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Green Synthesis, Characterization and Antimicrobial Activities of Silver Nanoparticles Using *Equisetum Ramosissimum* Extract

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ABSTRACT

This study reveals the green synthesis of silver nanoparticles of *Equisetum ramosissimum Desf* healing and medicinal plant present in valley of Swat, in Pakistan. The synthesized nanoparticles Silver nanoparticles (Ag-NPs) were characterized by various characterization techniques, such as UV-Vis spectrophotometry, Fourier Transmission Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM), X-Ray diffraction (XRD) analysis, Scanning and Atomic Force Microscopy (AFM). These results reveled the formation of nanoparticles in nano dimension range. Furthermore, silver nanoparticles were investigated for antimicrobial applications and exhibit good antimicrobial activities against bacteria like *Pseudomonas aeruginosa* and *Erwinia caratovora*, *Salmonella Typhi*, *Serratia marcescens*, *Morganelli morganii* and *Pseudomonas syringae*

Keywords: Silver nanoparticles, green synthesis, Antibacterial activity, Equisetum ramosissimum Desf

INTRODUCTION

The word green chemistry using in biochemical methods and product in direction to diminish or rather entirely stop the production and usage of dangerous resources. (Asif, Rana, Sharma, Singh, & Jakhmola, 2025) it represents a substantial shift from how environmental concerns have been taken into account or disregarded in the upfront design of the molecules and molecular transformations. It is crucial to remember that green chemistry addresses the inherent risks of chemicals rather than the situations and conditions of their usage that could make them more dangerous. (Krasnodębski, 2024) This helps to reduce risk and prevent pollution. (Awewomom et al., 2024) Green chemistry aims to eradicate pollution at its source so that beneficial life forms won't be endangered by the new chemistry. A fresh and creative strategy for advancing the goals of the chemical industry in the framework of sustainability is green chemistry. Nonetheless, chemistry could be strengthened, enhanced, and advanced by it. It specifically aims to inspire gifted young scientists and draw them to the field of chemistry (Tundo et al., 2000). Nanoparticles are leading aspect in advancing well-organized technologies for the time ahead, for manhood and the surrounding. (Hamzat, Aljabali, El-Tanani, & Tambuwala, 2025) A green chemistry technique that connects nanotechnology and plant biotechnology is the creation of green nanoparticles. (Elumalai, Sharma, Dantinapalli, Palanisamy, & Kuril, 2025) Metal nanoparticle synthesis uses plant extracts as a source of bio reduction. The presence of phenolic acid, alkaloids, protein, and sugar in plant extracts of metal ions gives them the ability to bio reduce into metal nanoparticles. (Dubey et al., 2024) The nanoparticles' property is totally detrimental to the bulk materials (Parveen, Banse, & Ledwani, 2016). Nanoparticles are considered as vital constituents and components in field of nanotechnology concern with size from 10-100nm.The nano range related particles is employed via several manufacturing industries and manhood (Biswas & Wu, 2005). Floras and their secondary metabolites have loaded with various features in medicinal discipline because of their bactericidal flavonoid, and analgesic features. Nanotechnology is a holistic field of research and nanoparticles utilized for food purpose plus in medication as well (Ercan, 2023). The infectious disease is cured through using of anti-biotic and the overwhelming usages of antibiotic may lead to sever health disorder which created other complexity of health (Moodley, Krishna, Pillay, & Govender, 2020). It has been examined currently that nanoparticles obtain via using plants have antimicrobial features (Subramanyam et al., 2021). *Equisetum telmateia* commonly termed as horse tail and recognized well for its historical applications in therapeutic science like eczema, mouth, infection, stomach pain, urinary tract infection which is utilized for Silver nanoparticles synthesis (Altınay, Köse, Ateş, & Kızılbey, 2024). Different methods are employed for synthesis metal nanoparticles physical method i.e. grinding, spark discharge, gamma irradiation which need expensive apparatus chemical method like pyrolysis, sol gel method and thermal decomposition which involve chemical waste as by product and supposed as dangerous for environment**.** green method are ecofriendly procedure and inexpensive method as compare to physical and chemical method, green method employs the plants, fungi, algae and bacteria for synthesis of nanoparticles (Buarki, AbuHassan, Al Hannan, Henari, & Kumar, 2022). It is guessed that Silver nanoparticles treated about 650 diseases and also considered as nontoxic and protected antimicrobic agent. Because of its physical, chemical and biological importance Silver nanoparticles have a lot of uses in different field of industry and in medicinal field. Various factors like shape, size, coating distribution, morphology of particles and composition of nanoparticles influence efficacy of Silver nanoparticles (H. A. Widatalla et al., 2022). When protein, nucleic acid or lipid interact with free radical initiating various abnormalities comprising aging, cancer. So, it is important to prevent free radical formation through antioxidants and this antioxidants action is performed by Silver nanoparticles (D. Singh, Tiwari, Singh, & Singh, 2024). Some of other studies have exposed the fruitful fabricating of silver nanoparticles of size 5-100nm from diverse group and parts plants. Sphere-shaped silver nanoparticles were produced from *Murray koenji* of 5-20 nm nanoparticles dimension (Qais et al., 2019)**.** Metal nanoparticles like Silver nanoparticle and Gold nanoparticle have got tremendous attention because their uses and operation in catalysis, homoeopathic science, and also in other field of environment and electronics. Among different kind of nanoparticles silver nanoparticles have wide-ranging of implementation in the several field like pharmaceutical. The green synthesis of silver nanoparticles is inexpensive and has no lethal effect on atmosphere**.** The silver nanoparticles having size of 10 to 20 nm were synthesized from *Osimum sanctum***.** It has been described that aqueous fruit extract of phoenix dactylifera were employed for synthesis silver nanoparticle 20 to 100nm dimension (Hadi, Ng, Shamsuddin, Matmin, & Malek, 2021). crystalline Silver nanoparticles which spherical in shape and have average particle size of 20 nm were magnificently formed via Cestrum nostrum extract (Keshari, Srivastava, Singh, Yadav, & Nath, 2020). Silver nanoparticles are considered as a prominent entities for scrutiny in field of nanotechnology because of their application in odontology, wound recovery and also have fungicidal, antiviral and bactericidal features (Trang et al., 2021). It is also investigated that silver nanoparticles is utilized for the purpose of dental tools and bandages. Silver nanoparticles is incorporated with dental composites materials of coating which enhance the prevention of fungus and other microbes' growth (Muhammad Rafique et all 2 of016). Several papers have published about the silver nanoparticles from various genera of equisetum such as *Equisetum talmatia* however there is no work on synthesis of silver nanoparticles on *Equisetum ramosisimum*. So, in this work, we will explore an inventive contribution for the synthesis of silver nanoparticles via using *Equisetum ramosissimum* belong to the family equisetaceae**.**

MARTIALS AND METHODS

Preparation of Equisetum Plant Extract: The *Equisetum ramosissimum* plants were collected from natural environment of village Karal, Shalpin Swat having geographical coordinates (longitude 72.53074 and latitude 34.94862) and then dried or desiccated at shade up to three weeks. The dried plants then subjected to grinder for the purpose of grinding into powder. 50 grams of the plant powder of *Equisetum ramosissimum* blended in 1000 mL of distill water with the help of magnetic stirrer for 4 hours at 60ºC temperature.

