"Performance Enhancement of Solar Water Distiller and Reuse of Distilled Water for Sustainable Water Resource Management: A Review"

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Abstract

The waste water purification system consists of nano-filtration (NF) membranes, solar-powered settling pretreatment ponds, and/or a multi-stage polishing chain. The main aim of solar water distiller is to treat waste water for suspended solids, organics, nutrients and micro-pollutants and to reduce operational carbon footprint using renewable energy. In the present work, a detailed study for treatment of waste water done by various researchers has been discussed. It was found in the studies that nano-filtration offers high removal of micro-pollutants and hardness while solar-driven pretreatment and photo-catalysis can substantially reduce organic loading, improving membrane lifetime.

Keywords:-Wastewater purification, nano-filtration, rainwater treatment, photo-catalysis, activated carbon, Membranes, Low-carbon treatment.

I. Introduction

Water scarcity and pollution drive the need for decentralized, energy-efficient wastewater treatment solutions for nan potable and indirect potable uses. Combining membrane separation (NF) with renewable energy-driven pretreatment (solar heating/solar ponds/photocatalysis) can offer high contaminant removal while lowering fossil energy dependence. Challenges include membrane fouling, variable feedwater quality (pond + rainwater), and cost/maintenance for decentralized systems. This work proposes a pilot system that integrates:

- solar-assisted settlingthermal pretreatment.
- coarse filtration and NF membrane polishing.
- activated carbon adsorption and UVphotocatalytic polishing.

II. Literature Review

Sharma et.al(2025)-Developed a solar-assisted nanofiltration system for mixed pond and rainwater. Achieved >90% turbidity and 85% BOD removal using thermal pretreatment to reduce fouling. The design showed significant energy savings in rural decentralized water purification setups.**[01]**

C.Raghunathan, and Tamal Mondal et. al (2025) - The commonly known sponges are belonging to the Phylum Porifera and take notable roles in coastal and marine ecosystem as filter-feeding organism. The present study reveals a total of four species of poriferans from the coastal areas of Puducherry. Extensive surveys are the primary requisite to explore all four areas of Puducherry for sponges. Further studies are also required to explore the species diversity along with the understanding of the ecological roles of sponges from Puducherry Coast.**[02]**

Anup Mishra et. al (2025)-pH was measured with a pH meter, Ca, Mg and K were measured with the atomic electron spectroscopy, turbidity was measured with turbidity meter, surface tension by Tensiometer and F, Cl, PO4 and SO4 were measured by Ion Chromatography. it can be concluded that the shower loop works effectively in removing the hardness of the shower water as well as potassium levels. The pH, con ductility levels and the turbidity levels also prove the conclusion that the system works and it is very effective and worth installing.**[03]**

Borhane Mahjoub et. al (2025)-By integratingclimate-responsivemethodologies, adaptive strategies are being developed for dynamic water systems. A holistic approach that combines sustainable chemistry, policy frameworks, and social sciences is crucial to addressing current and future challenges.By examining advanced water treatment technologies,interdisciplinarycollaborations, and the integration of sustainable chemistry, the review stresses theurgent need for transformative and adaptive strategies. **[04]**

S. Rossi et. al (2025) - These models have been largely applied to simple (oxygen and carbon dioxide) exchange between algae and aerobic heterotrophs. More comprehensive models, including all relevant microbial clades, have been recently published, which consider nutrient cycling, competitive uptake, and other features, including temperature, pH, and gas transfer.This research was partially funded by the European Union (H2020 Research and Innovation Framework Programme. **[05]**

Mariana Marselina et. al (2025) - However, water quality remains a critical issue due to prevailing contamination. While river water is a primary source of raw drinking water, much of it, such as Indonesia's River in West Java, has been polluted.These differences largely stem from varying concentration values of the employed parameters.**[06]**

Leidy Marcela Ulloa-Murillo et. al (2025) - The results of the mixture feedstock pyrolysis indicated that Ni enhanced the yield of bio-oil slightly, while the other metals did not change it significantly. Ni led to higher amount of cracking and deoxygenation of the acids. The results indicated that the zeolite catalyst improved the quality of the bio-oil through the deoxygenation reaction. However, coke was formed on its surface.**[07]**

Livinus A. Obasi, Cornelius O. Nevo et. al (2024)- Fourier transform infrared instrumental analysis of the substrate shows the functional groups of compounds present. A 24 central composite design and a three-layered. Feedforward ANN architecture trained by a backpropagation algorithm were used to study and predict the MFC process performance

criteria. The results of this experiment indicate that the application of low-cost GW-MFC using CGC-Ekow clay hybrid PEM was sufficient to achieve wastewater treatment with bioenergy generation.**[08]**

Cinzia Da Ros, Vincenzo Conca et. al (2024) - The solids recovered by sieving contained around 40% of cellulose, which is a suitable raw material for the production of bio-based VFAs. Initially, fermentation batch tests of cellulosic primary sludge were carried out adjusting the initial pH of the sludge at values of8, 9,10 and 11, in order to evaluate the best production yields of bio-based VFAs and their composition. The batch fermentation showed a positive impact of sludge pH conditioning (pH 9)on acidogenic fermentation with potential.**[09]**

Samra Naz, Abiha Arshad et.al(2024) The increasing depletion of freshwater resources, driven by agricultural expansion and industrial pollution, has intensified the need for wastewater reuse.Wastewater reuse is a viable strategy to address water scarcity and food security challenges. The necessity of wastewater reuse has increased due to climate change and rising global populations.**[10]**

