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# Solar photocatalytic pathogenic disinfection: Fundamentals to state-of-the-art

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**Abstract**

It is necessary to treat pathogen-infected water before its utilisation. Of conventionally used treatment methods, solar photocatalysis has gained considerable momentum owing to its operational simplicity and capacity to use freely and abundantly available solar energy. This article systematically reviewed the disinfection of water with photocatalysis. It addressed the concerns of microbial infection of water and the fundamentals behind its treatment with photocatalysis. It presented an in-depth description of pathogenic deactivation with powerful reactive oxygen species. Special emphasis was given to process intensification as it is an attractive technique that provides multifunctionality and/or equipment miniaturisation. Solar reactor design regarding mobilised/immobilised photocatalysts and compound parabolic concentrators were elucidated. Finally, key parameters governing photoperformance, corresponding trade-offs, and the need for their optimisation were discussed. Overall, this article is a single point of reference for researchers, environmentalists, and industrialists who address the ever-severing challenge of providing clean water whilst also maintaining energy sustainability.


*Keywords:* Water; Solar light; Photocatalysis; Pathogen; *E. coli*; Intensification; Photoreactor; Disinfection

## 1. Introduction

Water is indispensable for humans and the entire ecosystem. According to the *United Nations World Water Development Report 2020: Nature Based Solutions for Water* (United Nations, 2020), there's a 1% rise in water demand every year. As stated by the World Health Organisation (WHO), 844 million people stay bereft of an elementary drinking water utility, including 159 million individuals who are reliant only on surface water (WHO, 2018). According to the World Water Assessment Programme, approximately 90% of the gross waste of developing countries is channelled to natural sources like rivers and lakes, without undergoing proper treatment. WHO has prescribed guidelines (Inamori and Fujimoto, 2018) for water quality, such as a limit of total coliform value of 0–100 $mL^{-1}$ in drinking water. Hence, there is an urgent need to treat malignant water before it is consumed.

Pathogenic contamination of water takes place primarily from human and animal excreta, although several other routes are rampant (Zhu et al., 2018). Most studies on microbial disinfection have focused on *Escherichia coli* (*E. coli*) bacteria commonly found in the intestine of humans and animals as a model species.

The concept of utilisation of solar energy for pathogenic annihilation came up with the concept of solar water disinfection (SODIS). SODIS has a key advantage of effective use in rural areas with less access to chemical oxidants (Chaúque and Rott, 2021; McGuigan et al., 2012; Byrne et al., 2021). To accelerate the disinfection process, a simple SODIS can be combined with photocatalysis. Méndez-Hermida et al. (2007) fed SODIS operating reactors with $TiO_2$-coated plastic inserts to disinfect *Cryptosporidium parvum* oocysts. They reported

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