The crude solution has been prepared which then filter through muslin cloth and then through whatman filter paper and pure extract were attained for synthesis of silver nanoparticles.

Preparation of a stock solution: The required stock solutions were prepared, i) Stock solution of silver nitrates were prepared by dissolving of Silver nitrate salt in distilled water of 500 mL. ii) Other solution of plant powder which was prepared by dissolving 50 grams of plant powder in 1000 mL distill water.

Preparation of Silver nanoparticles: The silver nanoparticles were synthesized via mixing of 3mL of silver nitrate solution (Silver nitrate solution contained 0.25 g,2.94 mM in distilled water) and 8 mL of diluted plant extract which is then exposed to sunlight till possible color change from yellow to brown color as shown in given figure 2A and B. Plant extracts play its roll in reduction process of Silver Nitrate into Silver nanoparticles and sunlight speed up the process of reduction.

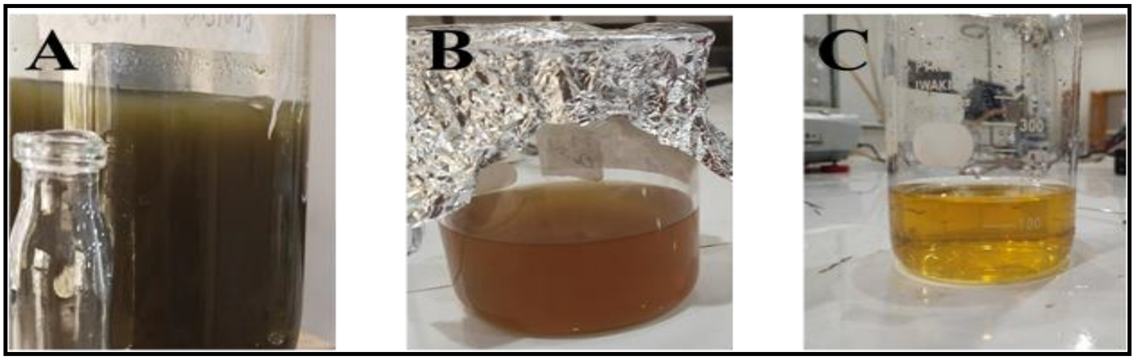

Figure .1. (A) represents crude solution of *E. ramosissimum*, (B) represents extract after filtration and (C) represents plant extract after dilution

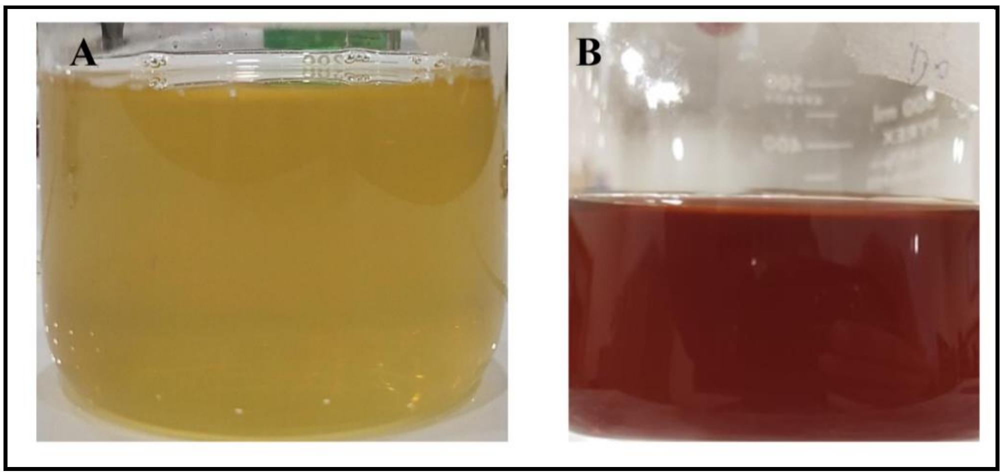

Figure. 2. (A) color of extract of after addition of silver nitrate. (B) Color plant extract and silver nitrate solution after complete reduction.

Effect of pH: A series of reduction, nucleation, growth, and stabilization stages are typically involved in the synthesis of nanoparticle solutions at neutral pH. Mild reducing agents that are active at neutral circumstances, like *E. ramosissimum* plants, convert metal salt precursors into neutral atoms in this process. After forming stable nuclei through aggregation, these reduced atoms expand under control to become nanoparticles. Functional groups like -OH, -COOH, and $-NH_2$ remain somewhat ionised in the ideal environment provided by neutral pH, allowing for steric and electrostatic stabilisation while avoiding unchecked aggregation. (Ahmed, Ahmad, Swami, & Ikram, 2016; Sharma, Yngard, & Lin, 2009; M. Singh, Sinha, & Mandal, 2009) It is explored as well that the nanoparticles formation influenced via pH. The Silver nanoparticles creation is elevated at pH 7 to 8. The synthesis of nanoparticles declined if pH is rise from 8 and onward due to the instability of silver ions and excessive nucleation may lead to agglomeration or irregular synthesis, hence reducing the efficiency of nanoparticle formation. (Marciniak, Nowak, Trojanowska, Tylkowski, & Jastrzab, 2020) Nanoparticles synthesis also reduces if pH decrease to 3 or below 3. The silver nanoparticles were formed as well at basic pH 8. In neutral pH the formation of nanoparticles is very high so we have tried to synthesize the nanoparticles on pH 6 to 7.

Collection of solid particles: The Silver nanoparticles in solid form were isolated with the help centrifugation. The solution of silver nitrate salt and *Equisetum ramosissimum* extracts were subjected to centrifuge at 10000 rpm for 30 minutes.

Antibacterial Assay of Ag-NPs : *Equisetum ramosissimum*-Silver nanoparticles (Ag) and were tested for its antimicrobial activities thorough well diffusion method. (Hossain, 2024) In this pursue, the effects of silver nanoparticles were studied against *Pseudomonas aeroginosa Erwinia caratovora, Salmonella Typhi, Serratia marcescens, Morganelli morganii* and *pseudomonas Syringae*, gave extremely impressive results which show that *Equisetum ramosissimum* is extremely operative in the synthesis of antibacterial product.

Instrument used in title study: The produced silver nanoparticles were characterized structurally and physiochemically using a variety of analytical methods.

FTIR (Fourier Transform Infrared Spectroscopy, Bruker Alpha II) was used to determine the functional groups. The UV-Visible spectrophotometer (Shimadzu UV-2600i) was used to analyse the absorption characteristics. By using X-ray diffraction (XRD, PANalytical X'Pert PRO), the crystalline structure and phase identification were ascertained. The Atomic Force Microscope (AFM, Bruker Dimension Icon) was used to analyse the topographical features and surface morphology. Thermogravimetric Analysis was used to evaluate thermal stability (TGA, TA-Instruments Q500). The digital pH meter (Benchtop pH Meter, PH-B600L) was used to measure the pH of the solutions.

