ZnO nano for remediation of methylene blue dye: A short review

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Abstract
The presence of dyes in wastewater and water resources is one topic that is getting attention on a global scale. In the present decade, dye-based categories have seen vast development due to the rising need for garments by the increase in population. Mostly used dye in textiles is Methylene blue, which gives dye outflow contamination. It is dangerous and very risky for the surroundings. There are countless sources of methylene blue dye and their adequate medical care methods are inscribed in this present review. The multifunctional ZnO nanomaterial is more effective as a semiconductor photocatalyst than other materials because of its low cost, eco-friendliness, structure-dependent characteristics, and complete mineralization of pollutants. Among nanoparticles photocatalysts, ZnO have shown major capability for photoactive methylene blue deterioration. These metal oxides nanoparticles are the best perfect matter for abolishment of water contaminants, like materials are connected to the attributes of purity, malleability, adaptability, productivity and are highly reactive. The structure of methylene blue dye is highlighted and health impact as well as their effect environment are also discussed. Taking account of all these crucial aspects, the recent advances for remedy of cationic dyes methylene blue by applying ZnO nano is spotlighted in this current review.

Keywords: ZnO nanoparticles, dye degradation, methylene blue, environmental remediation

1. Introduction
Water pollution is an earnest ecological delinquent that threatens the delicate balance of the ecosystem. Growing population means that more unnecessary water is being dumped into essential water sources. One of the contaminants in waste water is dye, that is broadly applied in a diversity of industries, like the manufacturing of food, textiles and paper. (Al-Tohamy et al., 2022) [1]. Above 10,000 diverse kinds of dyes are available worldwide, and over 7,000,000 tonnes are generated annually, according to the Colour Index. Over 87.5 tonnes of dyes are released as waste annually in staining and dyeing operations in the fabric industry as a result of the inadequate dying process (Artifon et al., 2021) [12]. Industrial wastes that are released into the environment pose major environmental risks because of their color, high COD, and intricate chemical composition. These hues are only slightly affected by detergents, temperature, light, soap, chemicals, water, and other factors like perspiration and bleach. Unwanted water attention does not benefit dyes, and they last a very long time in nature. Due to their artificial manufacture and complex behavior, antimicrobial combinations prevent biodegradation. Mostly dyes are poisonous and can impair microbial diversity, fish species, and produce mutagenesis and other adverse effect (Rolton et al., 2022) [5]. They can even kill individuals by harming the reproductive system, central nervous system, and brain. Some colors use benzidine and other aromatic compounds, which are known to be lethal poisons. Dye discharge poses a problem since 1 ppm of dye in potable water may not be suitable for human consumption. Organic molecules known as dyes can interact with a variety of materials or fabrics to provide long-lasting, vibrant color and they may be organic or nonorganic. The existence of aromatics, metals, as well as other substances in dyes makes them potentially harmful to marine life. Since most dyes are synthetic, they are more persistent and challenging to degrade due to their complex aromatic molecular structure. Chromophores and auxochromes are the two categories of chemicals that make up a dye (Vats et al., 2022) [7]. In this review, the methylene blue dye's structure is emphasised, and its effects on the environment and human health are also covered.
In addition, this paper highlights recent developments in ZnO nanotechnology for the treatment of cationic dyes like methylene blue.

2. Structure of Methylene Blue
The molecular weight of (heterocyclic basic dye) methylene blue (MB) is 373.9 g/mol and the highest peak wavelength is 665 nm. Its technical name is basic blue, and the chemical formula of Methylene blue is C₁₅H₁₈N₂S₂Cl. The figure shows the chemical makeup of MB dye. More poisonous than anionic dyes are the cat-ionic Methylene Blue dye. A few of the industries that use MB are rubber, leather, textile, cosmetics, plastics, food sectors, and pharmaceuticals (Modi et al., 2022) [6]. The structure of Methylene dye shown in Figure 1.

![Fig 1: The structure of Methylene dye](https://www.chemistryjournal.net)

3. Environmental and Health Effect of Methylene Blue
A pigment, index, and microbiological chemical, MB is a cationic and basic dye that is frequently used in medical field as medicine. Methylene Blue dye has been linked to cancer, hemolysis anemia, hyperbilirubinemia, mutation, lung toxicity, chromosomal failure, and acute renal failure. A tiny level (microgram) of MB is thought to produce cytotoxicity in human astrocytoma cells and neuroblastoma (U-373 MG and SK-N-MC, respectively). The calculated median lethal dose (LD₅₀) for MB in oral form was to be 1180 mg/kg (Ding et al., 2016; Modi et al., 2022) [3, 6]. When endotoxemia occurs, moderate and low concentration of MB raise arterial blood pressure, but high doses exacerbate myocardial depression, systemic hypertension and hypotension. High doses of MB have negative effects on gas exchange and increase vascular resistance in the mesenteric and renal blood flow. In addition, it results in a bluish patch of mucosa and skin and self-limiting greenish-blue urine (Oladoye et al., 2022) [2]. Because they are resistant to biodegradation and have high thermal and photostability, dyes may be persisted in the environment for extended time periods, which presents a number of health and environmental problems. The main way that dyes affect the environment is by their ability to absorb and reflect sunlight, which is another key point to remember. Future technological advancements could include the applications of ZnO nanocomposite, with removal efficiencies ranging from 90 to 97% (Choudhary et al., 2023) [14]. From these results, MB was remediated from the aqueous solutions using the created ZnO nanocomposite, with removal efficiencies ranging from 90 to 97% (Choudhary et al., 2023) [14]. By measuring the photo-enhanced catalytic activity of ZnO produced from the broccoli extract against MB under UV light irradiation, 74% degradation efficiency of the subsequent dyes were attained (Osunotun et al., 2019) [14].

5. Conclusion
The primary focus of this review is on the use of modified and pure ZnO for the removal of MB dyes. Dye degradation using photocatalysis is a potential and promising strategy. The most effective method, according to a plethora of research and testing, is dye degradation mediated by ZnO and ZnO modified by dopants or composites. The literature research indicates that ZnO is a cost-effective and easily accessible photocatalyst than other types. ZnO was altered to improve its ability to break down dye compounds and other contaminants. In addition, the light, temperature, pH, dopant concentration, dye concentration and catalyst dose all have a significant impact on how efficiently materials degrade. ZnO is a superior option for research since it breaks down dyes more effectively in the presence of sunlight, which is another key point to remember. Future technological advancements could include the applications of ZnO (As a photocatalyst) to break down contaminants like dyes. It is anticipated that interest in ZnO will grow, leading to the identification of new uses for the substance.

6. References
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