

RESEARCH PAPER

## Ecofriendly Synthesis and Characterization of Silver Nanoparticles Using Typha Domingensis with Different pH Values and Multiple Temperature: an Experimental Study

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### ABSTRACT

Nanobiotechnology is a highly promising domain within contemporary technology and nanoscience. Nanoparticles of metal are utilized in various applications across multiple domains, including agriculture, medicine, electronics, and catalysis. Silver nanoparticles were synthesized using Typha domingensis extract, an essential component in nanotechnology, to address the high cost and low biocompatibility associated with chemically and physically synthesized nanoparticles. This research aimed to explore the feasibility of synthesizing silver nanoparticles (Ag-NPs) using an aqueous extract of Typha domingensis. The synthesized Ag nanoparticles were characterized using SEM, EDX, XRD, and UV-vis spectroscopy. The produced colloidal silver solution exhibited maximal absorption at 243 nm in UV-vis spectroscopy, with the best findings obtained at pH 9 and 45°C, and the silver nanoparticles had a spherical form with an average particle size of 31–69 nm, according to the X-ray diffraction and analysis. At concentrations of 25%, 50%, and 75%, the antibacterial activity of silver nanoparticles was examined against Escherichia coli and Pseudomonas aeruginosa (Gram-negative), and Staphylococcus aureus and Streptococcus (Gram-positive). The results showed that silver nanoparticles inhibited bacterial growth.

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### INTRODUCTION

Nanotechnology refers to the scientific and engineering disciplines that utilize phenomena at the nanoscale for Currently regarded as the most promising technology of the twenty-first century, nanotechnology has been investigated by researchers as a novel approach to medical research. Nanotechnology can boost industrial sectors' capacity and quality while also promoting economic growth [1]. Particles known as nanoparticles vary in size from 1 to 100 nm, which is nearly 1000 times smaller than a human hair's

diameter [2]. The nanoparticles can be classified as 0D, 1D, 2D, or 3D according to their morphology [3]. The importance of these nanoparticles became evident when researchers observed that size influences the physicochemical features of substances, including visual characteristics [4]. The diameter of a human hair is over 1000 times larger than nanoparticles, which are particles that range in size from 1 to 100 nanometers [5-11]. There are two types of approaches for synthesizing nanoparticles: top-down and bottom-up [12].

The development of There is an urgent

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demand for a non-toxic, ecologically safe NPs production technology. Motivated by the security-by-design theory, a number of green in recent years, synthesis techniques for NPs have been developed. that are safe, simple, economical, reproducible, and scalable. Thus, a number of biological systems, including, nowadays, NPs, are produced using a variety of green synthesis techniques, including the utilization of bacteria, fungus, yeast, and plant extracts. Among these green biological techniques, The gold standard for NP green synthesis is plant-based. due to its ease of use and variety of species [11, 13]. There are many different kinds of phytochemical substances found in plants, including flavonoids, terpenoids, polysaccharides, and phenolics, which have the ability to oxidation and reduction. Therefore, they are preferred for use in environmentally friendly nanoparticle synthesis. [14]. Strong anti-inflammatory and antioxidant qualities, as well as strong antibacterial and anticancer qualities, are among the many major therapeutic qualities of these compounds [15]. Silver nanoparticles were used in this work to produced utilizing the plant *Typha domingensis*. the study aims to evaluate the antibacterial activity of the synthesized Ag NPs against selected bacterial strains to assess their potential as antimicrobial agents.

## MATERIALS AND METHODS

### Collection of *Typha domingensis* leaves

*Typha domingensis* leaves were obtained from the marshes of the Al-Chibayish area, Nasiriyah city, Iraq, in July 2024. The collected leaves were air-dried after being cleaned with distilled water.

in a place away from sunlight for 14 days. They were then ground using a high-speed grinder to obtain a fine powder and kept in a refrigerator at 4°C until use.

### Preparation of Plant extract and Test Active Compounds

In a water bath, 50 g of dried the leaves were extracted using 500 ml of deionized water and agitated for 48 hours. After that, the extract was filtered three times with a Tetron cloth and once with a gauze cloth. After gathering the extract, A rotating evaporator was used to extract the solvent. set to 45 °C, and the crude extract was stored at 4 °C for additional tests.