RESULTS AND DISCUSSION

UV-visible analysis of Ag-NPS: UV–vis spectroscopy is extremely advantageous in evaluating NPs and inspecting the stability of metal NPs in water solutions. While synthesizing Silver nanoparticles color of solution altered. The discoveries showed a sharp plasmon resonance (PR) at nearly 443 nm, explicit to AgNP formation, the spectra recorded from300–800 nm. (Lavecchia, García-Martínez, Contreras-Ropero, Barajas-Solano, & Zuorro, 2024) Subsequently, the thoroughgoing absorption wavelength with minute or no growth was recognized, which demonstrated the stability of Silver nanoparticles (NPs) in water solutions (Figure 3). The plasma resonance frequency and width of metal nanoparticle influenced through size, dielectric constant and shape of nanoparticles. UV Vis spectroscopy analysis is done to examine the shape, effect reaction time on Silver nanoparticles which concern with the peaks while sharpen and size metal NPs in aqueous suspensions. (Sati, Ranade, Mali, Ahmad Yasin, & Pratap, 2025) The intensity could be raised ascribed to the increasing NP amount because of silver salt reduction in the aqueous solution to Silver nanoparticles (Sedaghat & Omidi, 2019).

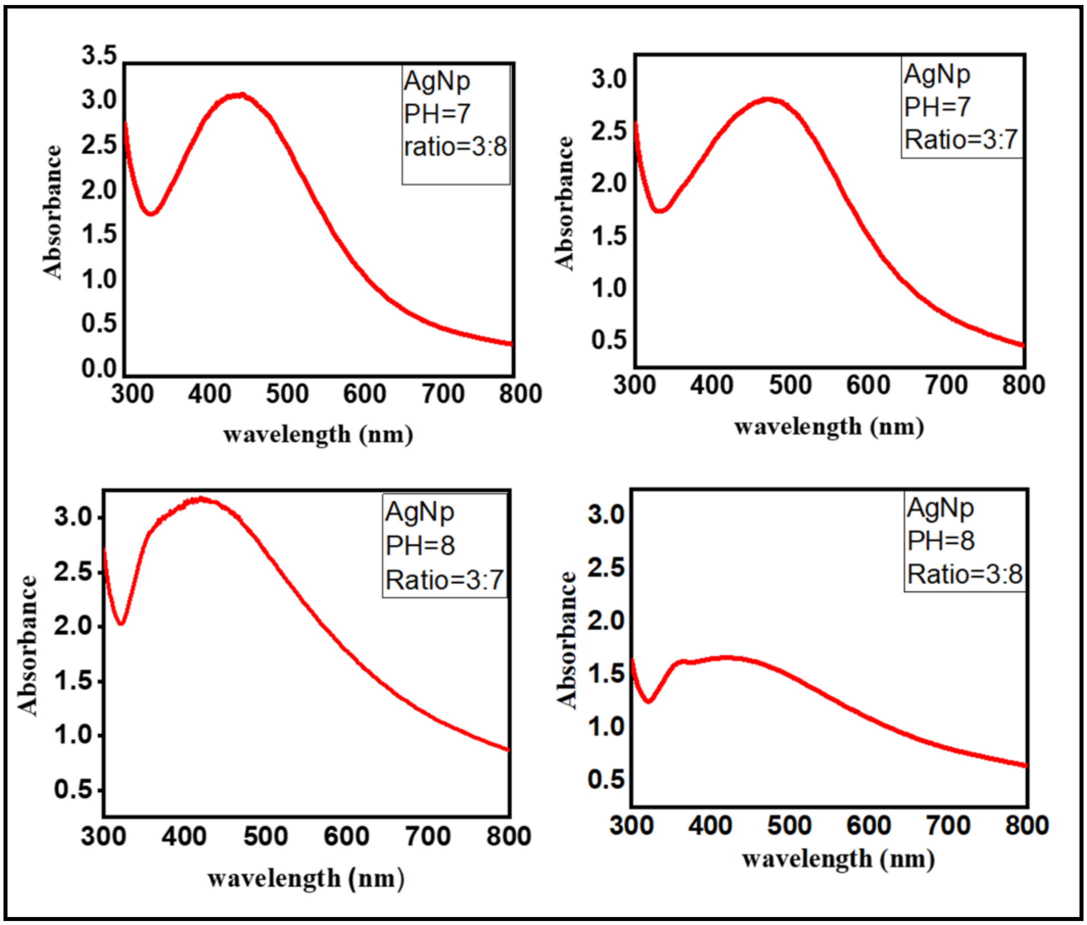

Figure 3 UV vis Spectra of Ag-NPs attained after mingling $AgNO_3$ and different concentrations of plant extract of *Equisetum ramosissimum* at different pH

X-ray Diffraction (XRD) analysis of Ag-NPsS: The XRD analysis of Silver nanoparticles revealed the silver nanoparticle's crystalline structure. Figure 4 show X-ray diffraction pattern Silver nanoparticles (AgNps). On the Basis of face-centered cubic (FCC) structure, several Bragg reflection peaks were originated at 2θ values of

27.87°, 32.3°, 38.18, 44.4, 46.29°, 54.82°, 57.51°, 64.50°,76.80.°. These peaks were related to the (210), (122), (111), (200), (231), (142), (241), (220), (311) and 222 planes respectively of pure silver. (Alam et al., 2025) The XRD results obviously display that the Silver nanoparticles (Ag) produced by the extract of *Equisetum ramosissimum* plant, are crystalline in nature. Some other unwanted peaks are present in X Ray diffraction (XRD) which confirm the existence of crystallization of caping agents and reducing agents on Silver nanoparticles AgNps (Meng, 2015), (Bankura et al., 2012).

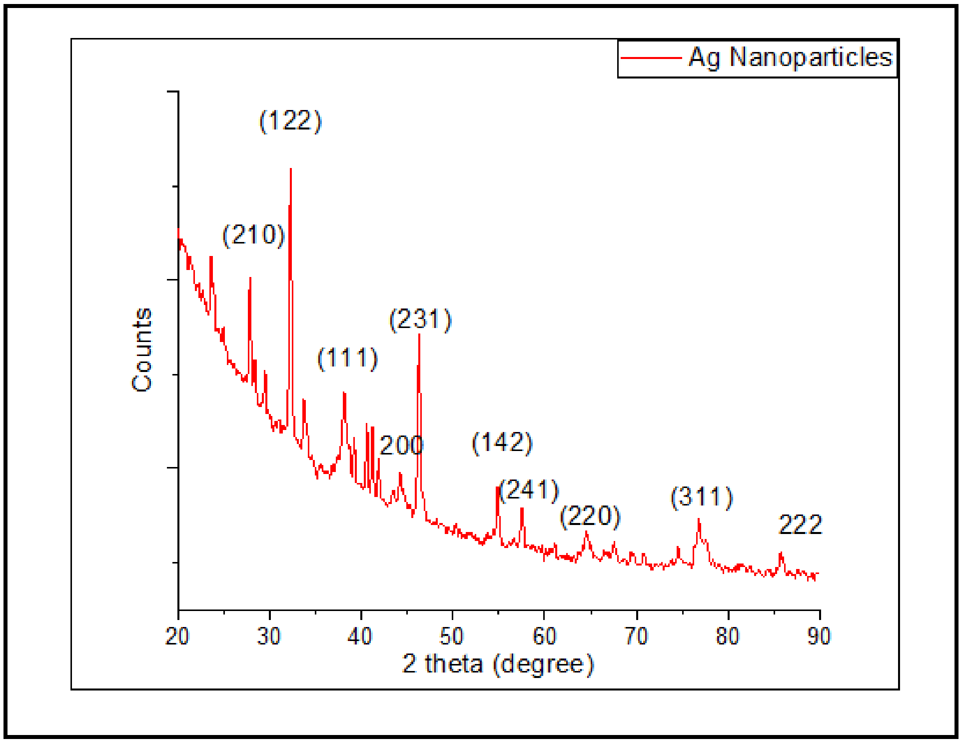

Figure 4 XRD analysis of Ag-NPs synthesized from AgNO3 and *Equisetum ramosissimum*

