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Preface

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THE 4th INTERNATIONAL CONFERENCE ON ENVIRONMENT, SUSTAINABILITY ISSUES AND COMMUNITY DEVELOPMENT (INCRID)

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On behalf of the committee, I would like to express my sincere gratitude to all colleagues, professors, lecturers, researchers, and welcome you all to the 4th INCRID 2022 "Supporting the Realization of Zero Carbon Environment by Implementing Circular Economy". This conference provides a great opportunity for researchers, students, industries, and governments to communicate their research results on the fundamentals and application of sustainability issues and community development.

INCRID 2022 was held on 1 September 2022 in the online system and the theater room 5th floor of the Faculty of Engineering Diponegoro University, Semarang (hybrid). Keynote and invited speakers were Prof. Ramaraj Boopathy Nicholls State University, USA, Dr. Premakumara Jagath (Institute for Global Environmental Strategies, Japan), Prof. Pau Loke Show (University of Nottingham Malaysia), Prof. Sudharto P. Hadi, MES, Ph.D. (Universitas Diponegoro, Indonesia), Prof. Ir. Tjandra Setiadi, M.Eng., Ph.D. (Institut Teknologi Bandung, Indonesia), Prof. Dr. Soraya Heuss-Aßbichler (Ludwig-Maximilians-Universität München, Germany).

At this conference we have contributions from seven countries. We received about 118 submissions of papers for presentation at this meeting. Each paper was evaluated by a reviewer and about 85 of these are accepted for presentation, divided into 12 parallel presentation sessions. The topics of this conference include Environmental, Health and safety; environmental science, technology, and education; Green infrastructure; and Energy Conservation and Efficiency. It is my hope that the 4th INCRID 2022 will be able to achieve its objective of creating an international forum for researchers, students, industries, and governments to communicate their research results, to share and exchange ideas on the fundamentals and application of environmental, sustainability issues, and community development.

By bringing up this theme, the Department of Environmental Engineering and the INCRID 2022 Committee want to support the efforts of the World to achieve the goal of emission reduction and Net Zero Emission (Carbon neutrality). Furthermore, this activity is expected to support efforts to implement the concept of the circular economy.

Last but not least, my deepest gratitude goes to the Advisory Board, Organizing Committee, International Scientific Committee, institutions, companies, and volunteers who have directly and indirectly supported the success of this conference. Although we try our best to be professional, on behalf of the committee, we request you to accept our sincere apologies for any inconvenience.

Dr. Yustina Metanoia Pusparizkita, S.T., M.T.
Chairman of the 4th INCRID 2022

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NAME OF THE EVENT

The 4th International Conference on Environment, Sustainability Issues and Community Development 2022 (4th INCRID 2022)

THEME

"Supporting the Realization of Zero Carbon Environment by Implementing Circular Economy."

The topics of the conference are as follows.

A. Environment, Health, & Safety

– Environment, health, and safety system
– Environmental modeling and computation
– Risk analysis

B. Environmental Science, Technology, and Education

– Waste management and treatment
– Water and wastewater engineering
– Environmental education

C. Green Infrastructure

– Life cycle assessment
– Green building and technology option

D. Energy Conservation and Efficiency

– Clean and renewable energy
– Climate change and global warming

OBJECTIVES OF THE EVENT

The objections of INCRID 2022 are as follows:

- To create an international forum for researchers, students, industries, and governments to communicate their research results on the fundamentals and application of environment, sustainability issues, and community development.
- To share and exchange ideas, thoughts, and discussions on all aspects of the environment, sustainability issues, and community development.
- Facilitate the formation of networks among participants to enhance the quality and benefits of research and development.

PARTICIPANTS

This international conference is open to academicians, researchers, students, and professionals worldwide.

SPEAKERS

Keynote Speakers

No	Name	Institution and Country
1	Prof. Ir. Tjandra Setiadi, M.Eng., Ph.D	Institut Teknologi Bandung, Indonesia
2	Prof. Sudharto P. Hadi, MES, Ph.D	Universitas Diponegoro, Indonesia
3	Prof. Dr. Soraya Heuss-Aßbichler	Ludwig-Maximilians-Universität München, Germany
4	Prof. Pau Loke Show	University of Nottingham, Malaysia
5	Dr. Ramaraj Boopathy	Nicholls State University, USA
6	Dr. Premakumara Jagath	Institute for Global Environmental Strategies, Japan

