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Exergy analysis of the active solar distillation systems integrated with solar ponds

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Abstract Active solar distillation system integrated with solar pond is the green energy system for desalination without negative environmental impact. This clean technology has potential to contribute a lot to water security, sustainable development, and world stability. In this article, results of the energy as well as exergy analysis performed on this novel system integrated with solar pond are presented. This theoretical analysis is carried out in the climatic conditions of New Delhi (India) during a typical summer day. The model and procedures can be helpful in the design, and performance investigation of the actual system anywhere in the world. The daily productivity, energy, and exergy efficiency of the passive solar still are found to be 5 L/m^2, 38.63 %, and 2.71 %, respectively, corresponding to a sum total of 24.436 MJ/m^2 day solar energy input in passive mode. With the integration of solar pond in the active solar still, the daily productivity, energy, and exergy efficiency rises to about 9.5 L/m^2, 46 %, and 14.81 % respectively, for thermal energy input from 100 to 500 W/m^2 during off-sunshine hours. The further improvement in the performance of the same system is observed if the thermal energy is supplied continuously (24 h) to the solar still in addition to incident solar radiation. The proposed system will meet the demand of freshwater in both rural and urban areas and help in reducing the load of CO_2 emission on the environment, saving high grade energy consumed for desalination through conventional devices and technologies.

Keywords Energy and exergy efficiency · Thermodynamic analysis · Green energy system · Clean technology · Renewable energy sources · Solar energy · Active and passive solar stills · Freshwater

List of symbols

Variables

A_b	Area of basin-liner (m^2)
A_g	Area of the glass cover (m^2)
C_w	Specific heat of saline water in the solar still (J/kg K)
$E_{X_{e,w-g}}$	Rate of exergy flow due to evaporative heat transfer from saline water to glass cover (W/m^2)
$E_{X_{sun}}$	Exergy of the solar radiation on the solar still per unit area (W/m^2)
G_s	Solar radiation incident on the glass cover of the solar still per unit area (W/m^2)
$h_{e,w-g}$	Evaporative heat transfer coefficient between saline water and glass cover (W/m^2 K)
h_{fg}	Latent heat of vaporization of water (J/kg)
K_g	Thermal conductivity of glass cover (W/m K)
K_i	Thermal conductivity of insulating material (W/m K)
K_w	Thermal conductivity of saline water (W/m K)
M_w	Mass of saline water in the basin (kg)
m_{wo}	Hourly distillate output from the passive solar still (kg/m^2 h)
q_b	Rate of heat loss from basin-liner to ambient (W/m^2)
$q_{c,b-w}$	Rate of convective heat transfer from basin-liner to saline water (W/m^2)
$q_{c,g-a}$	Rate of convective heat transfer from glass cover to the atmosphere (W/m^2)

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