Atomic Force Microscope (AFM) analysis: The silver nanoparticles which synthesized from *Equisetum ramosissimum* plant extract were characterized through atomic force microscope (AFM). Picture of atomic force microscope shows 1micro meter x 1 micro meter shown in figure 5. Atomic force microscope was used to scan Silver nanoparticles which was synthesized from *Equisetum ramosissimum* plant extract. It shows the size of Silver nanoparticles while processed through atomic force microscope which was synthesized from *Equisetum ramosissimum* plant extract. The discoveries obviously displayed that *Equisetum ramosissimum* plant extract have future ability for manufacturing silver nanoparticles of different sizes which are suitable for proper utilization. As seen in the image, the largest particle had a diameter of 60 nm and 38nm is an average grain size while the smallest particles size is 23nm of the synthesized nanoparticles (Duman et al., 2024).

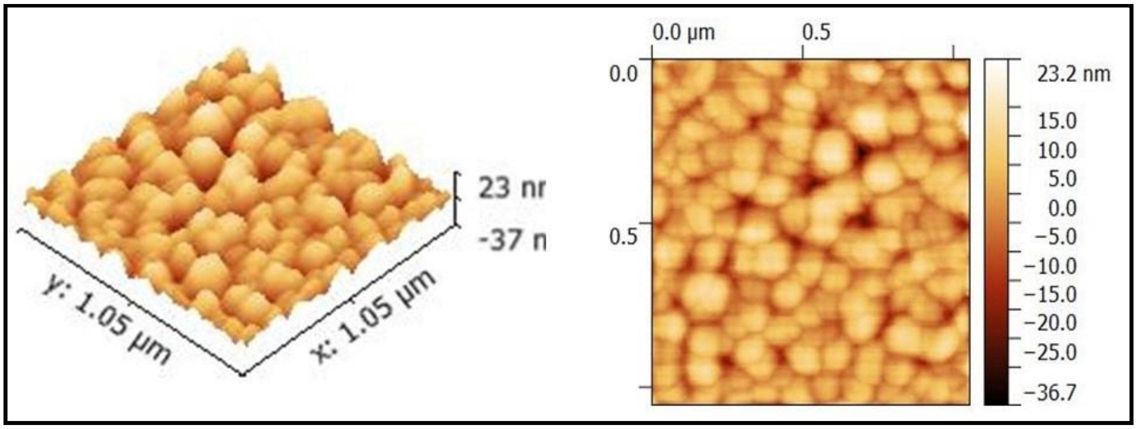

Figure 5 AFM analysis of Ag-NPs synthesized from AgNO3 and extract of *Equisetum ramosissimum*.

Fourier Transform Infrared Spectroscopy (FTIR)-analysis: The broad band at 3394.72 cm^{-1} in the spectrum of pure *E. ramosissemum* extract provides information about the stretching vibration of O-H bonds, while the doublet bands at 2927.94 cm^{-1} and 2856.58 cm^{-1} specify stretching vibrations of carbon hydrogen bond (C-H), which relates the CH_3 and CH_2 groups of aliphatic related compounds. Bands at 1608 cm^{-1} confirm the existence of N–H amide N-H deformation bending, CO stretching vibration or the stretching of C=C of aromatic rings. Band at 1508.33 $cm^{-1,}$ 1419.61 cm^{-1}, and 1255.66 cm^{-1} indicates, the bending vibration of the C-H bond of the CH3, CH2 groups and the C-O stretching vibration of an organic compound. Lastly, bands of C-O, C=C, and C-O-C groups was confirmed by spectra at 1139.93 cm^{-1}, 1087.85 cm^{-1}, and 921.97 cm^{-1} which were initiated to stretch carbohydrates and bend vibrations of C-H bonds. The main functional groups which found in phytochemicals like vitamins, flavonoids, alkaloids, phenolic compounds proteins, terpenes, tannins, and saponins are O-H, C-H, and N-H. Because of the interatomic vibrations, metal oxide nanoparticles typically displayed absorption bands below 1000 cm^{-1}.

The FTIR scrutiny of Silver nanoparticles were taken to identify the biomolecule which is operating in reduction of Ag^+ ions to silver nanoparticles while using *Equisetum ramosissimum* plant extract. For the analysis of Silver nanoparticles (AgNPs) were employed in the form powdered. The spectrum of Fourier transmission infrared spectrum (FTIR) seems at 3280 cm-^{1}, 1763 cm-^{1}, 1602 cm-^{1}, 1376cm-^{1}, 1195 cm-^{1}, 1108 cm-^{1}, 824 cm-^{1} and 616 cm-^{1}. The broad peak at 3280 cm-^{1} specifies OH group of Phenol and carbonyls functional group of aliphatic carboxylic acid. The FTIR information express that silver nanoparticles connect with biological molecule like carboxylic group of protein. The hydroxyl groups of phenolic compounds, and proteins. The existence of C=C double bond in aromatic compound specified via absorption band at 1602 cm^{-1} and C=O stretching in polyphenol, aldehydes or ketones and also N–H stretching in amine as well. The decline in intensity of peaks from 1610 to 1602 and from 3394 to 3280 approve the presence of Silver nanoparticles. IR spectrums that were seemed at 1376 $cm^{-1,}$ and 1763 cm^{-1} and found as new peak which may because of the silver nanoparticles. The peak which concerns with 1106 cm^{-1} directs C–O stretching in compounds of carbohydrates, ether or ester. The IR spectrum which delivers sharp band at 825 cm^{-1}demonstrates C=C of disubstituted benzene. Sharp peak 616 cm^{-1} is correspondence with the Ag–N and Ag–O bond vibration of Silver nanoparticles (AgNps). These compounds utilized as reductants, caping agent and stabilizers for Silver (Ag^+) to silver nanoparticles. Some peaks of plant extract, which give bands at 2927.94 cm^{-1}, 2856.58 cm^{-1}, 1508.33 $cm^{-1,}$ 1419.61 cm^{-1}, 1255.66 cm^{-1}, and 921.97 cm^{-1} were vanished in the spectrum of nanoparticle, confirm that these constituents had a straight collaboration with Silver nanoparticles which initiates the oxidation of Silver ion and thus it is not reveal on the surface of nanoparticles. The upper mentioned functional group of bio molecules which were analyzed through FTIR utilized for the purpose agents as stabilizers and develop the steric hindrance to avoid agglomeration. These compounds help in the transferring of electrons to make the reduction process ease for the synthesis of Silver nanoparticles from Silver salt. The decrease in an intensity of –OH moieties 3394-3280 and CO around 1600 in FTIR spectra before and after the synthesis of nanoparticles clearly demonstrate the synthesis of Ag-NPs (Mohammed & Hasan, 2024), (Jabbar et al., 2023),

