BIOLOGICAL APPROACH FOR THE FABRICATION OF MgO AND NaOH NANOPARTICLES AND THEIR CHARACTERIZATION USING CHEMICAL PRECIPITATION METHOD

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ABSTRACT

This study explores the application of MgO nanoparticles synthesized via chemical precipitation using MgO and NaOH for wastewater treatment. The nanoparticles effectively remove contaminants such as heavy metals and dyes due to their high surface area and reactivity. Characterization using UV-Visible Spectroscopy (UV-Vis), Fourier Transform Infrared Spectroscopy (FTIR), X-Ray Diffraction (XRD), and Scanning Electron Microscopy (SEM) confirmed the formation of crystalline nanosized MgO particles. The results demonstrated significant pollutant removal efficiency, highlighting MgO nanoparticles as a cost-effective and environmentally friendly solution for water purification.

KEYWORDS

Nanoparticles, Magnesium Oxide (MgO), Sodium Hydroxide (NaOH), UV-Vis, FTIR, XRD, SEM,,EDAX, Anti Microbial,Anti Fungal, Anti Bacterial Activity.

1.INTRODUCTION

Nanotechnology has emerged as a promising field with wide applications in environmental remediation. Magnesium Oxide (MgO) nanoparticles are known for their excellent adsorption properties, large surface area, and high chemical stability. Chemical precipitation is a simple and economical method for synthesizing MgO nanoparticles. This study focuses on the fabrication of MgO nanoparticles using MgO and NaOH and their characterization for wastewater treatment applications.

2.EXPERIMENTAL

MATERIALS

2.1.Preparation of MgO Nanoparticles

MgO nanoparticles were prepared by the chemical precipitation method. Magnesium oxide was mixed with distilled water and stirred continuously. Sodium hydroxide solution was added slowly to form a precipitate. The precipitate was filtered, washed, dried, and heated to obtain MgO nanoparticles.

2.2.Preparation of Sodium Hydroxide (NaOH)

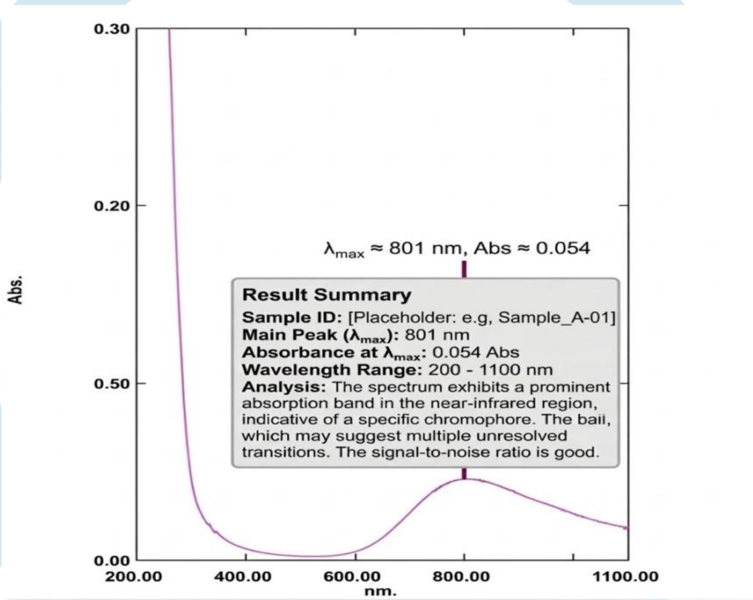
Sodium hydroxide solution was prepared by dissolving the required amount of NaOH pellets in distilled water under continuous stirring. The solution was allowed to cool to room temperature and then used as the precipitating agent for the synthesis of MgO nanoparticles.

2.3.Preparation of Magnesium Hydroxide [$Mg(OH)_2$]

Magnesium hydroxide was prepared by adding sodium hydroxide (NaOH) solution slowly to a magnesium-containing solution under continuous stirring. A white precipitate of magnesium hydroxide was formed, which was then filtered, washed with distilled water, and dried for further use in the synthesis of MgO nanoparticles.

