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An Artificial Neural Network Approach for Modeling and Prediction of Energy Consumption in a Seawater Greenhouse

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ABSTRACT: Seawater greenhouse using humidification-dehumidification method can desalinate saline water and utilize fresh water for the greenhouse and drinking. Many parameters affect the performance of the seawater greenhouse. In this study, the effect of the width and length of the greenhouse, the height of the first evaporator and the roof transparency parameters on the energy consumption in the seawater greenhouse were investigated with the artificial neural network method. Artificial neural networks of the multi-layer perceptron have been used for modeling. An appropriate structure for this method was obtained and the mathematical statistics of the percent of the average absolute relative error, root mean square deviation, and square correlation coefficient were used to evaluate the network performance. The existing method is in good agreement with experimental data. Using this optimized network, the effect of each parameter on the energy consumption was evaluated. Finally, a greenhouse with a width of 125 meters, a length of 200 meters, an evaporator height of 4 meters, and a roof transparency of 0.6, which produces 161.6 m^3/day of fresh water and 1.558 kWh /m^3 of energy consumption, was introduced as an optimal seawater greenhouse.

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1. INTRODUCTION

Seawater greenhouse is a type of desalination unit that, using sunlight and seawater, humidifies the air inside the greenhouse and produces fresh water. This fresh water can be used for irrigation of agricultural products and drinking. Various studies on the seawater greenhouse have been carried out [1-7]. But, an artificial neural networks method to predict the behavior of the seawater greenhouse has not been proposed until now. The use of this method can be very effective in predicting the parameters due to the presence of various variables in the performance of the greenhouse.

In this research, the effective parameters of the seawater greenhouse have been studied using an intelligent neural network method and Multi-Layer Perceptron (MLP) method based on available data. The general objective of this study is to investigate changes in greenhouse width and height, evaporator height and roof transparency on the amount of water production and energy consumption.

2. THE SEAWATER GREENHOUSE MECHANISM

In the seawater greenhouse, humidification and dehumidification method is used for desalination of seawater or brackish water. In the humidification and dehumidification method, which works like a water hydrological cycle in nature, the air is first moisturized, and then this humid air is condensed and fresh water is produced. A simple seawater greenhouse consists of two evaporative cooling evaporators, a condenser, a fan, seawater and distilled water pipes, and crops between two evaporators. A view of the seawater greenhouse is given in Fig. 1.

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3. METHODOLOGY

In this research, an artificial neural network was used to optimize and improve operational conditions in a seawater greenhouse. One of the most important and most widely used smart methods is the multi-layer perceptron method.

Different learning algorithms such as conjugate gradient, gradient descent method, Levenberg and Marqwardt Algorithm are used. Choosing any algorithm is effective in computational time and network accuracy [8]. The results show that Levenberg and Marqwardt algorithm has the best performance in this system.

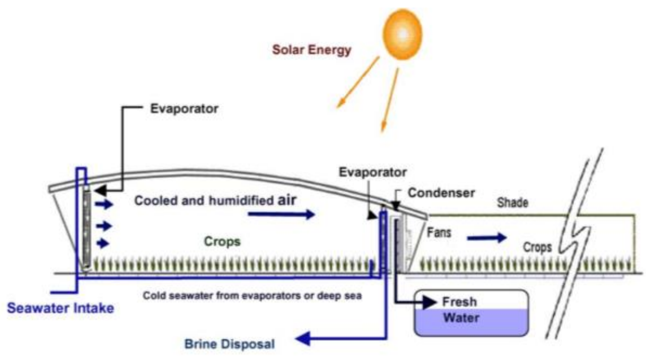

Fig. 1: Schematic of the seawater greenhouse [1]

4. RESULTS AND DISCUSSION

In this study, Goosen et al. [1] experimental data were used for the simulation of the seawater greenhouse parameters. They presented a thermodynamic model for the process of using mass balance and heat transfer equations. Given the configuration of the given greenhouse dimensions and the temperature and weather information of the site, their model estimates the amount of fresh water produced. The variables are classified into three groups: greenhouse (greenhouse orientation, roof transparency, front, and rear evaporation pad height and condenser), seawater and air discharge. The information and change range for the input variables examined is presented in Table 1.