SCHEDULE

1st Round Submission

Deadline for Abstract Submission	7 June 2022
Notification of Abstract Submission	9 June 2022
Deadline for Full Paper Submission	23 June 2022
Review Result	1 July 2022
Revised Paper Submission	9 July 2022
Deadline for Registration and Payment	23 June 2022

2nd Round Submission

Deadline for Abstract Submission	10 July 2022
Notification of Abstract Submission	12 July 2022
Deadline for Full-Paper Submission	26 July 2022
Review Result	2 August 2022
Revised Paper Submission	10 August 2022
Deadline for Registration and Payment	26 July 2022

Presentation File Submission

(28th August 2022)

Conference Day

(1st September 2022)

VENUE

Online and 5th floor Faculty of Engineering Universitas Diponegoro

Jl. Prof. H. Soedarto, S.H., Semarang, Indonesia

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2. Dean of Engineering Faculty, Diponegoro University
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Published online: 16 November 2022

Open all abstracts

Preface

Environment, Health and Safety

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PAPER • **OPEN ACCESS**

Effect of Glass Cover Thickness and Inclination Angle on Distillate Efficiency of Single-Stage Solar Still

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Effect of Glass Cover Thickness and Inclination Angle on Distillate Efficiency of Single-Stage Solar Still

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Abstract. Solar desalination is one of many methods to separate excess salt from seawater. In this work, solar energy is applied because of its economical and environmental value. Additionally, solar energy is practical to use in the coastal region. To increase the distillate produced by the solar still, four variations of cover thickness and three variations of inclination angle are applied to the still. The cover thickness and inclination angle used in this work are 3 mm, 5 mm, 8 mm, 10 mm and 25°, 30°, 45°. The type of still that is used in this work is a rectangular-shaped single-stage solar still with an area of 0.8 m^2. The desalination processes in this work were done from 09.00 until 16.00 and the data was collected every hour in the processes. The result of this work shows that the distillate efficiency produced by the solar still is 1.03% - 6.91%. The highest solar intensity is 1231.97 W/m^2 and the lowest solar intensity is 101.03 W/m^2. The most effective efficiency was obtained with the variation of 3 mm cover thickness and 25° inclination angle, while the lowest efficiency was obtained with the variation of 10 mm cover thickness and 30° inclination angle.

1. Introduction

Water is one of the most important components for the human being. According to the *United States Geological Survey* (USGS), ninety-seventh percent of available water resources on earth are saline water and the other three percent is fresh water. Of the three percent of fresh water, only around one percent can be accessed by humans to fulfil their daily needs [1]. Out of one percent water that can be accessed, not all water can be used directly. The water needs treatment as it still contains pollutant and other harmful microorganisms. Because of the limited availability of fresh water, one of the alternatives that can be done is to utilize the abundantly available seawater.

To utilize the abundantly available seawater, the excess salt must be separated from the water. One of the methods to separate excess salt from seawater is solar desalination. Although the efficiency dan the distillate output of the solar desalination method is fairly low compared to the other desalination method, solar desalination is still being used because of its economical and environmental value. Also, solar desalination is more practical to use in the coastal region because it uses simple materials and simple operating procedures. Solar desalination can be classified into two types, direct solar desalination and indirect solar desalination [2]. In this work the types of desalination used is passive direct solar desalination. The passive direct solar desalination only used solar as it main source of energy, and the heat is directly transferred to the still [2].

The efficiency of the solar desalination is affected by several climate factors such as solar irradiation, weather, ambient temperature, wind speed, and humidity [3]. Solar desalination efficiency is also affected by brine depth, vapor leakage, the slope of the transparent cover, the thickness of the transparent cover and the material used as the transparent cover [4]. The operation of solar desalination is done by using an evaporation basin that was covered using a transparent cover. The sunlight was used to increase the basin and water temperature so that the water temperature rise and the water will be evaporated until it touches the transparent cover and turned into a water droplet that slides down the cover [4].

Previously, several research on desalination had been conducted. Wijaya (2021) has done the water desalination using the same desalination set used in this work using flannel color variation and different artificial saline water concentration. The maximum distillate efficiency obtained by Wijaya was 4,94% and the volume of the distillate produced was 570 ml with 645 W/m^2 solar irradiance using black colored flannel and the research was done from 09.00-15.00 [5]. Mulyanef (2015) has also done similar work to Wijaya (2021) using single stage solar still. The volume of the distillate produced on Mulyanef's research was 2012 ml/day with 451 W/m^2 solar irradiance and the research was done at 1 day time [6]. To improve the distillate efficiency in this work, glass cover thickness and inclination angle variation will be applied to the still to know the best cover thickness and inclination angle that can improve the efficiency of the distillate that is produced by the still.