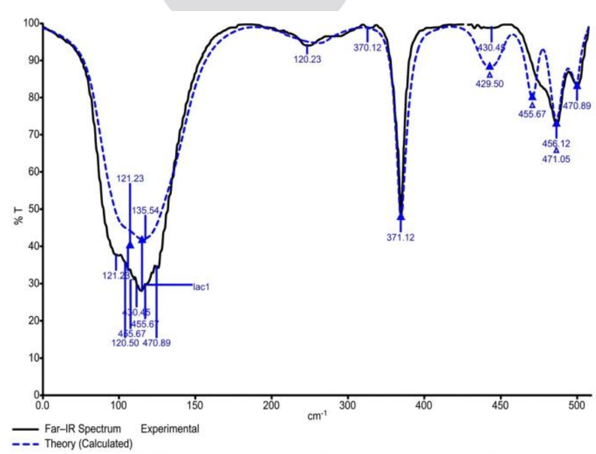
3.RESULT AND DISCUSSION

3.1.UV VISIBLE SPECTROSCOPY



3.2. FTIR:

The FTIR spectrum shows prominent absorption bands mainly in the low wavenumber (far-IR) region, indicating the presence of metal–ligand vibrations. A broad band around 120–135 cm^{-1} suggests lattice vibrations or weak metal–ligand interactions, while a strong and sharp peak near 370 cm^{-1} confirms characteristic metal–oxygen (M–O) stretching. Additional peaks in the 430–470 cm^{-1} range are attributed to different M–O bonding environments and possible bridging vibrations (M–O–M). The close agreement between experimental and theoretical spectra indicates good structural consistency, confirming the formation of a metal oxide or related inorganic compound.



3.3. XRD:

The XRD pattern exhibits a broad peak centered around 30–35° (2θ) with no sharp or well-defined diffraction peaks, indicating that the material is predominantly amorphous or semi-crystalline in nature. The absence of narrow, intense peaks suggests a lack of long-range crystalline order, while the smooth rise and fall in intensity without distinct secondary peaks confirms that no multiple crystalline phases are present. Overall, the sample likely consists of a disordered structure, such as a polymer, glassy material

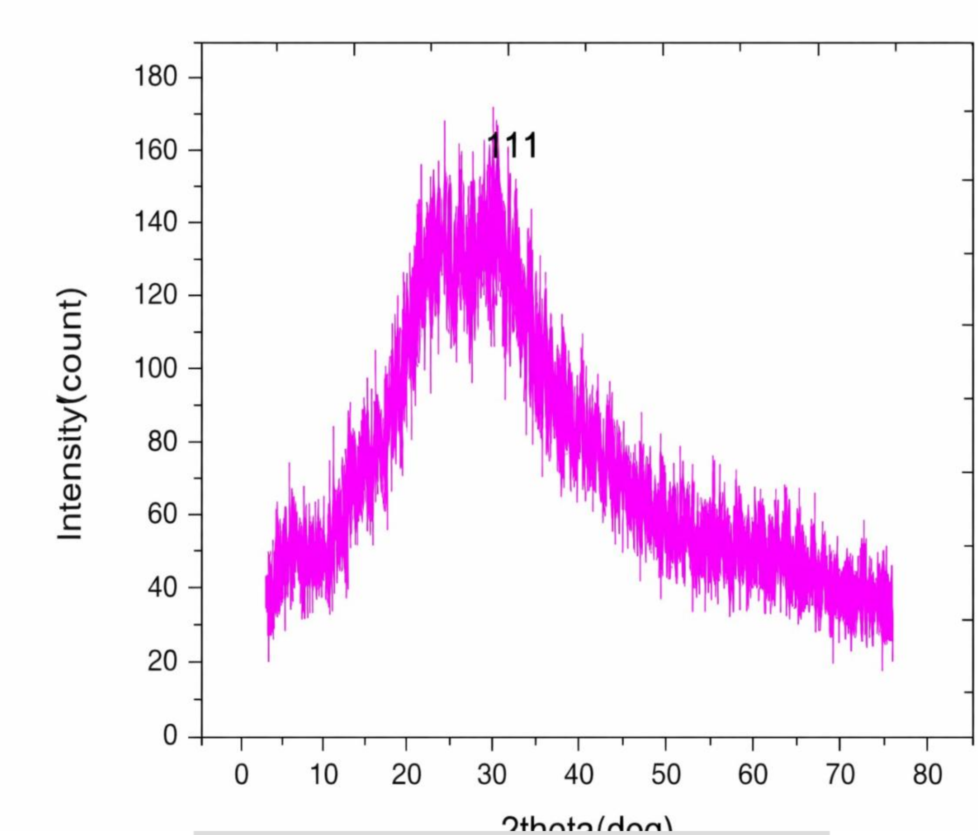


FIGURE 3.3

3.4. EDAX:

The EDX spectrum confirms the presence of Magnesium (Mg) and Chlorine (Cl) as the primary elemental constituents, with major peaks observed at approximately 1.25 keV and 2.62 keV, respectively. The high relative intensity of the Chlorine peak compared to Magnesium suggests a stoichiometric composition consistent with Magnesium Chloride (MgCl_2$). Trace amounts of Carbon (C) and Oxygen (O) were also detected, likely originating from the carbon mounting tape and surface oxidation or hydration. The absence of additional peaks in the high-energy range indicates that the sample maintains ahigh degree of elemental purity, free from significant metallic contaminants.

