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Green Synthesis of Silver Nanoparticles Using Neem Extract for Sewage Water Disinfection

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Abstract- The increasing generation of sewage water due to rapid urbanization and industrialization poses serious environmental and public health challenges. Conventional disinfection methods such as chlorination and ozonation suffer from limitations including toxic by-products and high operational costs. The present study explores an eco-friendly approach for sewage water disinfection using silver nanoparticles (AgNPs) synthesized via a green route using neem (Azadirachta indica) leaf extract. The biosynthesized nanoparticles were characterized using UV–Visible spectroscopy, showing a characteristic surface plasmon resonance peak around 420 nm, confirming nanoparticle formation. Sewage samples were treated with varying concentrations of AgNPs and analyzed for physicochemical parameters including pH, conductivity, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and ionic content. A significant reduction in BOD, COD, conductivity, and microbial load was observed. Maximum disinfection efficiency of approximately 99% was achieved at higher nanoparticle doses. The study demonstrates that neem-mediated AgNPs offer a cost-effective, sustainable, and highly efficient alternative for sewage water treatment.

Keywords— Silver nanoparticles, Green synthesis, Neem extract, Sewage treatment, BOD, COD, Antimicrobial activity

I. INTRODUCTION

Water pollution due to untreated sewage discharge is a major global concern. Sewage water contains organic matter, suspended solids, nutrients, and pathogenic microorganisms that pose serious environmental and health risks. Conventional treatment methods, although widely used, have several limitations such as incomplete microbial removal, high cost, and formation of harmful by-products.

Nanotechnology has emerged as a promising solution in wastewater treatment. Among nanomaterials, silver nanoparticles (AgNPs) are highly effective due to their strong antimicrobial properties and high surface area. Green synthesis of nanoparticles using plant extracts provides an eco-friendly alternative to chemical methods.

Neem (Azadirachta indica) is a medicinal plant rich in Bioactive compounds such as flavonoids, terpenoids, and phenolics, which act as natural reducing and stabilizing agents. The present study focuses on the synthesis of AgNPs using neem extract and their application in sewage water disinfection.

II. MATERIALS AND METHODS

1. Materials

Analytical grade chemicals including silver nitrate ($AgNO_3$), distilled water, potassium dichromate, sulfuric acid, and other reagents were used.

2. Preparation of Neem Extract

Fresh neem leaves were washed, shade-dried, and crushed. About 20 g of leaves were boiled in 100 mL distilled water at 70°C for 20–30 minutes. The extract was filtered and stored for further use.

3. Synthesis of Silver Nanoparticles

- 80 mL of 1 mM $AgNO_3$ solution was taken
- 20 mL neem extract added dropwise

- Heated at 60–70°C with continuous stirring

Observation
Color changed from pale yellow → dark brown indicating nanoparticle formation.

4. Characterization
UV–Visible spectroscopy was used in the range 300–700 nm. A peak around 420 nm confirmed AgNP formation.

5. Sewage Sample Collection
Samples were collected from municipal drainage in sterilized bottles and stored at 4°C before analysis.

6. Treatment Procedure
- Sewage divided into control and treated samples
- AgNPs added in different concentrations
- Stirred for 30 minutes
- Some samples exposed to UV radiation
- Allowed to settle for 24 hours and filtered

7. Analytical Parameters
- pH (digital pH meter)
- Conductivity (conductivity meter)
- BOD (5-day method)
- COD (dichromate method)
- Sodium & Potassium (flame photometer)
- Microbial load (plate count method)

III. RESULTS AND DISCUSSION

1. Formation of Silver Nanoparticles
The synthesis was confirmed by:
- Color change (visual confirmation)
- UV–Vis peak at ~420 nm (SPR band)

