

ISSN Print: 2664-6781
 ISSN Online: 2664-679X
 NAAS Rating (2026): 4.77
 IJACR 2026; 8(1): 23-27
www.chemistryjournals.net
 Received: 03-12-2025
 Published: 19-01-2026

Deepak Kumar Singh
 Laboratory of Microbiology
 and Metabolomics,
 Department of Botany, A.N.D.
 Kisan P.G. College, Babhnan
 (Affiliated to R.M.L. Avadh
 University, Ayodhya), Gonda,
 Uttar Pradesh, India

Suraj Singh
 Laboratory of Microbiology
 and Metabolomics,
 Department of Botany, A.N.D.
 Kisan P.G. College, Babhnan
 (Affiliated to R.M.L. Avadh
 University, Ayodhya), Gonda,
 Uttar Pradesh, India

Swati Dwivedi
 Laboratory of Microbiology
 and Metabolomics,
 Department of Botany, A.N.D.
 Kisan P.G. College, Babhnan
 (Affiliated to R.M.L. Avadh
 University, Ayodhya), Gonda,
 Uttar Pradesh, India

Arvind Kumar
 Laboratory of Microbiology
 and Metabolomics,
 Department of Botany, A.N.D.
 Kisan P.G. College, Babhnan
 (Affiliated to R.M.L. Avadh
 University, Ayodhya), Gonda,
 Uttar Pradesh, India

Manoj Kumar Shukla
 Department of Botany, M.L.K
 P.G. College, Balrampur
 (Affiliated to Siddharth
 University, Kapilvastu,
 Siddharth Nagar, Uttar
 Pradesh, India

Corresponding Author:
Deepak Kumar Singh
 Laboratory of Microbiology
 and Metabolomics,
 Department of Botany, A.N.D.
 Kisan P.G. College, Babhnan
 (Affiliated to R.M.L. Avadh
 University, Ayodhya), Gonda,
 Uttar Pradesh, India

Antioxidant and antibacterial efficacy of silver nanoparticles synthesized from extract of filamentous cyanobacterium *Scytonema* sp.

Deepak Kumar Singh, Suraj Singh, Swati Dwivedi, Arvind Kumar and Manoj Kumar Shukla

DOI: <https://www.doi.org/10.33545/26646781.2026.v8.i1a.354>

Abstract

Contemporary algal based metallic nanoparticles with magnified biological potential have gained considerable attention. In the present study, silver nanoparticles (AgNPs) were synthesised by using cell-free extracts of a filamentous cyanobacterium *Scytonema* sp., isolated from the rooftop of Acharya Narendra Deo Kisan P.G. College, Babhnan, Gonda. The *Scytonema* sp. was harvested during the late exponential growth phase to advance the efficiency of nanoparticle synthesis. The distinct change in color and the emergence of a specific surface plasmon resonance (SPR) peak at 410 nm in the UV-visible spectrum was evidenced of AgNPs synthesis after 60 h of incubation. The antioxidant potential of AgNPs, including DPPH and ABTS radical scavenging methods, revealed quite similar pattern and significantly higher activity (about two folds higher than that of crude extract at 80 µm/mL concentration). Furthermore, the AgNPs exhibited pronounced, dose-dependent antibacterial activity against *Escherichia coli* (*E. coli*). The findings of present study point up the *Scytonema* sp. as an effective natural resource for the green synthesis of AgNPs with promising antioxidant and antibacterial utilization in biomedical and ecological spheres.

Keywords: Green synthesis, silver nanoparticles, cyanobacteria, antioxidant activity, uv-visible spectroscopy

Introduction

Nanoparticles are materials that range from 1 to 100 nm in size. Recently, metallic nanoparticles have attracted considerable attention due to their wide range of applications in diverse fields (Pathak *et al.*, 2019a, 2019b; Yiblet and Mintessnot; 2025) [15, 16, 26]. Despite novel physicochemical properties, metallic nanoparticles may pose potential health hazards to living organisms, including humans, especially when synthesized using conventional chemical and physical methods. Therefore, the growing concerns within the scientific community have led to the development of non-toxic, ecofriendly biosynthetic approaches that employ renewable resources and require lower energy input (Pathak *et al.*, 2019a, 2019b; Bhardwaj *et al.*, 2024) [15, 16, 4]. Among these, green-synthesized silver nanoparticles (AgNPs) have emerged as potent agents exhibiting antimicrobial, antifungal, antibacterial, anticancer, antioxidant, and anti-inflammatory activities (Bhardwaj and Naraian; 2021; Takci *et al.*, 2023; Li *et al.*, 2024) [3, 24, 9].