### Synthesis of silver nanoparticles

After dissolving 2 grams of *Typha domingensis* powder in 50 ml of purified water, 10 ml of the aforementioned extract were added to 90 ml of 0.1 M AgNO<sub>3</sub> solution at temperatures of 70, 45, and 35, and pH was adjusted to 10 and 9 for each temperature. The mixture became brown, signifying formation Ag NPs. 24 hours were spent incubating. After centrifuging the solution, After disposing of the supernatant, the mixture was gathered [16], as depicted in Fig. 1.

### Disk Diffusion Test

The effects of antibiotics were studied using the disk diffusion approach [17]. The 0.5 McFarland standard was followed in the preparation of a microbial suspension from single bacterial colonies in order to examine the impact of the disk diffusion method. Individual bacteria were

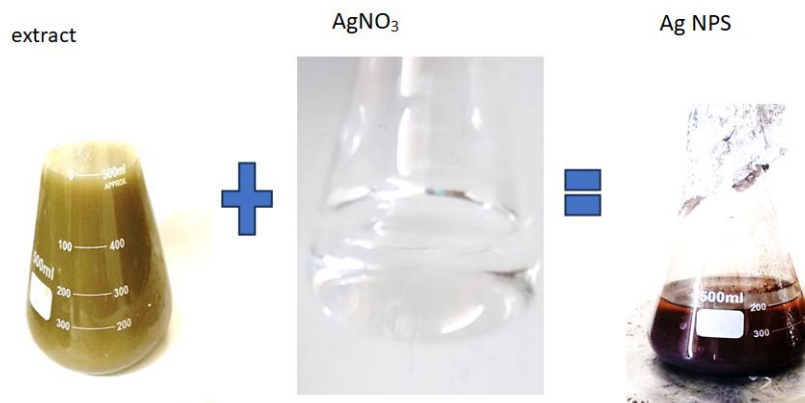


Fig.1. Synthesis of silver nanoparticles

cultivated on nutrient agar. Each plate had three disks with varying amounts of silver nanoparticles on it, along with positive and negative controls (antibiotics such as ATM, CAZ, CFM, and VA) and negative controls (water and DMSO). For every sample, 10  $\mu$ L was placed onto the disk. A 37°C oven was then used to incubate the plates. The microbial cloud was found to have ceased growing after a day [18]. Disk diffusion tests were conducted at 75%, 50%, and 25% concentrations.

#### Characterization of Ag NPs

The properties of the generated the green nanoparticles were investigated using a range of techniques, such as ultraviolet-visible spectroscopy to identify the surface plasmon resonance (SPR) band of the silver nanoparticles, scanning electron microscopy to assess the size and shape of the silver nanoparticles, and X-ray (XRD) to ascertain their crystal structure. (EDX) and (XRD) were used to determine the elemental composition and

chemical states of the silver nanoparticles [19].

## RESULTS AND DISCUSSION

### UV-visible spectroscopy

Nanoparticles range in from (2 – 100) nm, and their size changes depending on the metal, according to a study of the particles using UV-vis spectroscopy of absorption. Absorption spectroscopy of UV-vis has verified that the nanoparticles are usually formation between 300 and 800 nm [21]. Absorption of wavelengths between 200 and 800 nm was found to be appropriate for categorizing nanoparticles ranging in size from 2 and 100 nm [22]. The prepared silver nanoparticles gave an absorption range of 243-431 nm, which is close to the study conducted by Ghyadh, Bushra Ali [23].

### Energy Dispersive X-ray Spectroscopy

The compositional analysis (spectrum EDX) of the produced nanoparticles is displayed in Fig.