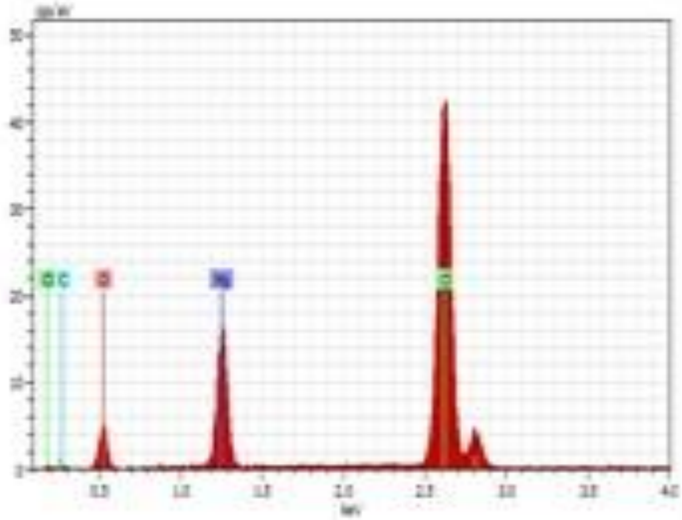


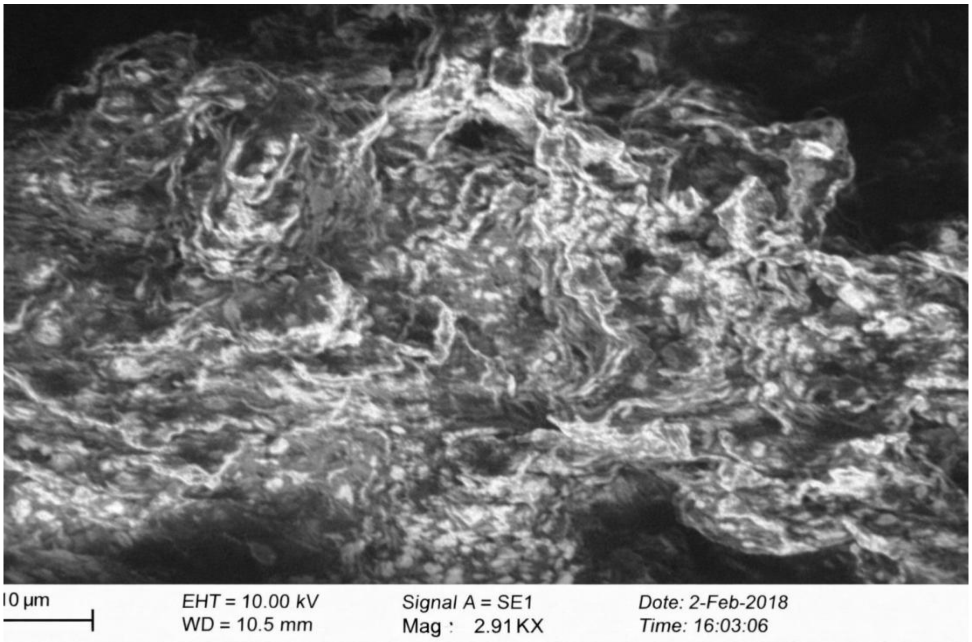
FIGURE 3.4

3.5. SEM:

The Scanning Electron Microscopy (SEM) image reveals a complex, highly irregular surface morphology characterized by a **heterogeneous distribution** of clustered particles. At a magnification of **2.91 kX**, the sample exhibits an **agglomerated structure** with a mix of porous regions and dense, globular formations. Small, spherical or grain-like features are interspersed throughout the larger, undulating matrix, suggesting a multifaceted growth process or a composite material. The high surface-to-volume ratio, indicated by the detailed textures and crevices, is a common trait in synthesized nanomaterials or biological templates. These morphological characteristics imply a high degree of surface area, which is often desirable for applications in catalysis, sensor development, or material reinforcement.