Cyanobacteria are a better biological candidate for nanoparticles synthesis because of having enhanced growth rate and biomass productivity (Pathak *et al.*, 2019a, 2019b; Bhardwaj and Naraian; 2021) [15, 16, 3]. Use of cyanobacterial extracts for the nanoparticles biosynthesis is being widely practiced these days, as the extraction of nanoparticles formed inside the cell is a very costly and complex process. The cell extracts of the cyanobacterium *Anabaena doliolum* were utilized for the synthesis of AgNPs (Singh *et al.*, 2014) [21]. Husain *et al.* investigated the biosynthesis of AgNPs from 30 different cyanobacterial strains (Husain *et al.*, 2015) [7]. Sonker *et al.* (Sonker *et al.*, 2017) [23] synthesized AgNPs utilizing the cell extract of the cyanobacterium *Nostoc* sp. strain HKAR-2 isolated from hot springs. Genus

Scytonema has tremendous potential for nitrogen fixation and rich source of various biologically active compounds such as phycobilins, antibiotics, mycosporine-like amino acids (MAAs), scytonemin, toxins, etc. (Nowruzi *et al.*, 2020) [11]. During the synthesis of AgNPs, these compounds act as reducing and stabilizing agents.

In the present investigation, we used the cell extract of the rooftop-dwelling cyanobacterium *Scytonema* sp. for the synthesis of AgNPs. We also attempted to screen the *in vitro* antioxidant and antibacterial activity of the biosynthesized AgNPs.

Materials and methods

Collection of *Scytonema* sp. and growth condition

The cyanobacterium *Scytonema* sp. was collected and purified from rooftop of Acharya Narendra Deo Kisan P.G College, Babhnan, Gonda and grown in BG-11⁻ medium (without nitrogen sources) (Rippka *et al.*, 1979) [19] under axenic conditions, at temperature 26 ± 2 °C, light intensity $40\text{--}50 \mu\text{mol photons m}^{-2} \text{ s}^{-1}$ and photoperiod 14:10 h (light/dark cycle).

Growth measurement

Growth of cyanobacteria was monitored by determining the changes in chlorophyll *a* (Chl *a*) content after desired time intervals. The Chl *a* was extracted in methanol. The recovered cyanobacterial sample was kept in 100% methanol overnight at 4 °C and its content was determined by method reported by Porra (Porra., 2002) [17] after observing absorption at 665.2 nm and 652 nm.

$$\text{Chl } a (\mu\text{g/ml}) = 16.29 \cdot A_{665.2} - 8.54 \cdot A_{652}$$

Where, A is the optical density (O.D.) at 665.2 and 652 nm, respectively.

Cell extract preparation and green synthesis of AgNPs

Cells of *Scytonema* sp. were harvested during the late exponential (log) phase. The collected cells were centrifuged (Remi mini centrifuge RM-02) at 6000 rpm for 15 minutes and the pellet was washed with double distilled water (DDW) and sonicated using ultrasonic vibration at 30% amplitude for 15 minutes. The homogenate was exposed to centrifugation (3 times), the supernatant was diluted through a series of dilutions with 1 mM AgNO₃, and the reaction mixtures (10 mL) were incubated at 37 °C for 60 h. Only the sample containing *Scytonema* cell extract served as the positive control. The formation of AgNPs was monitored visually at an interval of 12 h by observing the change in color of the reaction mixture.

Partial characterization of AgNPs by UV-VIS spectroscopy

The absorption spectrum was taken at different time interval (0, 12, 24, 36, 48, and 60 h) by using UV-Vis spectrophotometer (Shimadzu) with the resolution of 1 nm at the wavelength range of 200–800 nm, possessing a scanning speed of 200 nm/minutes.

2,2-Diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay

Free radical scavenging activity of desired concentrations (*e.g.*, 20, 40 and 80 $\mu\text{g/mL}$) of *Scytonema* sp. extract and biosynthesized AgNPs was measured using a conventional DPPH radical scavenging assay (Shen *et al.*, 2010) [20].

2,2'-azino-bis(3-ethylbenzothiazoline)-6-sulfonate (ABTS) radical scavenging assay

The antioxidant activity of *Scytonema* sp. extract and biosynthesized AgNPs of desired concentrations (20, 40 and 80 $\mu\text{g/mL}$) was evaluated using the ABTS radical scavenging assay following standard procedures provided by Re *et al.* (Re *et al.*, 1999) [18] with minor modifications. The reduction of ABTS^{•+} was monitored spectrophotometrically at 734 nm, and scavenging activity was expressed as percentage inhibition.