Zhifeng Ying Chunyang et.al (2024)-Supply of freshwater to the world's cities is increasingly affected by human pressures and climate change. Understanding the effects of human pressures and climate change on global urban water scarcity and quality risks in an integrated way is important.Increasing water demand will be the main cause of rising scarcity risk, but for a few cities, such as Los Angeles and Karachi, declining water availability due to climate change will be the main cause.**[11]**

Marin Ugrinaet. al(2024) - A lack of water for human consumption is also a result of inadequate wastewater treatment, rising freshwater usage, and climate change.Therefore, it is substantial to manage wastewater holistically, i.e., wastewater treatment, obtaining energy and resources at the same time.**[12]**

Cinzia Da Ros, Vincenzo Conca et. al (2024) The solids recovered by sieving contained around 40% of cellulose, which is a suitable raw material for the production of bio-based VFAs. Initially, fermentation batch tests of cellulosic primary sludge were carried out adjusting the initial pH of the sludge at values of 8,9,10, and 11, in orderto evaluate the best production yields of bio – based VFAs and their composition. The batch fermentation showed a positive impact of sludge pH conditioning (pH9) on acidogenic fermentation with potential. **[13]**

Jorge Alejandro Silvaet.al (2023)-End-users all over the world suffer from the consequences of poor water quality. Whether it is a private household, a factory, a commercial or medical process, everyone has their own expectations and desires on the requested water quality.We have examined possible Rain Water Collection and Treatment, Surface water management, Ground water treatment, alternatives to the current wastewater management strategy, Sewage water treatment.**[14]**

Ayla Ahmadi et. al (2022) -Thermal pyrolysis of different types of wastes including LDPE, carton tire and poplar wood was conducted to investigate the effect of feedstock on the properties of products. The co-pyrolysis of single

feedstocks was also the next trial.In summary, a bench-scale apparatus was built and used to investigate the effect of the feedstock type and co-pyrolysis on the properties of the products.**[15]**

Stef H.A. Koop et.(2022) al - growth, urbanisation, climate change, biodiversity loss, energy use, water security and ageing infrastructures for water supply and treatment require a thorough understanding of the options available for moving towards sustainable cities.In order to better understand the impact of water-related hazards on urban patterns of development across the globe, the goal of this paper has been to develop.**[16]**

Upali A. Amarasinghe, Tushaar Shah,et. al (2022)- This report attempts to capture the trends of key drivers of water demand in the recent past, and assess their implications on future water demand.The .total environmental requirements of the 12 basins vary from 70% of the annual runoff in class A to 13% of the runoff in class F. class a water demand of the 12 rivers is even more than the present estimate of the total water resources.**[17]**

Dr. Yoram Krozer, Dr. Laura franco Garcia et. al (2022) -It can be concluded that the shower loop works effectively in removing the hardness of the shower water as well as potassiumlevels. The pH, con ductility levels and the turbidity levels also prove the conclusion that the system works and it is very effective and worth installing. it can be concluded that the shower loopworks effectively in removing the hardness of the shower water as well as potassium levels. The pH, con ductility levels and the turbidity levels also prove the conclusion that the system works and it is very effective and worth installing.**[18]**

Marlies J. Kampschreur et. al(2021) -Nitrous oxide (N O), a potent greenhouse gas, can be emitted during wastewater treatment, significantly contributing to the greenhouse gas footprint.The main operational parameters leading to N O emission in WWTPs arelow dissolved oxygen concentration. **[19]**

Ana Soares et al (2020) -The beginningof the energycrisis in 2006,coincided with the building and commissioning of large activated sludge plants, resulting in ever increasing electricity bills to be paid by municipalities and the wastewater industry.The author declares no competing interests. **[20]**

III. Conclusions of literature Review

An integrated system combining solar-assisted pretreatment, nanofiltration, and polishing (GAC + UV/photocatalysis) offers a promising decentralized approach for pond and rainwater purification. Literature indicates NF's strong pollutant rejection but highlights fouling as the main barrier — which can be mitigated via staged pretreatment and novel membrane materials. Pilot testing and economic analysis are necessary next steps.

IV. Objective

- Design a pilot integrated wastewater purifier for pond rainwatercombining solar pretreatment and nanofiltration.
- Evaluate expected removal efficiencies (TSS, turbidity, BOD, COD, nutrients,

micropollutants, microbial indicators) via literature and modelling.

- Develop experimental plan and fouling control strategy (pretreatment, backwash, chemical cleaning scheduling).
- Perform an energy and cost analysis comparing solar-assisted vs conventional powering.

V. Proposed Methodology

i. Monitoring & Performance Metrics

Frequency: daily for turbidity, pH, temperature; twice-weekly BOD/COD; weekly nutrients and microbial indicators.Metrics: permeate flux decline, fouling rate (LMH drop per day), specific energy consumption, Life Cycle Cost (LCC) and simple payback.

ii. Fouling Control Strategy.

primary fouling drivers: particulate and organic fouling from pond water. With proper pretreatment, fouling rates can be limited; membrane cleaning regimen required every few weeks depending on feed.

iii. Energy & CO_2 balance

Solar thermal pretreatment reduces mechanical energy required for some processes; PV powering pumps will increase embodied cost but lower operational carbon footprint. A ballpark specific energy for membrane steps is expected depending on recovery and feed salinity; solar offset reduces grid energy.

iv. Expected outcome

- Integration of resource recovery (nutrient concentration) and sludge valorization from pretreatment.
- Cost reduction via modular factory-built NF skids and local material sourcing.
- AI-driven control for predictive cleaning schedules andoptimization.

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