



## Review

## Solar stills: A review of the latest developments in numerical simulations

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## Abstract

Using solar stills in arid regions is one of the affordable solutions to provide the drinking water from brackish water sources. Improvement of the configuration of conventional solar stills to enhance the productivity has always been the concern of engineers and researchers in the field of solar energy and related branches. Time-consuming and costly processes of solar still fabrication motivate the scholars to perform mathematical and computational fluid dynamics (CFD) simulations of solar stills to estimate the productivity. This paper presents the latest numerical studies on various types of solar stills including single slope, double slope, multi-effect, tubular and so on. The review unveils that many other studies can be conducted in the future on CFD simulation of solar stills where various techniques such as utilizing nanotechnology, reflectors, storage materials, fans, and fins have been considered for the efficiency enhancement of solar desalination systems.

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**Keywords:** Solar stills; CFD simulations; Mathematical modeling; Productivity enhancement techniques

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## Nomenclature

$A$	area, $\text{m}^2$	$X$	dimensionless horizontal coordinate
$Br$	Buoyancy ratio	$Y$	dimensionless vertical coordinate
$c$	concentration of species, $\text{kg m}^{-3}$	<i>Greek letters</i>	
$C_p$	specific heat, $\text{J kg}^{-1} \text{K}^{-1}$	$\alpha$	absorptivity
$G$	solar irradiance, $\text{W/m}^2$	$\rho$	reflectivity
$h$	heat transfer coefficient, $\text{W m}^{-2} \text{K}^{-1}$	$\varepsilon$	emissivity
$h_{fg}$	specific latent heat of vaporization $\text{J kg}^{-1}$	$\theta$	dimensionless temperature
$k$	thermal conductivity, $\text{W m}^{-1} \text{K}^{-1}$	$\sigma$	Stefan–Boltzmann constant
$L$	specific length, m	<i>Subscript</i>	
$Le$	Lewis number	$a$	ambient
$m$	specific mass, $\text{kg m}^{-2}$	$b$	basin
$Nu$	Nusselt number	$c$	convection
$P$	pressure, Pa	$E$	evaporator
$Pr$	Prandtl number	$eV$	evaporation
$q$	heat flux, $\text{W m}^{-2}$	$f$	refrigerant
$Ra$	Rayleigh number	$g$	glass
$Sc$	Schmidt number	$h$	horizontal
$T$	temperature, K	$r$	radiative
$t$	time, s	$w$	water
$U_t$	overall heat transfer coefficient, $\text{W m}^{-2} \text{K}^{-1}$		
$V$	wind velocity, $\text{m s}^{-1}$		
$W$	compressor power, W		

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## 1. Introduction

Water crisis will be a serious challenge in near future with increasing the global warming in the world. Even though water is one of the most abundant resources on the earth and covers around three-fourths of our planet's surface, nearly 97% of which are saltwater in the oceans. On the other hand, the remaining proportions of water are in the form of ice, groundwater, lakes, and rivers. Only less than 1% of the available water is fresh and accessible to humans (Kianifar et al., 2012; Kaushal and Varun, 2010; Sampathkumar et al., 2010). Demands for potable water are soaring substantially due to phenomena predominantly attributed to human activities, namely industrialization, motorization and population growth (Sharon and Reddy, 2015b). Depletion of the ground water resources is anticipating at a faster rate than the natural replenishment. Great deals of assessments have been stated that by 2025, approximately 1.8 billion people will have suffered from serious water scarcity around the globe (Elango et al., 2015). Utilization of solar stills is believed as an alternative solution to dominate such problems since solar energy is believed one of the abundant renewable sources. Solar stills

are devices usually with a simple configuration which are used for purifying brackish water. Solar radiation with the intensity of  $G$  struck at the glass cover is absorbed by the black surface effectively, and heat is transferred to the water in the still. As a result, the temperature of the brackish water increases, and it starts to be evaporated. The ascended vapor within the still is then condensed and released its latent heat of vaporization on the inner side of tilted glass cover which is relatively cold. Eventually, the condensed water gets collected into a container by the provided troughs.

Solar stills are mainly graded according to passive and active systems. The classification of different solar stills based on geometry is depicted in Fig. 1. Sampathkumar et al. (2010) reviewed the performance and thermal models used for active solar distillations established by preceding researchers, comprehensively. Velmurugan and Srithar (2011) reviewed the influential factors, namely temperature differences within the still, inlet water temperature, glass angle that affect the rate of productivity and performance of the solar stills. Ahsan et al. (2013) reviewed a few numerical models of solar distillation device and compared them with Dunkle and Ueda models.

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