS removal efficiency ranged from 87.67% at 400ml/path of algae amount to 66% with 300 ml/path algae amount. This means that the relation between the algae amount and TDS removal efficiency is directly proportional.
4. Using 400ml/path algae amount achieved the highest TDS removal efficiency which means that it is the best algae dose specially TDS removal decreased with the increase of algae amount. Or it can be said that this dose is the lowest best dose could be applied for water desalination that saves money and achieve the highest quality.
5. The number of stages depends on the degree of water salinity and the degree required of desalination.

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