2. Methodology

In this work, desalination processes were done on the 10th floor of Building I at Trisakti University, Jakarta and it was done from April until June 2022. Also, the desalination was done on 7 hours of observation from 09.00 until 16.00. The type of water used in this work was artificial saline water that was made by using fresh water and sea salt until the salinity reach 35‰.

The solar still used in this work is rectangular-shaped solar still with an area of 0.8 m^2. The solar still was insulated using styrofoam, while the still was made of aluminium so that the heat will be transferred equally inside the still. Also, black flannel is used as an absorber because the water flowed continuously into the still. The use of black flannel was done because the black color is easier to receive heat than the brighter colored flannel. The top of the still is covered with a transparent glass cover. The desalination set used in this work can be seen in Figure 1.

Figure 1. Solar Desalination Set

There are also several variations of glass cover thickness and inclination angle that are applied to the still. The glass cover thickness used in this work are 3 mm, 5 mm, 8 mm, and 10 mm. The inclination angle of the solar still used in this work are 25^o, 30^o, and 45^o. In this work, the data was collected on every hour of operation starting from 09.00 to 16.00 and for every variation, the data were collected on two days of operation. The solar still and reservoir temperature that were measured during the operation can be seen as in Figure 2.

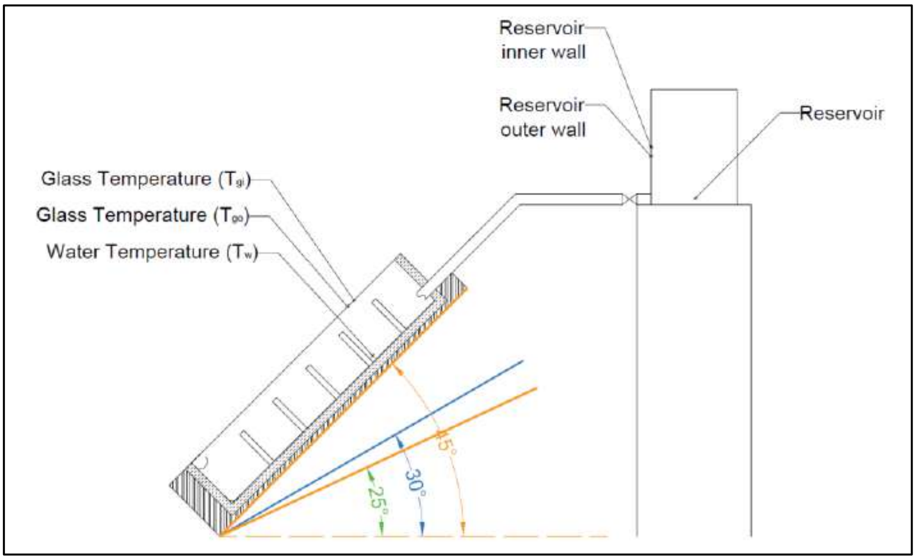

Figure 2. Temperature Measurement Point

The actual efficiency of the solar still is measured by using Equation 1 [7].

$$\text{Actual efficieny} = \frac{\text{SS distillate volume}}{\text{Volume of artificial saline water entered SS}} \text{ x } 100\% \quad (1)$$

The theoretical efficiency in this work is analyzed by using Equation 2 [8].

$$\text{Theoretical efficiency} = \frac{Q_u}{Q_{in}} \text{ x } 100\% \quad (2)$$

$$Q_u = M_d \text{ x } C \text{ x } \Delta T + M_d \text{ x } h_{fg} \quad (3)$$

$$Q_{in} = \propto \text{ x } I(t)_s \text{ x } A_c \text{ x } t \quad (4)$$

Where C is the specific heat of water (J/kg°C), ΔT is temperature differences (°C), M_d is distillate water (kg), h_{fg} is latent heat (J/kg), $\propto$ is Absorptivity, $I(t)_s$ is total solar irradiance (W/m^2), A_c is collector area (m^2), and t is the time of operation (s).

Water quality testing were also done on the distillate and brine produced by the solar still. The checked in-situ parameter was salinity, electric conductivity (EC), total dissolved solids (TDS) and pH. While the checked ex-situ parameter was turbidity, Cl^- ion, total hardness, magnesium hardness, calcium hardness, iron, and Escherichia coli. The ex-situ measurement in this work was done at Trisakti University Environmental Laboratory, Jakarta, Indonesia.

