Investigation and Design Seawater Desalination with Solar Energy

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Abstract: While the global population rises, the supplement of fresh water is becoming a major concern. A number of seawater desalination approaches have been designed during the decades to contribute for overcoming fresh water shortage. Two kinds of these system have been introduced in this paper to be installed close the sea and in second one in dried regions such as deserts. This system is environmental friendly and cost effective. All the system equipment is designed to make from recycling materials.

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Keywords: Seawater desalination; Fresh water; Energy; Solar evaporation; Recycling material, Wind catcher

1. Introduction

The world's population is becoming increasingly concerned and different challenges occurred regarding to food and fresh water security in the world. Shortage of fresh water is a major issue since only less than 0.5% of available water resources in the earth are as fresh water [1]. Fresh water is playing a critical role in human life as well as in agriculture and industrial process. Moreover, about 97% of the earth is covered by sea and ocean's water, which are unsuitable for human desires. One of the main strategies to solve this problem is water management through investigation of new source of water supply such as water desalination. Nowadays, desalination from the limitless resources of earth's water is becoming one of the precious challenges in the world [2]. Currently, many researches are being performed about desalination systems especially in dried and mid-dried countries such as Middle Eastern countries [3]. All the different desalination approaches has been developed during the decades are based on thermal distillation, membrane separation, freezing, and electrophoresis. Among these methods Reverse Osmosis (RO), multi-stage flash (MSF), and multiple-effect distillation (MED) are more worldwide and leading systems [4, 5]. Different source of energies are applied in a desalinating system, some of the systems are very expensive due to the type of energy being used to desalinate [2]. The application of free solar energy maintains the overall system expenses very low down. Basically in a desalinating based on solar evaporation, the process starts by heating up the seawater through sun rays, and the produced water vapor later condense by a cool surface. The main purpose of this study is to design a solar desalination system using recycling material, in which the cost of system will reduced dramatically. The proposed plan is at a concept level and can be potentially implemented at an industrial scale. Two desalination systems are presented in this paper, the first one is useful to install close to seawater in general for humid region and the second system could be establish in dry climate such as deserts.

2. Material and Methods

System 1 and 2: The required components as shown in figure 1 are the following:

Component 1 - Larger Dish made out of transparent plastic. The UV plastic material comparing to all other transparent or clear plastics is preferable because it has green house effect and also has a high absorption for heat. However this is not necessarily recommended to be implemented at industrial scale due to its high cost. The edge of this dish is flat but gets deeper toward the centre. This component is identified by number 1 in figures 1 and 2 of this document [6].

Component 2- Smaller Cone connected to a pipe. This cone receives water drops and moves them into a main pipe. This component is identified by number 2 in Figures 1 and 2 of this document.

The numbers in figure describes the following parts or energy, 1: larger dish, 2: smaller cone, 3: earth, 4: water vapor, 5: water droplets, 6: solar rays [7], 7: air valve, 8: wind catcher [7], 9: wind, 10: pump, 11: water collected storage.