Antibacterial activity

Antibacterial activity was assessed by the disc diffusion method against Gram negative bacterium *E. coli* following standard method with slight modification (Bauer *et al.*, 1966) [9]. *E. coli* was grown in Muller Hinton Agar (MHA) medium at 37 °C. The desired concentration (05 $\mu\text{g/mL}$ and 15 $\mu\text{g/mL}$) of AgNPs solution was soaked into separate discs on the Petri plates. Ampicillin served as positive control and double distilled water (DDW) was taken as negative control. After 24 h of incubation, the inhibition zones around the discs were measured.

Statistical analysis

The results express the mean values of three replicates of each experiment. One-way analysis of variance was performed for statistical analyses.

Results and Discussion

Growth profile of *Scytonema* sp.

The growth pattern of *Scytonema* sp., monitored by evaluating Chl *a* content at regular intervals, showed a typical sigmoidal pattern with lag, exponential, and stationary phases (Fig. 1). The late exponential phase is often associated with enhanced production and release of extracellular biomolecules (Singh *et al.*, 2014, San Keskin *et al.*, 2016) [21, 8]. These compounds are useful in biotechnological applications, including the biological synthesis of nanoparticles.

Partial characterization of AgNPs

The initiation of reduction of AgNO₃ solution into AgNPs started after 12 h of the addition of 1 mM AgNO₃ solution into the cell extract and completed after 60 h of incubation. The visual color change to dark red, and time-dependent increase in surface plasmon resonance (SPR) intensity at 410 nm confirm the successful extracellular biosynthesis of stable silver nanoparticles by *Scytonema* sp. extract (Harutyunyan *et al.*, 2025) [5] (Fig. 2).

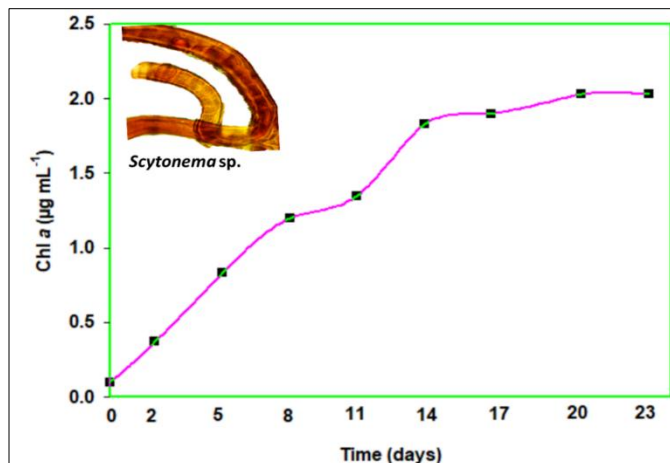


Fig 1: Growth profile (*In vitro*) of *Scytonema* sp. estimated by Chl-a content.

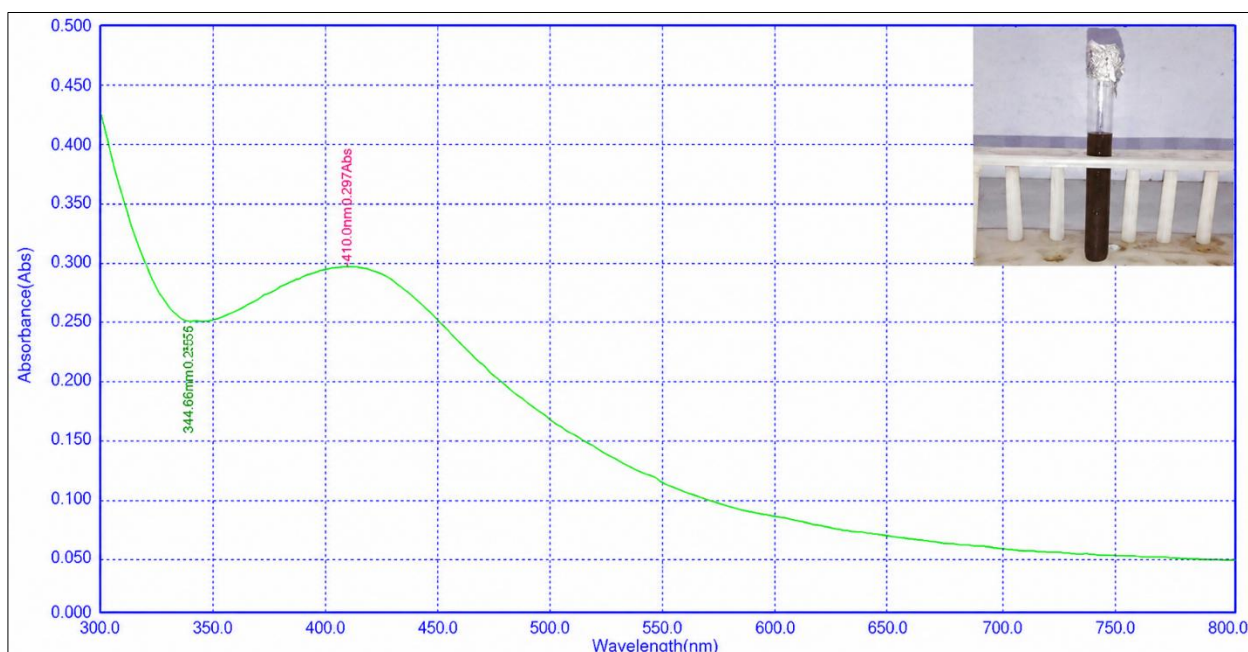


Fig 2: UV-VIS absorption spectrum of *Scytonema* sp. extract based AgNPs at 410 nm after 60 h of incubation.