Thermogravimetric analysis (TGA): Thermogravimetric analysis has been carried out which shows the degradation from 50 to 350 C°. it is observed that 5.81% heat loss having temperature 51 to 225°C and this heat loss is because of the evaporation of water in equisetum ramosissmum green synthesis of silver nanoparticles. It was recommended via thermogravimetric analysis (TGA) curve of Silver nanoparticles that t various organic molecules are present in sample of plant and utilizing for the reduction Silver ion and these organic molecules were confirmed by FTIR spectra and TGA analysis show that there was 11.79% loss of weight of the green synthesized Silver nanoparticles (Ag-NPs) because of the organic compound burning. Therefore, it is acknowledged that molecules accountable for the reduction of metal ions and keep stable the particles in the mixing solution are used to make plant extract of *Equisetum ramosissimum* stabilized Ag-NPs. Resultantly it was shown by thermogravimetric analysis (TGA) curve of Silver nanoparticles there was 17% weight loss till 333˚C from 5 ˚C (Show, Ghosal, & Chattopadhyay, 2016).

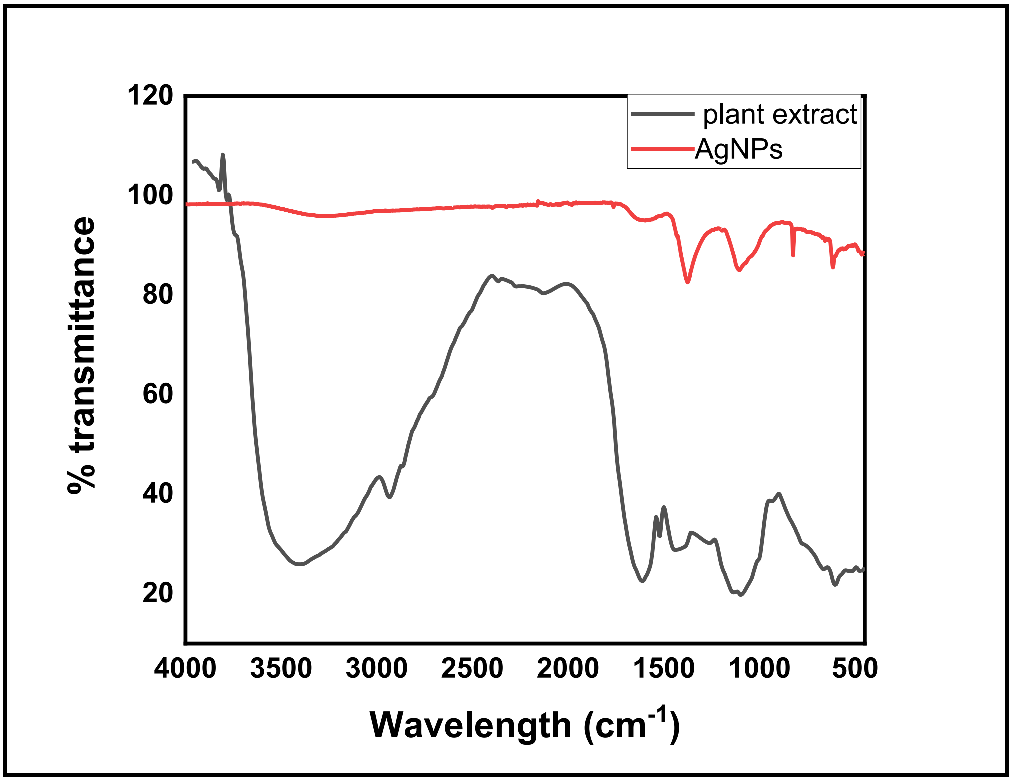

Figure 4 FTIR spectra of pure *Equisetum ramosissimum* extract (Black) (Mohammed & Hasan, 2024) and silver nanoparticles synthesized from equisetum ramossismum plant extracts (Red).

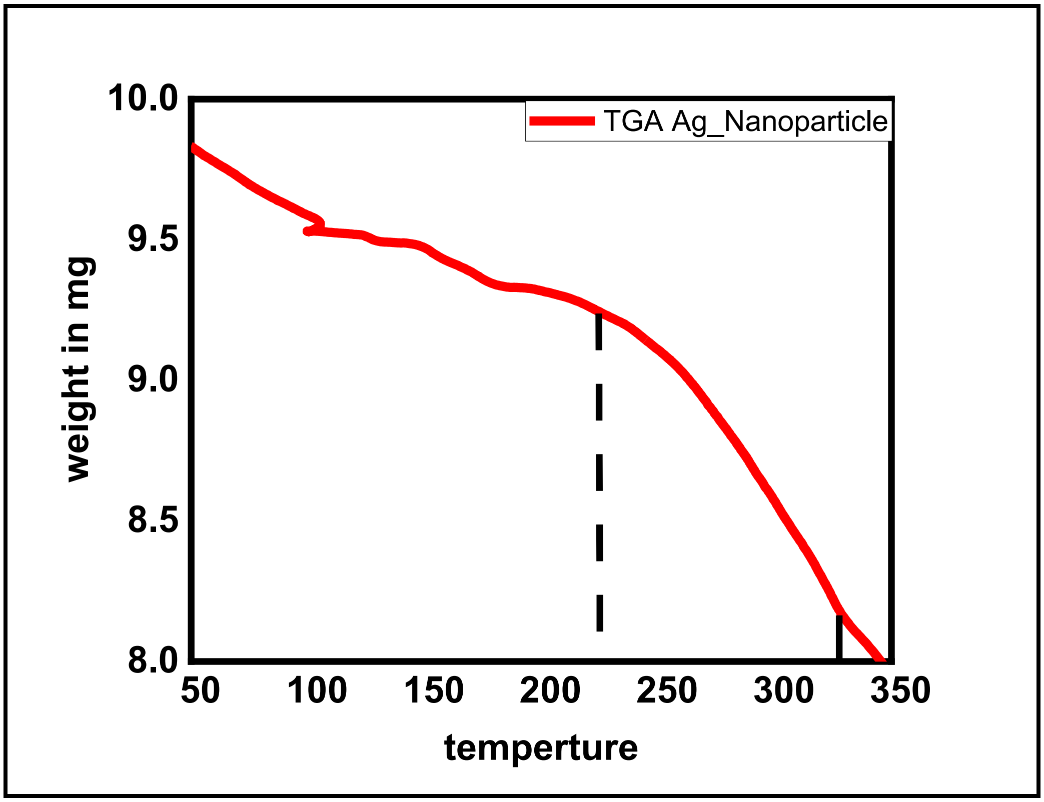

Figure 6 show thermogravimetric analysis of biosynthesized silver nanoparticles

Energy Dispersive X-ray analysis (EDX): Characteristic peaks noticed over energy dispersive x ray spectroscopic analysis (EDX). This study show that the observed sample include the element with transition of electrons with their respective principle quantum number which are shown in tables (Tărăboanță et al., 2023)

Table 1. energy dispersive X-ray spectroscopic analysis (EDX).