1.4. The Effect of Parameters on Energy Consumption in the Seawater Greenhouse

Fig. 2 shows the validation of the MLP model. The results show good agreement with experimental data. Fig. 3 shows the effect of the greenhouse width on energy consumption in the different lengths of the greenhouse. Fig. 4 indicates the effect of different evaporator height and greenhouse width on energy consumption

5. CONCLUSION

In this study, the effect of greenhouse design parameters such as width, length, the height of evaporator and roof transparency on energy consumption of greenhouse using artificial neural network was investigated. The results showed that the geometric dimensions of the greenhouse, such as width, length, and height of the evaporator, affect the energy consumption per unit of water produced. By increasing the width of the greenhouse in a constant length, the energy consumption initially increases and then decreases. At constant width, increasing the roof transparency, the energy consumption first increases and then decreases. As the evaporator height increases, the energy consumption may increase or decrease. The optimum greenhouse has 125 meters wide, 200 meters long, and the evaporator height of 4 meters and the roof transparency of 0.6. This greenhouse produces 161.6 cubic meters per day of fresh water and consumes 1.558 kWh/m³ energy.

Table 1: The variables range in the seawater greenhouse

Parameter of interest	Range of changes
Width	50-200 m
Length	50-200 m
Front evaporator height	2-4 m
Roof transparency	0.4-0.6

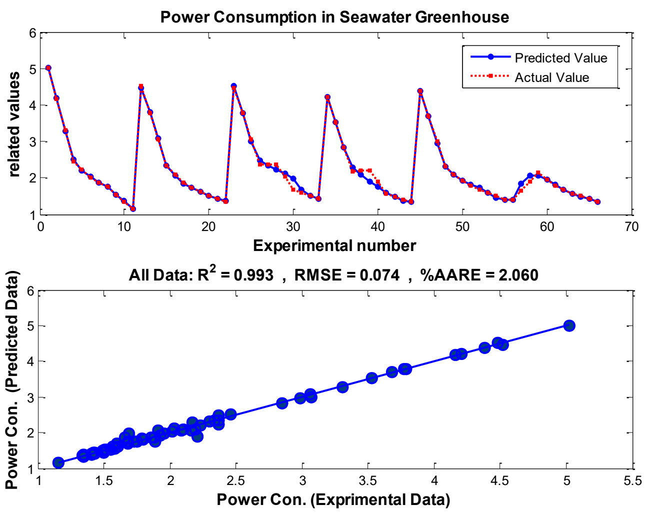

Fig. 2: Estimated values with MLP model of energy consumption (kWh / m³) versus experimental data

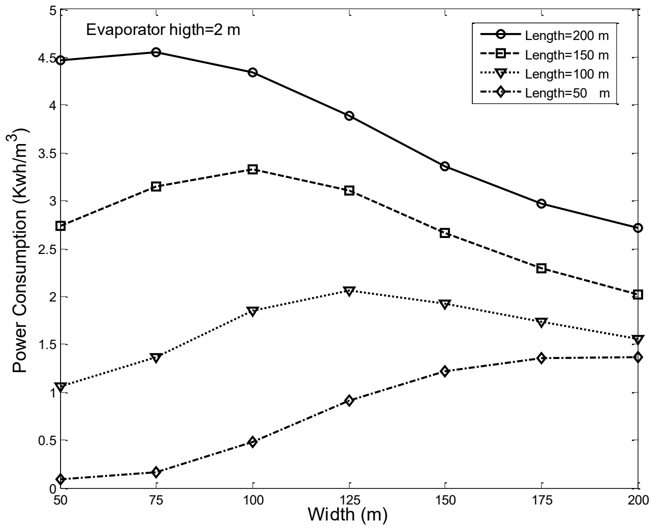

Fig. 3: Effect of greenhouse width on energy consumption at a constant evaporator height of 2 m and roof transparency of 0.6

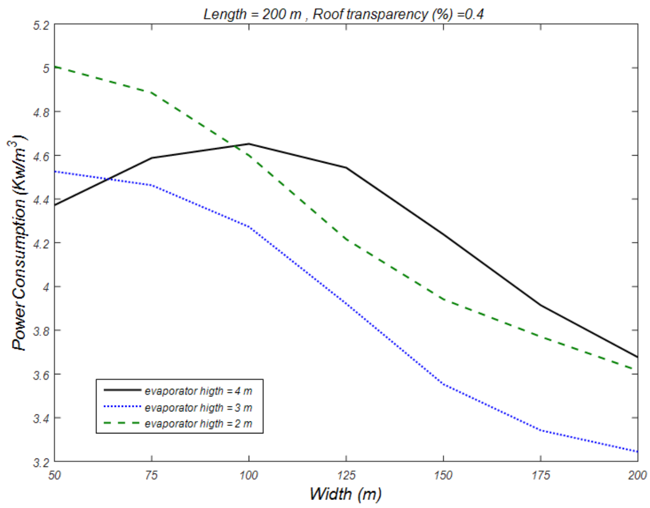

Fig. 4: Effect of different evaporator height and greenhouse width on energy consumption

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