3. Results and discussion

The data of the distillate amount on this work was measured every hour from 09.00 until 16.00 for every variation and can be seen in Figure 3.

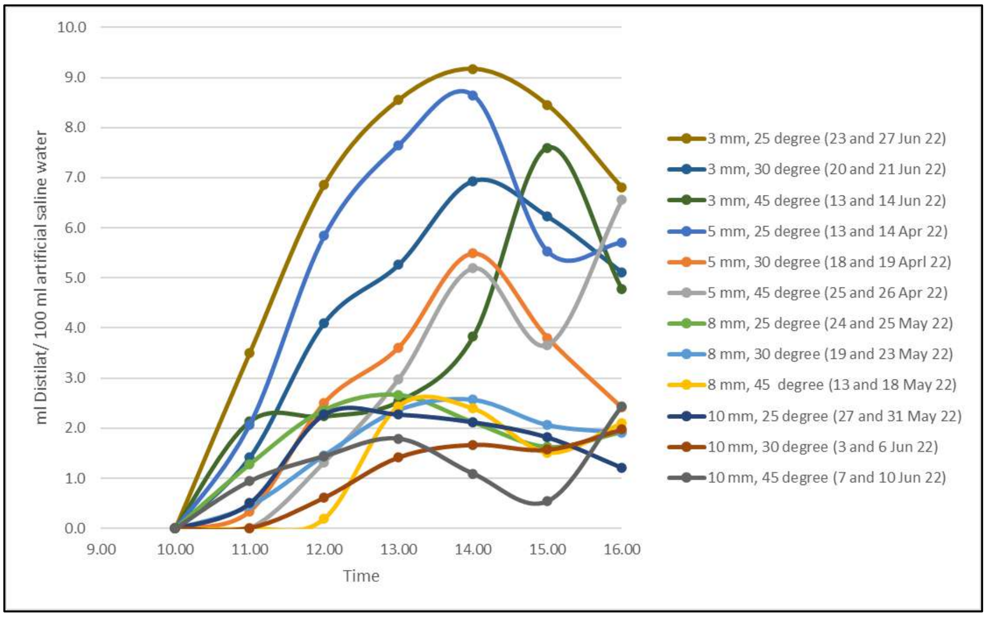

Figure 3. Distillate produced per hour

Figure 3 shows distillate that was produced per 100 milliliter artificial saline water which the value varies for every cover thickness and inclination angle. The highest distillate output was obtained using variation of 3 mm cover thickness and 25° inclination angle. While the lowest distillate output was obtained using variation of 10 mm cover thickness and 30° inclination angle. It could also be seen that the distillate only starts to produce at 11.00. The delay in the production of distillate was affected by the low water flow rate that is used in this work. It could also be seen that the distillate volume produced by the kept increasing until around 14.00 and then it would significantly gone lower affected by the sun movement that is also reducing the solar irradiation received by the still.

3.1. Distillate efficiency

Actual distillate efficiency that was produced by the solar still is calculated by using Equation 1 and the theoretical efficiency is calculated by using Equation 2. The actual and the theoretical efficiency can be seen in Table 1.

Table 1. Actual and Theoretical Efficiency

Cover Thickness	Angle	Actual Efficiency (%)	Theoretical Efficiency (%)	Actual Efficiency (%) Per Liter Artificial saline water
3 mm	25	6.19	7.13	0.91
	30	4.15	4.63	0.60
	45	3.30	6.12	0.47
5 mm	25	5.06	5.87	0.63
	30	2.59	2.71	0.36
	45	2.81	3.01	0.34
8 mm	25	1.71	2.40	0.24
	30	1.55	1.85	0.22
	45	1.23	1.43	0.17
10 mm	25	1.46	1.71	0.21
	30	1.03	1.43	0.15
	45	1.18	1.52	0.17

It can be seen from Table 1 That the highest actual efficiency and theoretical efficiency were obtained using variation of 3 mm cover thickness and 25° inclination angle amounting to 6.19% and 7.13% While the theoretical efficiency was obtained using variation of 10 mm cover thickness and 30° inclination angle amount to 1.03% and 1.43%. If compared to the previous work done by Wijaya (2021), it could be known that adjusting the cover thickness and inclination angle will affect the distillate produced by the still [5]. In Wijaya's work the highest actual distillate efficiency was 4,94% using 5 mm glass cover thickness and 25° inclination angle, while in this work the highest actual distillate efficiency was 6,19% using 3 mm cover thickness and 25° inclination angle.

