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# Solar-powered barometric vacuum desalination: modelling, simulation, and performance analysis for sustainable water production

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**ABSTRACT**

This study introduces an innovative, sustainable, energy-efficient approach to desalination using a barometric vacuum desalination system (BVDS). The system passively creates a vacuum through a barometric column, enabling the production of freshwater from saline water at near-ambient temperatures. By leveraging a passively generated vacuum via a barometric column, the system operates with minimal energy input, making it compatible with solar or other low-grade thermal sources. The configuration includes an evaporation chamber equipped with a solar collector, a condenser heat exchanger, and three vertical water columns—for saline intake, brine rejection, and freshwater collection—each connected to its own holding tank. Circulation pumps and control valves interconnect these components, ensuring a cost-effective and low-maintenance setup. A MATLAB-based simulation developed using thermodynamic, fluid dynamic, and heat–mass transfer principles confirms the system's operational feasibility, energy efficiency, and scalability for high-quality freshwater production. The BVDS also offers a low environmental footprint, making it particularly suitable for deployment in arid or remote regions. Future work will focus on scaling up the system and incorporating thermal storage solutions to enable continuous operation.

*Keywords:* Desalination; Solar distillation; Barometric vacuum; Renewable energy; Low-grade heat; Sustainable water production

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