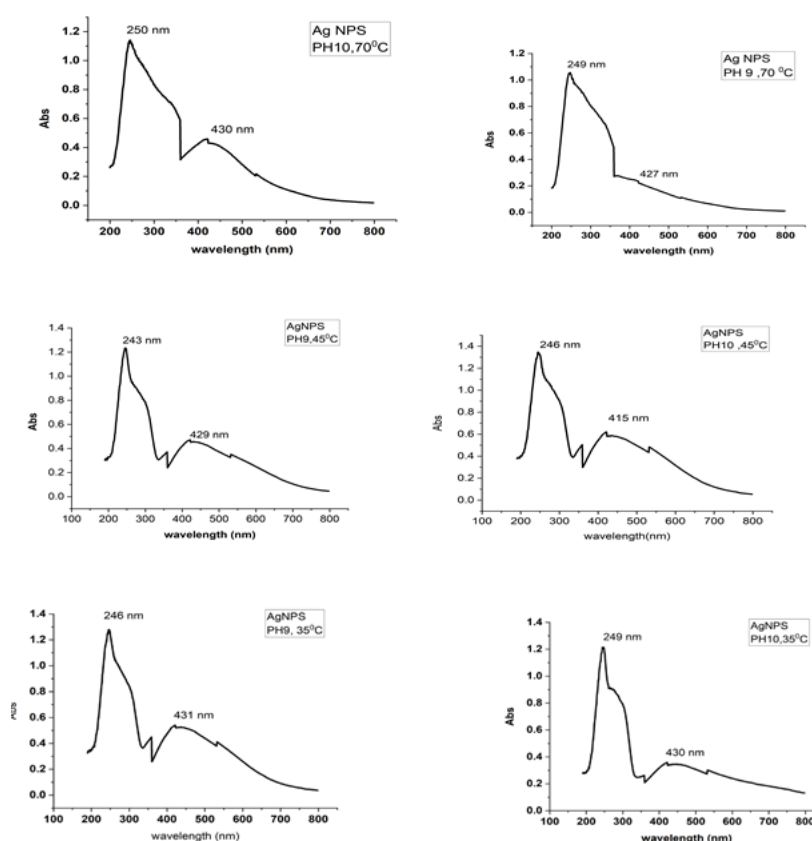


Fig. 2. analysis of Uv-visible of samples of Ag NPs.

3. The application of EDX analysis was to assess the combination of elements of Ag NPs, which were produced using *Typha domingensis* extract. Ag and Cl elements were found to have weight percentages of 93% and 7.0%, respectively, at pH 9 and 45 °C. Plant constituents are the source of carbon. The X- dispersive energy ray analysis supports the intensity (a. u.) of silver production and shows a high signal in the area of silver.

Weak C and Cl signals were also picked up. This is caused by the analysis plate in addition to the phytochemical elements found in the plant, or the bounded biomolecules on the Ag NPs surface may be the cause of other elemental signals seen in the spectrum [24, 25].