Element	Weight %	Atomic %
CaK	4.77	11.73
Fe K	1.53	2.71
Ag L	93.7	85.57

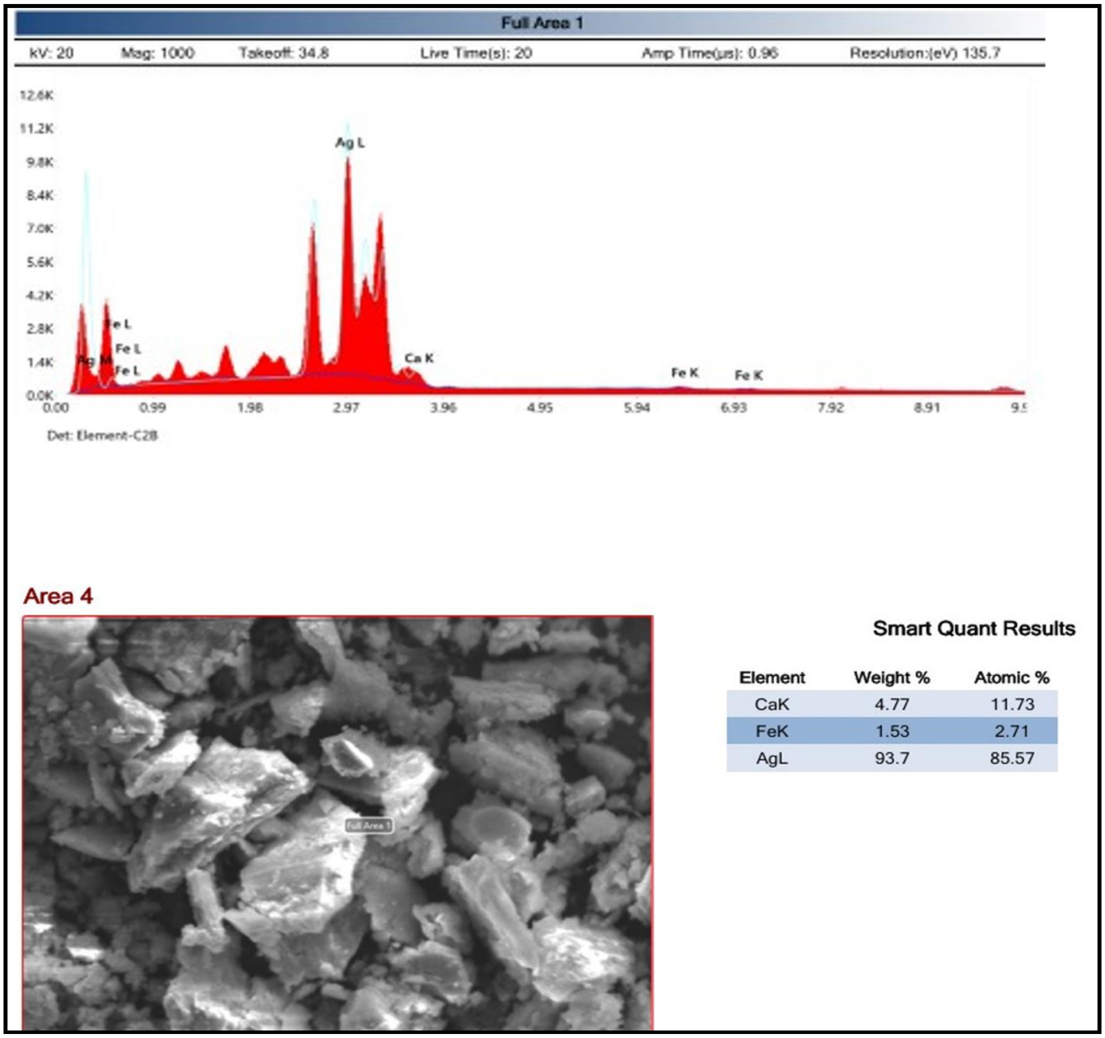

Figure. 7. Show EDX peaks of silver nanoparticles via SEM

Scanning Electronic Microscope (SEM): The given figure reveals that the SEM images elaborated *Equisetum ramosissimum* Silver nanoparticle (AgNPs) of different sizes, having size of nanoparticles range and also have the particles of larger sizes than the nano particles range shown in the given figures. The larger size of particles is owing to the aggregation of nanoparticles but in aggregate these nanoparticles are not in immediate or in straight connection with one another, the stabilizers of the herbal extractant verify this type of connection (Hiba Abbas Widatalla et al., 2022).

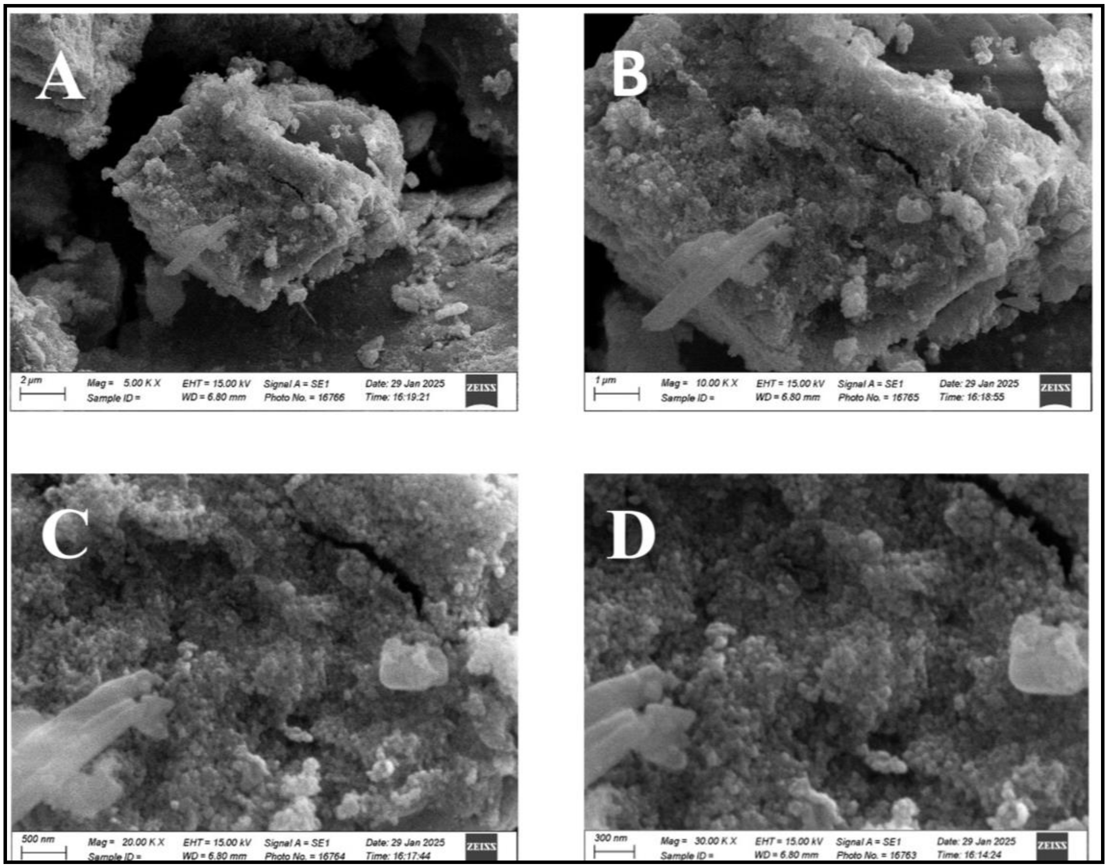

Figure. 8. show the images of silver nanoparticle at different magnification.