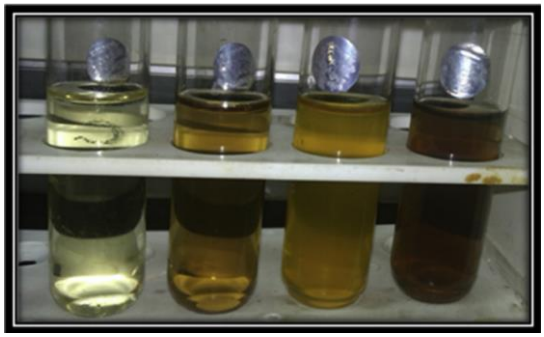

Figure 1 — Visual Color Change During AgNP Formation

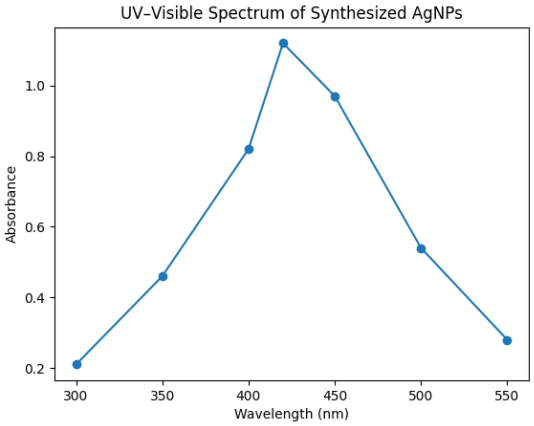

Figure 3.2 — UV–Visible Spectrum of Synthesized AgNPs

2 Effect on Physicochemical Parameters
pH
- No significant change observed, indicating stability of treatment.
- Conductivity
- Reduced after treatment, suggesting removal of dissolved ions.
- BOD Reduction
- Significant decrease observed, indicating reduction in biodegradable organic matter.
- COD Reduction
- Marked decrease showing reduction of oxidizable pollutants.

Table 1: Initial and Treated Sewage Parameters

Parameter	Untreated	Treated (Low Dose)	Untreated (High Dose)
pH	~7.5	~7.2	~7.0
Conductivity (µS/cm)	High	Reduced	Significantly Reduced
BOD (mg/L)	High	Moderate	Low
COD (mg/L)	High	Reduced	Significantly Reduced

3. Ionic Reduction
Flame photometric analysis showed reduction in sodium and potassium ions, indicating adsorption and coagulation effects.

Table 2: Sodium and Potassium Reduction

Ion	Before Treatment	After Treatment
Sodium (Na^+)	High	Reduced
Potassium (K^+)	High	Reduced

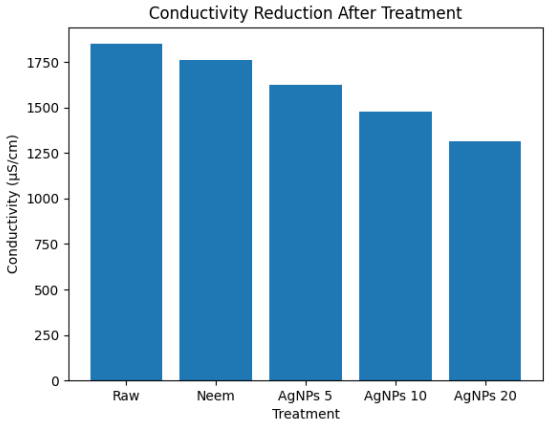

Figure 3 — Conductivity Reduction after treatment

3.4 Antimicrobial Activity

A drastic reduction in microbial load was observed:

- Maximum efficiency ≈ 99%
- AgNPs disrupt cell membrane, proteins, and DNA

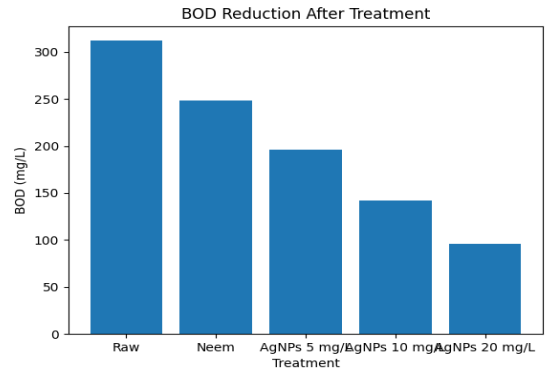

Figure 4 — Effect of AgNP Dose on BOD Reduction

5. Synergistic Effect (AgNPs + UV)

Combined treatment showed enhanced disinfection due to:

- DNA damage by UV
- ROS generation by AgNPs

6. Mechanism of Action

- Cell membrane disruption
- Enzyme inactivation
- DNA damage
- Oxidative stress

IV. CONCLUSION

The present study demonstrates that neem-mediated silver nanoparticles provide an efficient and eco-friendly method for sewage water disinfection. Significant reductions in BOD, COD, conductivity, and microbial load were achieved. The method eliminates the need for harmful chemicals and offers a cost-effective alternative suitable for rural and semi-urban areas.

With further large-scale studies and safety evaluation, green synthesized AgNPs can serve as a sustainable solution for wastewater treatment.

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