#### Scanning Electron Microscope

The electrons are used in the SEM technique to

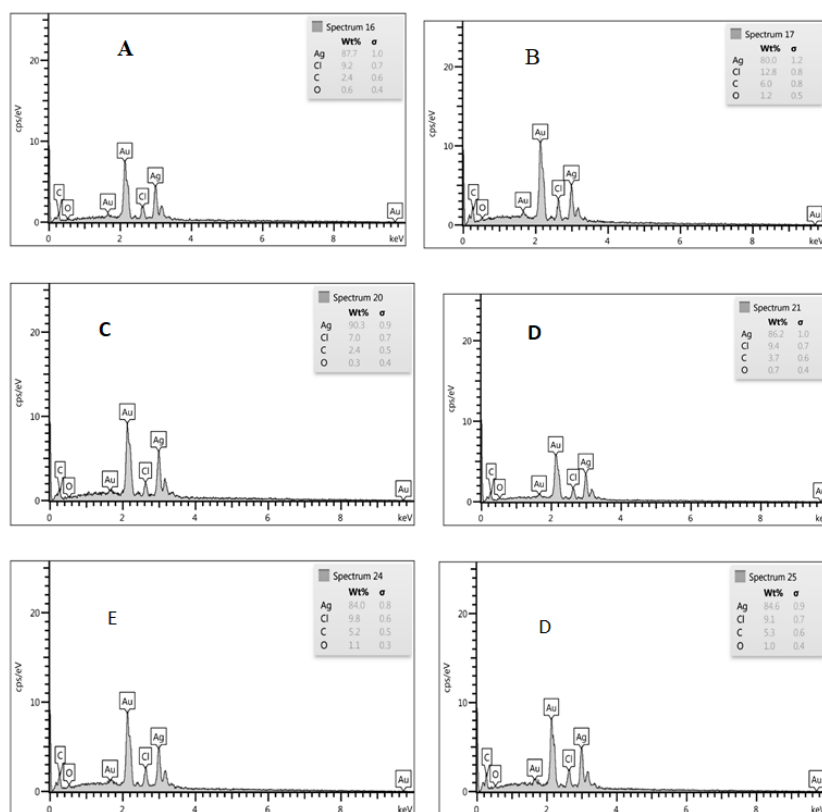


Fig. 3. EDX analysis of samples of Ag NPs in pH 9 and 10 and at temperatures of 70, 45, and 35 °C, respectively.

Table 1. size of Nanoparticles under different pH and temperature.

| pH | Temperature | Size of Ag NPS |
|----|-------------|----------------|
| 9  | 70 °C       | 50-82 nm       |
| 10 |             | 28-72 nm       |
| 9  | 45 °C       | 31-69 nm       |
| 10 |             | 37-71 nm       |
| 9  | 35 °C       | 34-63 nm       |
| 10 |             | 23-84 nm       |

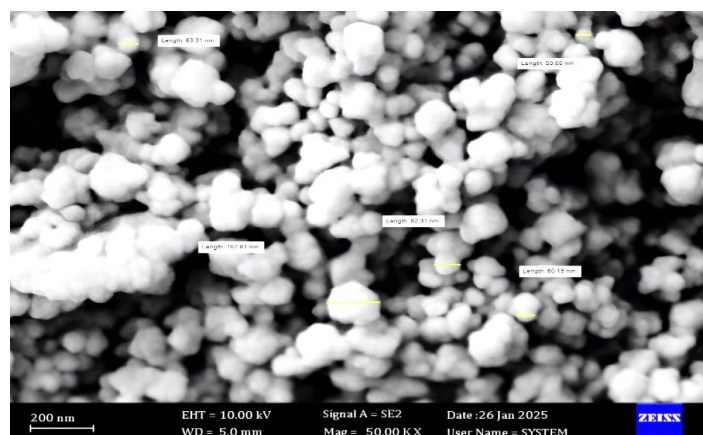


Fig. 4. SEM image for Ag NPs pH 9, 70 °C.

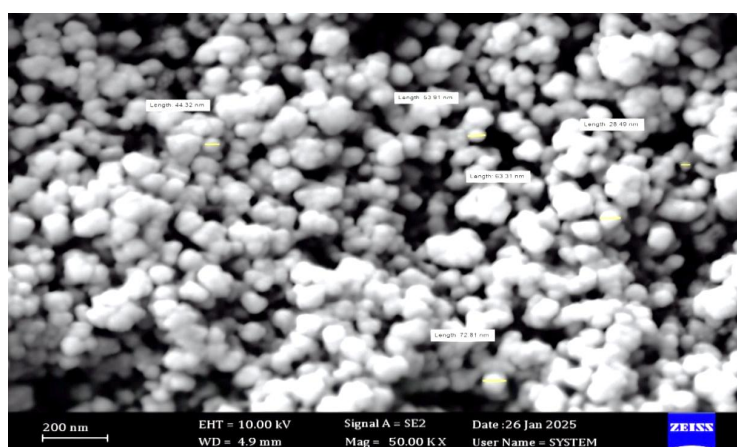


Fig. 5. SEM image for Ag NPs pH 10, 70 °C.