Assessment of antibacterial: According to the results, *Equisetum ramosissimum* synthesized silver nanoparticles (Ag) were used for the antimicrobial activities thorough well diffusion method. First of all Nutrient agar was autoclaved and then poured in the sterile glass plates. Next day human and plant pathogens were diluted through MacFarland standard in nutrient broth placed 100 µL of broth on nutrient agar plate and spread the bacteria through sterile glass rod uniformly. In addition the well were made on agar plate through borer and different concentration of silver nanoparticles were used inside the well. Along with that only plant extract were used to whether plant extract shows activity against these pathogens or not among them Antibiotic such as ciprofloxacin were used as positive control and sterile disstiled water was taken as negative control. During these experiments all of the concentration shows maximum activity on maximum concentration i.e 2.5mg/ml shows 25mm inhibition zone, 1.25 mg/ml shows 23mm inhibition zone, 0.625 mg/ml shows 20mm zone, 0.3125 mg/ml shows 15mm zone, 0.156 mg/ml shows 12mm and 0.078 mg/ml shows 8mm zone of inhibition.

These experiments explored that the antimicrobial activity of silver nanoparticles which prepared from *Equisetum ramosissimum*. The Silver nanoparticles (AgNPs) exhibited the most active antimicrobial activity. Silver nanoparticles is a non-venomous constituent accomplished the killing numerous disease-causing microbes. Silver nanoparticles will utilize as anti-microbial agent in future due to exhibition of its antimicrobial properties. Silver nanoparticles (AgNPs) synthesized from *Equisetum ramosissimum* could extremely operative for denaturing of microbes. The strong antimicrobic result of synthesized silver nanoparticles (AgNPs) showed that *Equisetum ramosissimum* could be a wanted choice for the synthesis of antimicrobic nanoparticles. The effect of silver which was synthesized through using *Equisetum ramosissimum* plants extract, have studied. In this pursue, the effects of silver nanoparticles were studied against plant pathogens (Erwinia *caratovora* and *pseudomonas Syringae*, as well as human bacterial pathogens (*Pseudomonas aeroginosa, Salmonella Typhi, Serratia marcescens, Morganelli morganii)* gave extremely impressive results which show that *Equisetum ramosissimum* is extremely operative in the synthesis of antibacterial product.
the antibacterial activity of silver nanoparticles which were synthesized by *E. ramosissinum*, was examined against *Salmonella Typhi* (is a bacteria which cause typhoid fever) *Serratia marcescens* (is a rod shape and gram negative human pathogen which cause various

complication in human such as UTI, pneumonia and infection of heart valves) *Morganelli morganii* (it is gram negative bacteria found in intestine which cause various disease like sepsis, abscess and purple urine bag syndrome) on the other side plant pathogens *pseudomonas Syringae* (it is rod shape and gram negative plant pathogenic bacteria and threaten crop production) *Pseudomonas aeroginosa* and *Erwinia* caratovora. Different concentrations (like 2.5, 1.25, 0.625, 0.3125, 0.156mg/ml and 0.078mg/ml) of silver nanoparticles were used against these bacteria *Salmonella typhi,* Pseudomonas aeruginosa*,* *Serratia marcescens, Morganelli morganii, pseudomonas Syringae,* and *Erwinia caratovora* which shows inhibition zone of different mm.

Antibacterial activity of biosynthesized silver nanoparticles was evaluated by using disc diffusion method. The nanoparticles exhibited an inhibition zone in contradiction of almost all tested human pathogens and plant pathogens *Salmonella typhi,* Pseudomonas aeruginosa*, Serratia marcescens, Morganelli morganii, pseudomonas Syringae,* and *Erwinia caratovora* The Silver (Ag) nanoparticles able to detect the inhibitory effects against different bacteria. The maximum Zone of inhibitions i.e 25mm 23mm, 20mm, 15mm, 12mm and 8mm at concentration of 2.5, 1.25, 0.625, 0.3125, 0.156mg/ml and 0.078mg/ml) which results that Minimal inhibitory concentration (MIC) is 0.078mg/ml or 78µg/ml for *Morganelli morganii, Salmonella Typhi, Serratia marcescens, Pseudomonas aeruginosa, Erwinia caratovora,* and *Pseudomonas Syringe respectively* (Nisha et al., 2015).