From Table 1, it could also be seen that the actual efficiency was lower than the theoretical efficiency. The 3 mm cover thickness and 25° inclination angle has higher efficiency than the 10 mm cover thickness and 30° inclination angle was affected by the energy loss because the thicker glass cover and the higher inclination angle will result in more energy lost [9]. The actual efficiency was calculated based on the distillate produced by the solar still, while the theoretical efficiency was calculated based on the thermal processes inside the still. Percent actual efficiency achieved to theoretical efficiency can be seen in Figure 4.

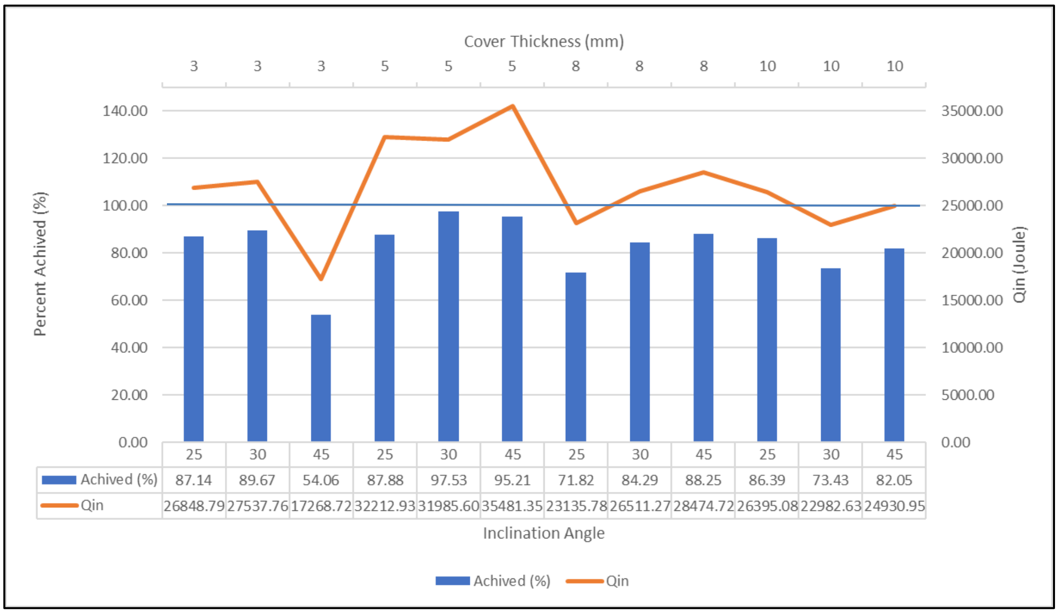

Figure 4. Achieved actual efficiency to theoretical efficiency

From Figure 4, the percentage efficiency achieved follows the fluctuation of incoming energy to the still. The incoming energy was calculated based on the solar irradiation as shown in Equation 4. Therefore, it could be known that the percentage of actual efficiency to theoretical efficiency achieved by the still was affected by the fluctuation of solar irradiation. It could also be seen from Figure 5 that it is true that the distillate efficiency and the incoming energy to the evaporator has a linear relationship [10].

3.2. Cover Thickness

The optimum cover thickness in this work was analyzed by calculating the distillate volume per 10.000-joule incoming energy and can be seen in Figure 5. The incoming energy was calculated based on the solar irradiation as shown in Equation 4.

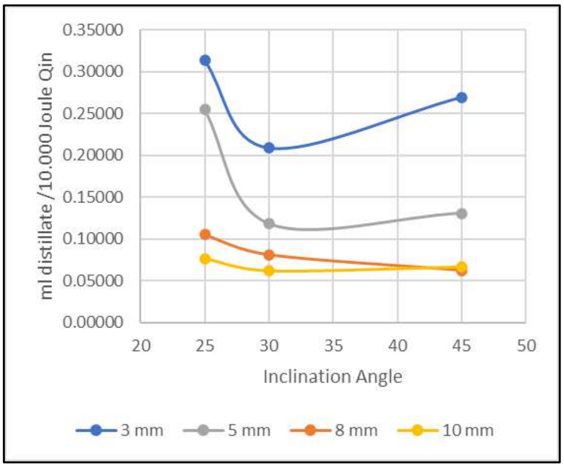

Figure 5. Distillate volume per 10.000 joule Q_{in}

Figure 5 shows that the most distillate volume produced by the still was obtained by using 3 mm, 5 mm, 8 mm, and 10 mm cover thickness respectively. The difference in the produced distillate for every cover thickness was affected by the still temperature. The thicker glass cover has lower water temperature than the thinner glass cover [11]. So that the distillate water produced by using 10 mm glass cover was significantly lower than the 3 mm, 5 mm. and 8 mm glass cover. Although the more thinner glass cover has higher distillate efficiency, it is also important to note that the thinner glass cover is more prone to breaking, so that the thinnest glass cover used in this work is 3 mm.