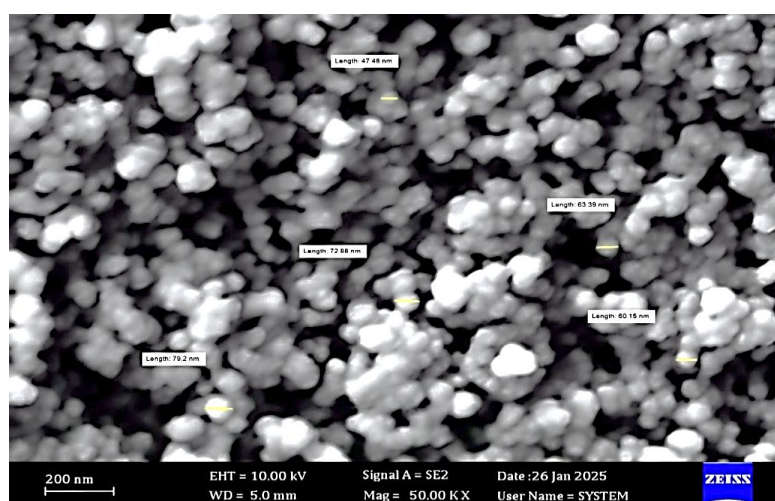


Fig. 6. SEM image for Ag NPs in pH 9, 45 °C.

create an output image [26]. The SEM evaluation is utilized to signify the dimensions Form, morphology, and distribution of produced silver nanoparticles [27]. The nanoparticles synthesized from the plant extract exhibited sharp peaks, indicating that they were on the nanoscale. The mean size of the silver the range of nanoparticles was (20 – 100) nanometers and were spherical in shape [28]. In this study, nanoparticles of different sizes were obtained at different pH levels and temperatures. The best nanoparticle size was obtained at pH 9 and 45°C, with sizes ranging from (31-69) nm, which is similar to the research carried out by Liaqat et al [29]. The prepared

nanoparticles' sizes under other conditions were as shown in Table 1.

#### *X-ray dispersive spectroscopy (XRD)*

Material atomic structures can be investigated using X-ray diffraction. This system facilitates the process of determining the qualitative and quantitative levels of materials. The size and structure of hard crystalline nanoparticles were determined and confirmed using X-ray dispersive spectroscopy analysis. [30]. In order to investigate the particle dimension of nanomaterials from X-ray dispersive spectroscopy data, the width of the Bragg reflection law used the Debye-Scherrer

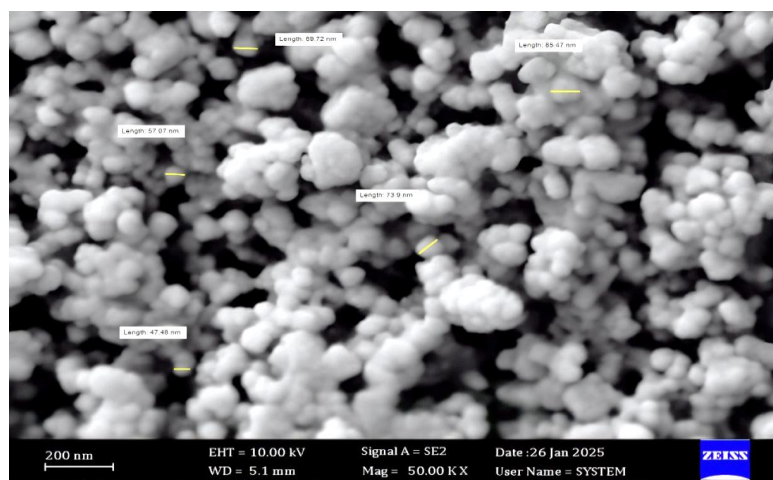


Fig. 7. SEM image for Ag NPs in pH 10, 45 °C.

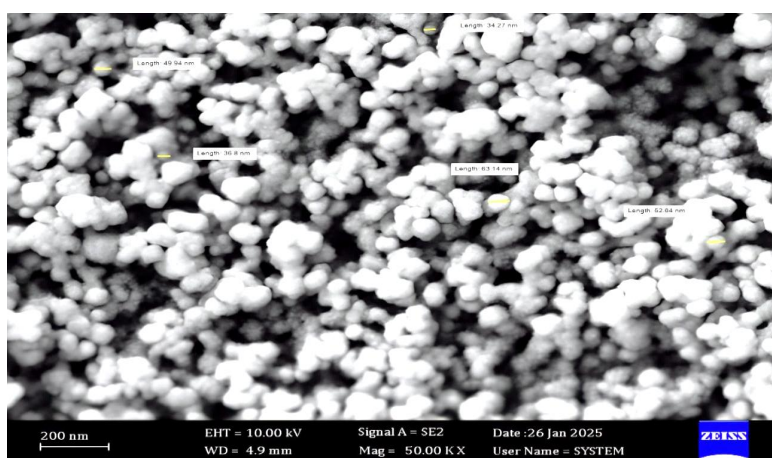


Fig. 8. SEM image for Ag NPS in pH 9, 35 °C.