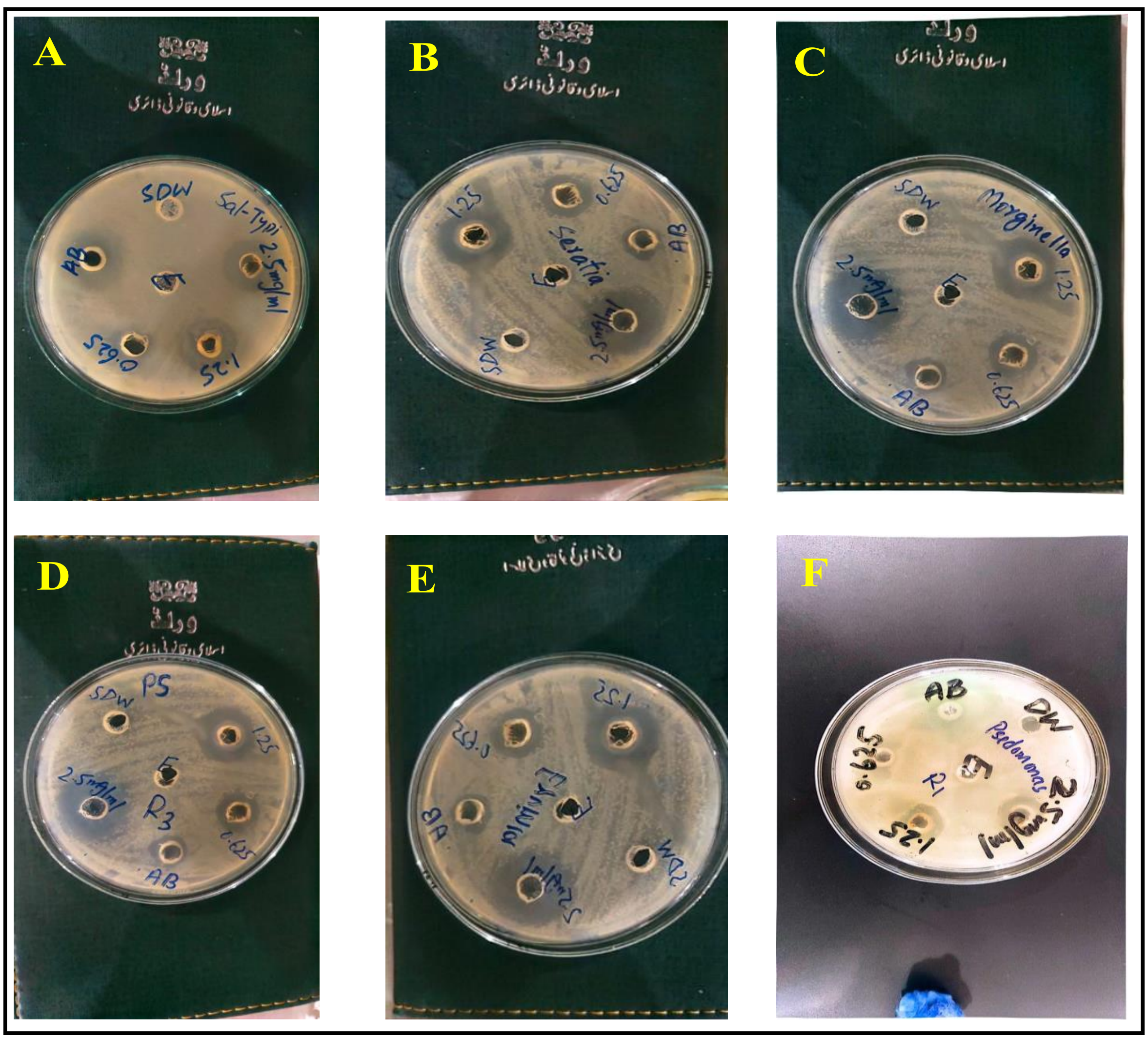

Figure 9 Appearances of inhibitory zones with (A) *Salmonella Typhi* (B) *Serratia marcescens* (C) *Morganelli morganii* (D) *Pseudomonas Syringa* (E) *Erwinia caratovora* (F) *Pseudomonas aeruginosa* bacteria.

Antibacterial mechanism: the antibacterial mechanism of AgNPs in contradiction of bacterial cells. The ability of AgNPs is to lead to the death of bacteria is because of the providing of silver ions from their surface, which can extinguish molecules comprising Sulphur and phosphorus, for instance bacterial DNA and proteins (Behravan et al., 2019). The manner of achievement of AgNPs is usually pronounced through immediate metal ion release, oxidative stress and non-oxidative mechanisms (Shaikh et al., 2019). Furthermore, the production of reactive oxygen species (ROS) hinders the antioxidant defense structure and create mechanical impairment to the cell membrane. Like Ag+ ions, AgNPs enhance well communication with bacteria because of a larger surface area. AgNPs can directly interact with the proteins and phospholipids of the cell membrane by neutralization of the surface electric charge, violating its integrity and permeability. Once within the cell, the as soon as AgNPs' bind to the active site of thiol group (–SH) in respiratory enzyme along with subcellular organelles like mitochondria, lead to homeostasis of the cells to be disturbed. The AgNPs, through the cytoplasmic channels may arrive the nucleus which in conclusion initiate the destruction of the DNA double helix, consequently interrupt their functions and certainly make possible the cell's death. The Silver nanoparticle has the ability to create (ROS) which initiate the killing mechanism of bacteria because more reactive singlet oxygen metabolites (OH^-, O_2^-, H_2O_2) produced in the existence of trace metal ions (Agarwal et al. 2019). This is because. Thus, at high concentrations of ROS, further damage to biomolecules occurs, in which AgNPs exhibit concentration-dependent antimicrobial activity against microbes. These numerous mechanisms significantly recommend the benefit of the plant biosynthesized AgNPs to constrain bacterial growth, thus killing it (Hadi, Ng, Shamsuddin, Matmin, & Malek, 2022)

Table 2: Highlights and key differences

Reducing and stabilizing agents	Natural phytochemical compond like poly phenol or protein etc	Plant extract act reducing and stabilizing agent
Medium	Equisetum ramosissimum and distill water	Green method is nontoxic as compare to chemical method
Stability	Nanoparticle stable due to caping agent of plant	While in conventional surfactant is adding as stabilizing agents
Key difference	The equisetum ramosissimum were not use previously	While some other plants have been studied
Source for synthesis	We have synthesized nanoparticles by exposure to sun light	While in major cases of synthesis of nano particles were carried by heating

CONCLUSION

The present investigation reports the synthesis of silver and its application in antibacterial activity. The *Equisetum ramosissimum* extract was used as reducing agent to the synthesis silver nanoparticle. In deduction, the research successfully manufactured silver nanoparticles by the using *Equisetum ramosissimum*, stressing the implication of at different pH Ag-NPs'. The extract plant was employed for a reducing action, and the different ratios of plant extract and $AgNO_3$ was taken to enhance the synthesis Silver nanoparticles and the Silver nanoparticles (Ag-NPs) were recognized through UV-vis study, which displayed characteristic peaks at 443 nm. The synthesis procedure was meaningfully affected via pH, which altered the Ag-NPs' size and shape. Lesser nanoparticles were formed at P^H of higher values and ideal nanoparticles were formed at pH5 to 8. The nanoparticle formation is more ease on pH 6 to 7 as compare to pH7 to 8. Different technique such as SEM, XRD, UV, TGA EDX and AFM are some techniques which is used for the characterization purpose that give information about shape, the size, and crystalline structure of the synthesized Ag-NPs. The face-centered cubic structure of nanoparticles, was confirmed by XRD analysis. SEM analysis show the morphology nanoparticles that were regularly spread and had a normal size of nanoparticles. TGA use to determine the stability of nanoparticles. The range of constituent particles sizes made known through the AFM results sights the prospect of modifying silver nanoparticles for precise uses and application through using stem extracts from equisetum ramossismum. By means of providing vital new attentions about the exact synthesis of Silver nanoparticles (Ag-NPs) from plant extracts, this study unlocks the entrance to employ green synthesis in nanotechnology and medication. Among the test bacterial culture, the nanoparticles exhibit efficient activity against *Pseudomonas aeroginosa Erwinia caratovora, Salmonella Typhi, Serratia marcescens, Morganelli morganii* and *pseudomonas Syringae*. Now the important task is to find out the release of silver ions from silver nanoparticles and explore the mechanism of antibacterial activity of silver nanoparticles and silver nanoparticles

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AUTHOR'S CONTRIBUTION

Muhammad Ishfaq, Imad Ud Din, and Adnan Shahzad (wrote the original manuscript), Rahmat ali, Amjad Ali Khan, and Husna Iqbal (supervised the work and provide FTIR facility) Asadullah Khan and Rafi Ullah (antibacterial activity), Saif Ullah Khan and Brikhna Khalid (provided characterization facilities)

AUTHORS CONFLICT OF INTEREST

All the authors clearly declared no conflict of interest.

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