Parameter	Value
Parameter	2.91 kX
Scale Bar	10 μm
Acceleration Voltage (EHT)	10.00 Kv
Working Distance (WD)	10.5 mm

FIGURE 3.5



3.6. Antioxidant -radical scavenging activity

DPPH radical scavenging activity

Principle

Dpph (2,2-diphenyl-2-picryl hydrazyl), a stable free radical, when acted upon by an antioxidant, is converted into diphenyl-picryl hydrazine with a color change from deep violet to light yellow colour. This can be quantified spectrophotometrically at 518 nm to indicate the extent of dpph scavenging activity by the test sample.

REAGENTS

Magnesium Oxide with Sodium Hydroxide

1. DPPH (0.3 mm in methanol)

2. Methanol

Procedure

Three different concentration of the test* (0.1, 02 and 0.3 ml) and the solution was made up to 0.5 ml with methanol. 0.5ml of methanolic solution of dpph was added to each tube. The mixture was allowed to react at room temperature for 30minutes. Methanol alone served as blank and dpph in methanol, without the plant extracts, served as positive control. After 30 minutes of incubation, the dis colorization of the purple color was measured at 518nm. The radical scavenging activity was calculated as follows

$$\text{Scavenging activity (\%)} = \frac{\text{A518 [Control]} - \text{A518 [Test]}}{\text{A518 [Control]}} \times 100$$

ABTS scavenging activity

Principle

In this decolourisation assay, abts, the oxidant, is generated by per sulphate oxidation of 2,2 azinobis (3-ethylbenzoline-6-sulphonic acid) (abts2•), based on the inhibition of the

absorbance of the radical cation ABTS•+, which has a characteristic long wavelength absorption spectrum. This can be measured spectrophotometrically at 745nm to analyze the ABTS scavenging ability of the test* sample.

Reagents

1. ABTS solution (7mM with 2.45 mM ammonium persulfate).

2. Ethanol

Procedure

ABTS radical cations (ABTS+) were produced by reacting ABTS solution (7 mM) with 2.45 mM ammonium per sulphate. The mixture was allowed to stand in the dark at room temperature for 12-16 hours before use. Three different concentration of the test* (0.1, 02 and 0.3 ml) were added to 0.3 ml of ABTS solution and the final volume was made up to 1ml with ethanol. The absorbance was read at 745 nm and the percent scavenging activity by the test* sample was calculated using the formula

$$\text{Scavenging activity (\%)} = \frac{\text{A518 [Control]} - \text{A518 [Test]}}{\text{A518 [Control]}} \times 100$$

Sample Name	Volume (ml)	Concentration (µg)	DPPH Scavenging Activity (%)	ABTS Scavenging Activity (%)
Magnesium oxide with Sodium hydroxide	0.1	250	26.5	74.2
	0.2	500	47.2	93.3
	0.3	750	60.3	95.3
Standard- Ascorbic acid	0.1	250	94.3	

3.7. Antimicrobial activity

Determination of minimum inhibitory concentration (mic)

The anti-microbial activity for the given sample was carried out by Disc Diffusion Technique (Indian Pharmacopoeia 1996, Vol II A-105). The test microorganisms of Staphylococcus aureus, Proteus vulgaris , Salmonella typhi , E.coli and Fungus Aspergillus niger, Candida albicans were obtained from National Chemical Laboratory (NCL) Pune and maintained by periodical sub culturing on Nutrient agar and Sabouraud dextrose agar medium for bacteria and Fungi respectively. The effect produced by the sample was compared with the effect produced by the positive control (Reference standard Ciprofloxacin 5 µg/disc for bacteria; Nystatin 100 µg/disc for fungi).

fig (Anti mic) Agar diffusion method (A) disk-diffusion of microbial extract using C.Albicans as test microorganism,(B) Agar well diffusion method of essential oil using Aspergillusniger (A.niger) as test microorganism, and (C) Agar plug diffusion method of protecus sp, (D) Agar diffusion method extract using staphylococcus aureus (s.aureus), (E) Agar diffusion method of microbial extract using E.coli as test microorganism, (F) Agar diffusion of microbial extract using salmonella typhi (s.typhi) as test microorganisum.