3.3. Inclination Angle

The optimum inclination angle in this work was analyzed by calculating the distillate volume per 10.000-joule incoming energy and can be seen in Figure 6.

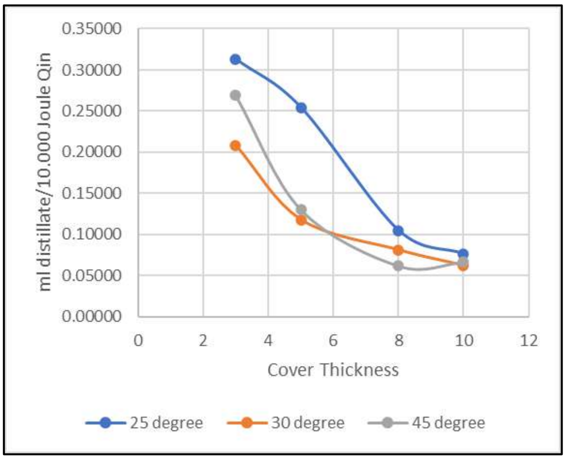

Figure 6. Distillate volume per 10.000 joule Q_{in}

Figure 6 shows that the most distillate volume produced by the still was obtained by using 25° cover angle. The difference in the produced distillate for every inclination angle was affected by energy loss The higher inclination angle will reflect more heat energy to the environment so that the energy that enters the still would be lower than the 25° inclination angle [9]. If the inclination angle used was lower than a certain degree, it could also be possible that the still would produce fewer distillate because the distillate would fall to the still before it reaches the effluent channel [12].

3.4. *Water Quality*

Water quality is also tested in this work. The result of the water quality tested in this can be seen in Table 2. The tested parameters are pH, turbidity, Cl^- ion, total hardness, calcium hardness, magnesium hardness, iron, electric conductivity, total dissolved solids, salinity, and Escherichia coli.

Table 2. Water Quality

Parameter	Artificial Saline Water	Brine	Distillate	Standard*
pH	8.16 – 8.73	8.4 – 8.86	7.4 – 8.66	-
Turbidity (NTU)	8.86 – 35.6	0 – 7.69	0 – 3.55	4
Cl^- ion (mg/L)	20,593.61 – 27,591.44	23,392.75 – 35,389.07	4 – 53.98	200-300
Total hardness (mg/L)	1,452 – 2,120	1,464 – 2,608	0	-
Ca hardness (mg/L)	40.4 – 486.4	81.6 – 707.2	0	100-300
Mg hardness (mg/L)	116.16 – 379.2	111.36 – 464.64	0	-
Fe (mg/L)	0 – 4.17	0 – 2.18	0 – 0.68	0.3
EC (µS)	56,000 – 58,100	58,500 – 100,500	14-214	<600
TDS (mg/L)	28 – 29.2	20.6 – 52.5	7 - 83	-
Salinity (‰)	34.8 – 35.7	35.6 – 69.2	0	-
E-coli	0	0	0	0

*WHO drinking-water guideline

Based on the WHO drinking-water guideline [13], the water produced by this solar desalination cannot be consumed directly because the water still contained an excess iron parameter and further processing is required for the water to lower the iron parameter.

4. Conclusion

The highest actual efficiency was 6.19%, obtained using variation 3 mm cover thickness and 25° inclination angle. While the lowest actual efficiency was 1.03%, obtained using variation 10 mm cover thickness and 30° inclination angle. The highest theoretical efficiency was 7.13%, obtained using variation 3 mm cover thickness and 25° inclination angle. While the lowest theoretical efficiency was 1.43%, obtained using variation 10 mm cover thickness and 30° inclination angle

Distillate water produced by the desalination processes met the quality standard for turbidity, Cl^- ion, calcium hardness, TDS, and Escherichia coli parameters. While the iron parameter is still above the quality standard, so the water has to undergo more processes to be consumed directly as drinking-water

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