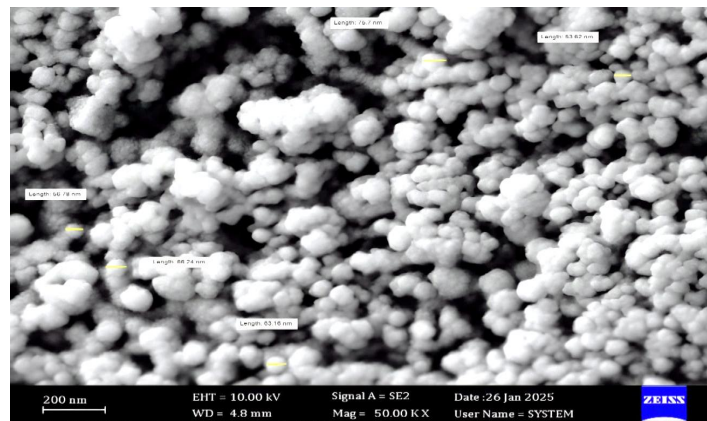


Fig. 9. SEM image for Ag NPS in pH 10, 35 °C.

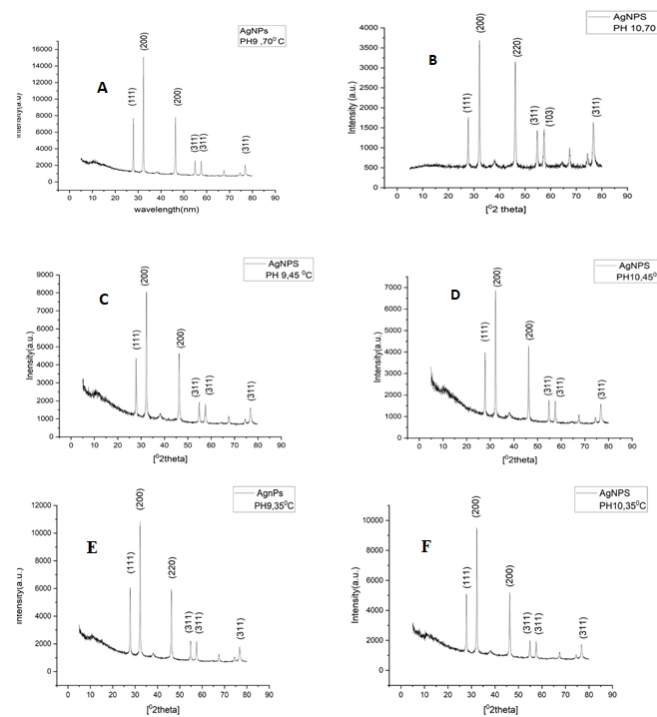


Fig 10. EDX analysis of samples of Ag NPs.



Fig. 11. Antibiotics activity against (Staphylococcus aureus and Streptococcus pneumoniae) and Gram-negative (Pseudomonas aeruginosa and Escherichia coli).

formula to compute. This equation is [31,32].

$$d = \frac{K\lambda}{\beta \cos \theta}$$

where  $\beta$  is the full width half maximum and  $\lambda$  is the X-ray wavelength,  $d$  is the particle size (in

nanometers),  $K$  is the Scherrer constant, and  $\theta$  is the diffraction angle that corresponds to the lattice plane [33]. Fig. 10 (C,F,E,A, B, D) demonstrates the peaks in the prepared NPs XRD peaks for  $2\theta$  values of  $76.8^\circ$  (311),  $46.3^\circ$  (200),  $32.2^\circ$  (111),  $57.5^\circ$  (311), and  $54.82^\circ$ , corresponding to the (220) planes of silver, were observed [31, 34-37].  $27.9^\circ$  (100) [31].