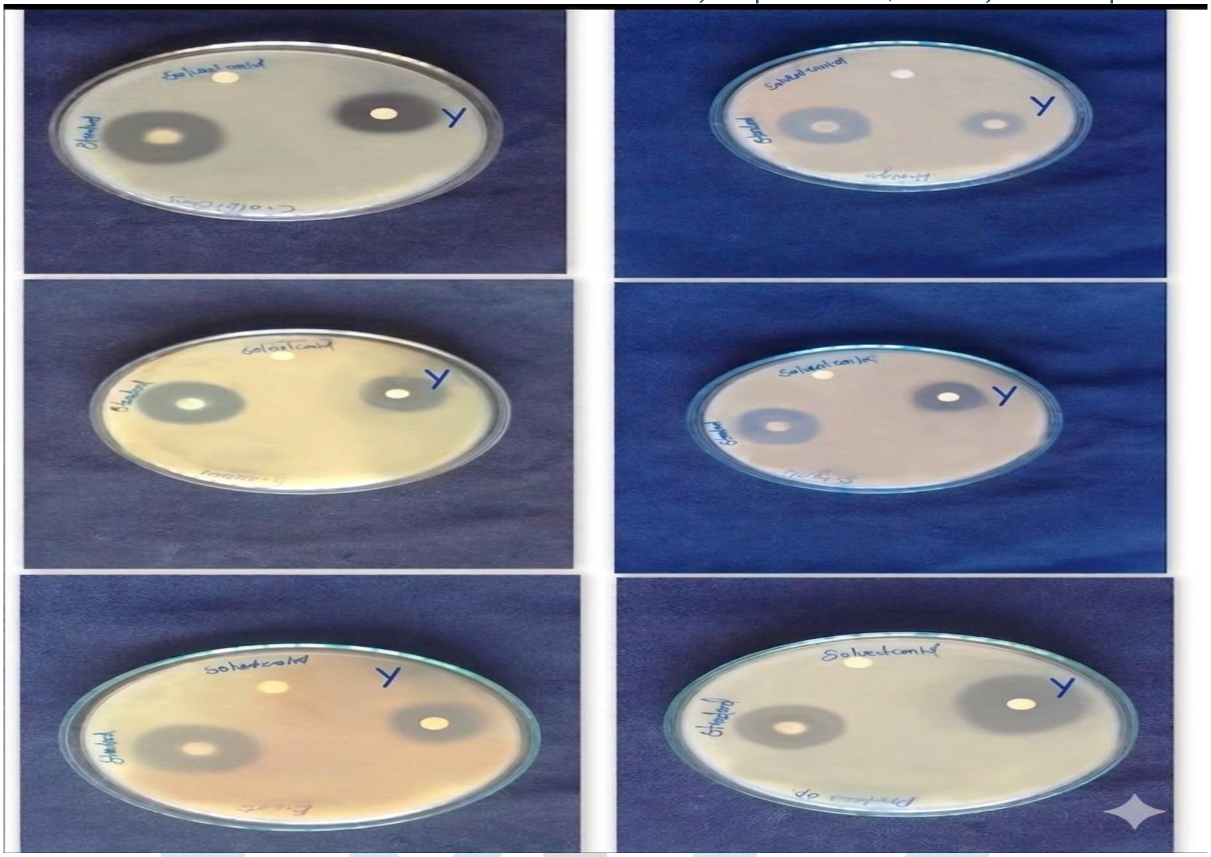
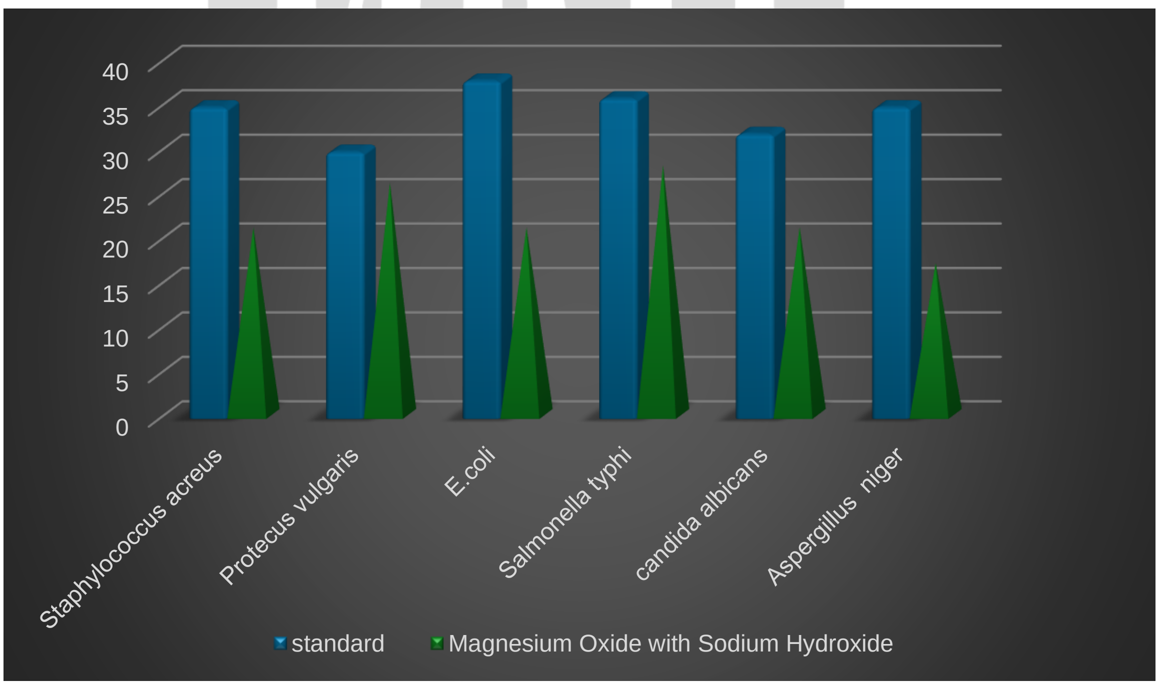


