



Comprehensive passive-mode performance analysis on a new multiple-mode solar still for sustainable clean water processing

Tijani Oladoyin Abimbola^{a,*}, Husna Takaijudin^a, Balbir Singh Mahinder Singh^b, Khamaruzaman Wan Yusof^a, Abdurrahman Said Abdurrahman^{a,c}, Ebrahim Hamid Hussein Al-Qadami^a, Abubakar Sadiq Isah^a, Kai Xian Wong^a, Nur Farhanah Ahmad Nadzri^a, Samiat Abike Ishola^d, Tunji Adetayo Owoseni^e, Suleiman Akilu^f

^a Department of Civil and Environmental Engineering, Universiti Teknologi PETRONAS, 32610, Bandar Seri Iskandar, Perak, Malaysia

^b Department of Fundamental and Applied Sciences, Universiti Teknologi PETRONAS, 32610, Bandar Seri Iskandar, Perak, Malaysia

^c Department of Civil Engineering, Ahmadu Bello University, Zaria, Kaduna State, Nigeria

^d Department of Marine Sciences, University of Lagos, Akoka, Lagos State, Nigeria

^e Department of Mechanical Engineering, The University of Nottingham, NG72RD, United Kingdom

^f Centre for Nanotechnology Research, Universiti Teknologi PETRONAS, 32610, Bandar Seri Iskandar, Perak, Malaysia

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ABSTRACT

The solar still is potential to augment clean water supply in the rural and low-income settlements. However, the current efficiency of the device is low. In this study, we report the fabrication and experimental performance analysis of a high-efficiency multiple-mode solar still—tagged Desal-1.5. The solar still was investigated in passive mode, relying entirely on natural insolation. Both desalination and ordinary water purification experiments were conducted on the device using seawater and moderately polluted lake water, respectively, between 09:00 and 18:00 h of Malaysia's tropic weather. The optimum freshwater yield of the prototype within the interval was 5780.5 ml/m², while the optimum solar-to-vapor conversion efficiency, evaluated using the transient latent heat of vaporization, was 161.4%. Furthermore, for the first time on a solar still geometry, condensate loss due to condensate collection channel slope has been estimated in this study for our Desal-1.5. The loss amounted to 18.5% of the actual condensate collection. Eventually, water quality assessments of distillates from the device showed good compliance with both WHO and Malaysian drinking water standards. Thus, the recommendation of the solar still to ameliorate freshwater scarcity and support sustainable clean water provision in the rural and low-income regions is strengthened.

1. Introduction

One of the significant challenges of the current era is freshwater scarcity (Belhassen, 2021; Richard, 2005). Climate change, population growth, industrialization and pollution dispersal in water resources have created a fierce competition for the finite freshwater reserves (Sayed et al., 2021). The effect of this scarcity is more pronounced in the rural and low-income territories around the world owing to the inadequacy of freshwater reserves and the dearth of infrastructures for the delivery of clean and potable water in those regions (Mesfin and Arjen, 2016). To deal with water scarcity, various measures have been implemented from the combined natural, conservational and economic points of view. Unfortunately, these measures were not sufficient to curtail the problem

of water scarcity—they have only helped to either conserve or manage the use and the delivery dynamics of the available water. Consequently, engineering solutions – by means of seawater desalinate (Abdulrahman, 2019; Akshay et al., 2018; Menachem and William, 2011) and recovery of clean water from wastewater (Gude, 2017) – were advocated as viable options to augment the global freshwater index.

Reverse osmosis, multi-stage flash distillation, multi-effect distillation, electrodialysis and nanofiltration are prominent amongst the several techniques that have been developed to desalinate seawater (Abimbola et al., 2021; Jones et al., 2019). However, these techniques are expensive and energy-intensive (Voutchkov, 2018). Due to huge installation capital, high operational technicalities and sophisticated maintenance procedures, the adoption of the highlighted techniques at the rural and low-income settlements – despite the vulnerability of those

* Corresponding author.

E-mail addresses: abulabbasy@gmail.com, tijani_18003161@utp.edu.my (T.O. Abimbola).

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