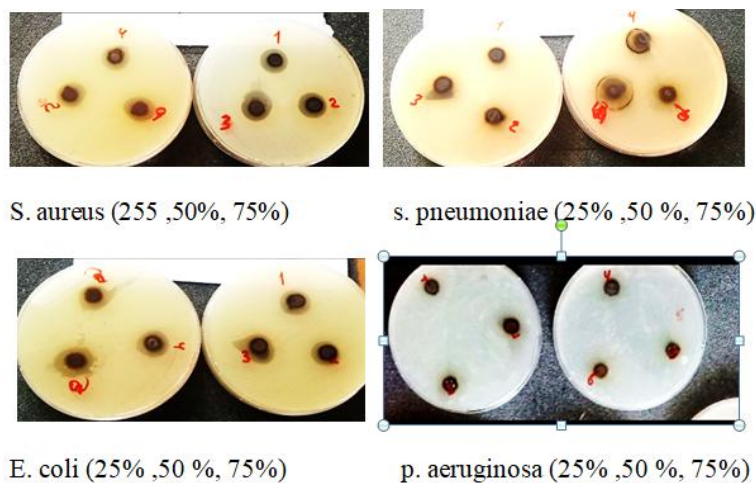


Fig. 12. antibacterial activities.

Table 2. The inhibitory ability of silver nanoparticles against strains.

| Bacteria name                 | Bacteria strain | Inhibition zone (mm) |     |     |    |     |     |     |      |
|-------------------------------|-----------------|----------------------|-----|-----|----|-----|-----|-----|------|
|                               |                 | 25%                  | 50% | 75% | VA | CFM | CAZ | ATM | DMSO |
| P. aeruginosa in pH 10, 70 °C | –               | 20                   | 23  | 30  | 28 | 0   | 0   | 0   | 0    |
| P. aeruginosa in pH 9, 45 °C  | –               | 19                   | 28  | 29  | 28 | 0   | 0   | 0   | 0    |
| E. coli in pH 10, 70 °C       | –               | 25                   | 28  | 29  | 0  | 0   | 0   | 0   | 0    |
| E. coli in pH 9, 45 °C        | –               | 25                   | 27  | 29  | 0  | 0   | 0   | 0   | 0    |
| Streptococcus in PH 10, 70 °C | +               | 25                   | 26  | 28  | 0  | 0   | 0   | 0   | 0    |
| Streptococcus in PH 9, 45 °C  | +               | 31                   | 30  | 29  | 0  | 0   | 0   | 0   | 0    |
| S. aureus in pH 10, 70 °C     | +               | 25                   | 26  | 29  | 20 | 30  | 0   | 0   | 0    |
| S. aureus in pH 9, 45 °C      | +               | 25                   | 24  | 23  | 20 | 30  | 0   | 0   | 0    |

### Antibacterial Activity

Using the agar disk diffusion method, the antibacterial activity of silver nanoparticles (Ag NPs) against four pathogens was found to be effective against both Gram-positive (*Staphylococcus aureus* and *Streptococcus pneumoniae*) and Gram-negative (*Pseudomonas aeruginosa* and *Escherichia coli*) bacteria. As seen in Figs. 11 and 12, the antibacterial activities were also contrasted with those of the antibiotics (ATM, CAZ, CFM, and VA) According to the data, silver nanoparticles had a strong capacity to stop microbial development. Silver nanoparticles had the strongest antibacterial action against *S. aureus* (29 mm), *streptococcus* (31 mm), *E. coli* (29 mm), and (30 mm) for *P. aeruginosa*. Both the zones of inhibition of silver nanoparticles and the zones of bacterial inhibition of ATM, CAZ, CFM, and VA tablets against *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Streptococcus*, and *Escherichia coli* are displayed in Table 2. The green synthesis silver nanoparticles outperformed conventional antibiotics in terms of their potent antibacterial action. The outcomes closely matched the research carried out by Kredy, Husam M [24].

### CONCLUSION

Using the reducing qualities of an aqueous extract of *Typha domingensis* leaves, we present an easy and eco-friendly way to create silver nanoparticles. When exposed to silver ions, the *Typha domingensis* leaf extract produces silver nanoparticles within minutes. This extract has stabilizing and reducing properties, and it is easy, quick, and inexpensive to make the nanoparticles.

### CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

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