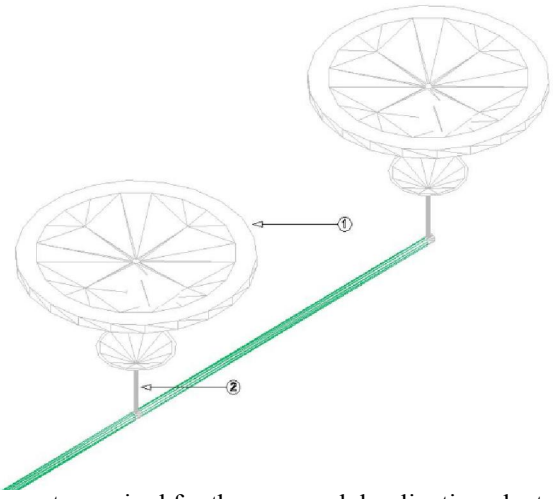

Figure 1. Components required for the proposed desalination plant

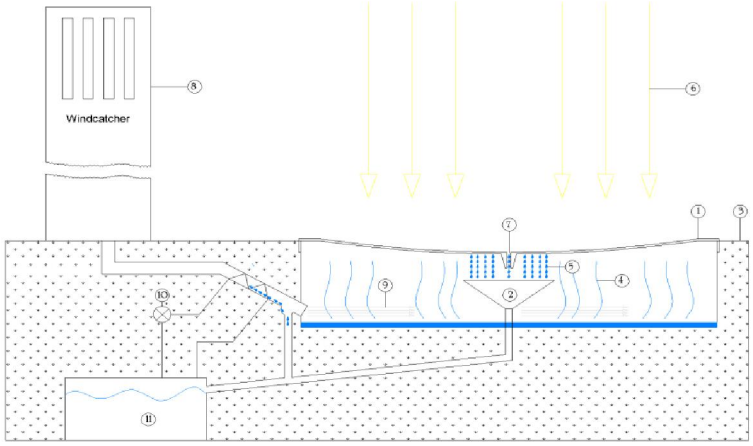

Figure 2. Desalination concept

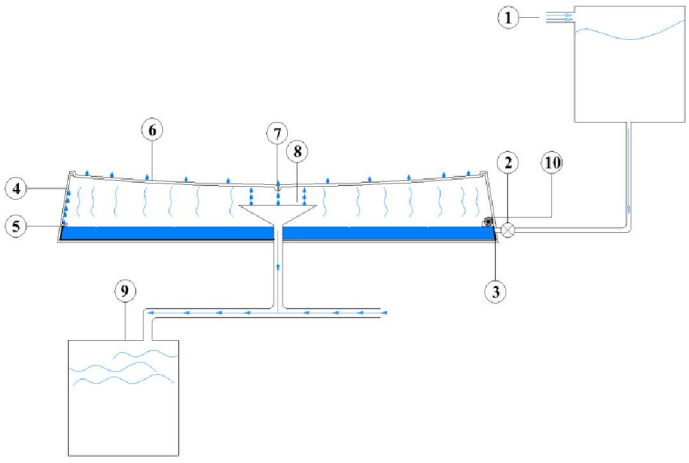

Figure 3. System 2 for water desalination useful for setting up in desert

3. Installation Guide

1. Dig a ditch in the sand by the sea as shown in figure 2. The dimension of this ditch depends upon the dimensions of components 1 and 2 described above.
2. Insert component 2 (smaller cone) into the ground such that part of the pipe is into the ground. This is shown as number 2 in figure 2 of this document.
3. Locate Component 1 (larger dish) to cover the ditch such that the flat edges are inserted into the ground [6]. This is shown as number 1 in figure 2 of this document.

4. Desalination Mechanism

Sand on the shoreline absorbs significant amount of water from the sea while also removing some of the salt and excess minerals from the water. Sun heat reflected toward the Larger Dish (shown as number 6 in Figure 2) as well as the water in the sand will cause the green house effect in the ditch. Moreover, the temperature difference between inside and outside of the ditch will cause the humidity inside the ditch to be evaporated and raised to the convex surface of the larger dish (Component 1) as desalinated water (shown as number 4 in figure 2) and will then slide toward the center, and finally will be poured into component 2 (shown as number 5 in figure 2) which is connected to a pipe linking to the final destination. The final destination (number 11) is storage for collecting the fresh water. In order to maximize production of our desalinated water system, the following extra parts added to the system. Number 7 is designed as an air valve in the center of the larger dish which will open due to the weight of collected rain and later it conducts the rain toward the smaller cone. Furthermore, number 8 is a wind catcher in order to increase the evaporation process and lastly, number 10 is a pump, which contributes the circulation of water around air entrance gate. This pump obtained its energy from wind turbine and this mechanism convert the humid air to dry air before let it go [8].

Moreover, the second system designed to be set up in dried regions such as lout and center deserts of Iran. The main mechanism of system 2 is similar to our previous system with some modification. Figure 3 represents the schematic of system 2 in which number 2 is an automatic valve to adjust the amount of water entrance. Next, the system applied a dark plate that attract the solar rays and transfer the involved energy [9] to water as heat source. Moreover, number 4 is a transparent plastic structure in order to catch the maximum duration of solar energy and number (10) 5 collect the droplets from slopped wall. The slopped water itself is helpful for easier collecting of the water droplet. Finally a fan is designed (number 10) that produce air circulation to increase the evaporation rate and obtained its energy from solar energy.

Number 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 describes the following respectively water entrance gate, automatic valve, dark plate, slopped wall, water droplet conductor, larger dish, air valve, smaller cone, water collector storage, and fan.

5. Conclusion

This paper has introduced an innovative and effective approach to desalinate water by proposing a cost effective concept, which is low not only in capital, but also maintenance, and operational cost. The system is also environmental friendly and does not require any fossil based energy and all system is made of recycling materials. The disadvantage maybe slow pace and the low capacity of produced desalinated water, and also the flavor that the resulted water will contain. Therefore, applicability of this system is mostly advantageous for irrigation, in particular any landscaping including plants and grass by the seaside. For future advances the growing of sea plants mostly algae in these systems could increase the quality of fresh water by reducing the nitrate from sea water [11]. Both systems include number of advantages such as application of wind catcher in system 1 has the main purpose as using fan in system 2. Both of these parts increase the overall yield of system by referring to formula [13]

$g = \Theta A (XS - X) / 3600$

g is amount of water evaporation.

$\Theta = (25 + 19 V)$ = evaporation coefficient (kg/m^2h)

V = velocity of air above the water surface (m/s)

A = water surface area (m^2)

XS = humidity ratio in saturated air at the same temperature as the water surface (kg/kg)
(Kg H_2O in kg dry air)

X = humidity ratio in the air (kg/kg)
(Kg H_2O in kg dry air).

For example, suppose there is no wind in area A, g would be equal to

$$g = (25 + 19 \times 0) \times 3.14 (0.019826 - 0.0115)/3600)$$

= 1.81 kg/s

and if the wind consider as 1 m/s, g is calculated 3.195 kg/s, almost the double amount of evaporation through using wind power. In addition, a number of important elements of seawater such as sodium, potassium, magnesium, and etc [12] will settle and could be collected and use for other purposes Figure 4.

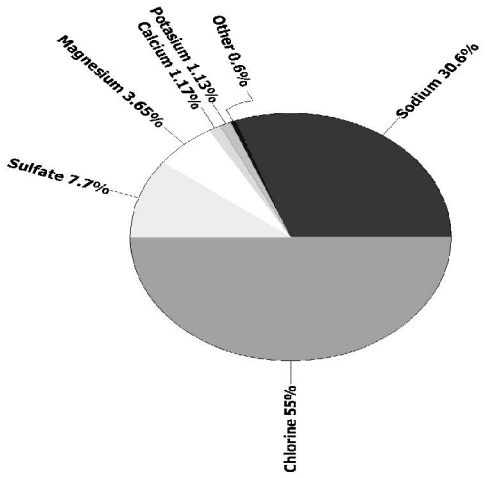

Figure 4. Amount of different elements in oceans [12]

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