Fig Antimicrobial Activity3 .7

The graph plot for Anti-microbial Activity ofMagnesium Oxide with Sodium Hydroxide**:**



The table for Antimicrobial Activity of Magnesium Oxide with Sodium Hydroxide:

The obtained results are tabulated as follows:

S.No	Name of the organism	Sample	Zone of Inhibition in mm		
		Y		Solvent control	Standard
1.	*Staphylococcus aureus* (NCIM 2079)	21		Nil	35
2.	*Proteus vulgaris* (NCIM 2027)	26		Nil	30
3.	*E.coli* (NCIM 2065)	21		Nil	38
4.	*Salmonella typhi* (NCIM 2263)	28		Nil	36
5.	*Candida albicans* (NCIM 3102)	21		Nil	32
6.	*Aspergillus niger* (NCIM 105)	17		Nil	35

Standard- Ciprofloxacin 5µg /disc for bacteria

Nystatin 100 units / disc for fungi.

Solvent – distill water.

3.8.ANTIFUNGAL ACTIVITY

Spore germination assay

Principle

Lactophenol cotton blue stains the fungal cytoplasm and provides a light blue background, against which the walls of the hyphae can readily be seen. It contains four constituents: phenol which serves as a fungicide, lactic acid as cleaning agent, cotton blue to stain the cytoplasm of the fungus and glycerol to give a semi-permeable preparation.

Reagents

Lactophenol cotton blue stain

Procedure

Aliquots of spore were prepared by mixing loopful of fungal spores in sterile distilled water. 25µl of spore suspension was added to 10µl of the test sample* and placed in separate glass slides. Slides with 25µl of spore suspension alone served as the controls. Slides were then incubated in moist chamber at 25 ± 20oC for 24 hours. Each slide was fixed in lactophenol cotton blue stain. The mold was mixed gently with the stain using two teasing needles. A coverslip was placed on the preparation and examined under the compound microscope for spore germination.

Results

In control plate- Good hyphae and good morphology of fungal spores were observed

In test plate* - Damaged and shrunken spores of *Aspergillus niger* was observed

Sample Name	Spore inhibition of *Aspergillus niger*
Control (Without test sample)	-
MgO with NaOH	+

(+) indicates Spore inhibition caused by Magnesium Oxide with Sodium Hydroxide.

(-) indicates no inhibition of spores.

4.CONCLUSION:

The present study successfully demonstrated the fabrication of magnesium oxide (MgO) nanoparticles using a biological approach combined with the chemical precipitation method. The use of biological materials (such as plant extracts or natural reducing agents) makes the synthesis process eco-friendly, cost-effective, and safe compared to conventional chemical methods.

The chemical precipitation technique provided a simple and efficient route for producing MgO nanoparticles with good yield. The synthesized nanoparticles were characterized using various analytical techniques, which confirmed their formation, purity, and structural properties. The results indicated that the nanoparticles possess desirable physical and chemical characteristics such as small particle size, high surface area, and stability.

Overall, this method proves to be a reliable and sustainable approach for the synthesis of MgO nanoparticles. The synthesized nanoparticles can be further utilized in various applications including antimicrobial, antifungal, and catalytic activities. This study highlights the potential of combining biological and chemical methods for advanced nanomaterial synthesis.

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