DPPH and ABTS assay

The results of antioxidant assay showed a clear concentration-dependent increase in radical scavenging activity of the AgNPs in both (DPPH and ABTS) assays (Table 1), indicating their effective antioxidant capacity. The free radical scavenging activity in DPPH and ABTS

assay follow quite similar pattern and was about two folds higher than that of crude extract at 80 µg/mL concentration, though slightly lower than that of ascorbic acid at equivalent concentrations. This observation is consistent with previous reports (Bedlovičová *et al.*, 2020) [2].

Table 1: *In vitro* antioxidant activity of biosynthesized AgNPs evaluated by DPPH and ABTS radical scavenging assays at varying concentrations.

Sr. No.	Sample	Concentration(µg mL ⁻¹)	DPPH radical scavenging (%)	ABTS radical scavenging (%)
1.	Cell extract of <i>Scytonema</i> sp.	20	13.1 ± 1.4	16.2 ± 2.1
		40	23.6 ± 1.1	27.2 ± 1.2
		80	37.2 ± 1.2	40.1 ± 1.9
2.	AgNPs	20	32.8 ± 1.3	29.2 ± 2.1
		40	51.0 ± 1.0	55.3 ± 1.1
		80	72.1 ± 1.2	72.4 ± 2.0
3.	Ascorbic acid(standard)	20	46.1 ± 1.9	43.2 ± 1.0
		40	63.6 ± 1.2	67.0 ± 1.4
		80	82.3 ± 1.7	79.1 ± 2.3

Antibacterial assay

The results of antibacterial assay showed a clear, concentration-dependent antibacterial response, as

evidenced by the increasing diameter of inhibition zones with increasing AgNP concentrations. The observed dose-dependent increase in inhibition zones (5 µg/mL and 15

µg/mL) is consistent with earlier reports demonstrating enhanced antibacterial efficacy of biosynthesized AgNPs against *E. coli* at increasing concentrations (Sondi and Salopek-Sondi., 2004; Patel *et al.*, 2014) [22, 14]. The ampicillin (positive control) produced a prominent inhibition zone. AgNPs are known to show antimicrobial effects through multiple mechanisms, possibly due to loss of cellular integrity and leading to bacterial cell death (Park *et al.*, 2011; Huang *et al.*, 2016; Tang *et al.*, 2018; Parmar *et al.*, 2022; Michailidu *et al.*, 2025) [12, 6, 25, 13, 10].

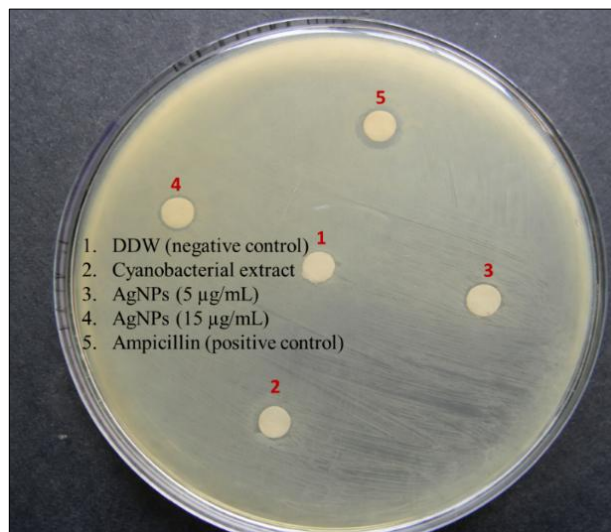


Fig 3: Zone of inhibition exhibited by AgNPs biosynthesized from *Scytonema* sp. extract against *E. coli*.

Conclusion

The present study explores a sustainable step towards the green synthesis of AgNPs using cell-free extracts of the rooftop dwelling cyanobacterium *Scytonema* sp. The harvesting of *Scytonema* sp. at late exponential phase enabled effective nanoparticle synthesis and was confirmed by a characteristic SPR peak at 410 nm. The results of antioxidant and antibacterial efficacy of AgNPs provide valuable insight and highlight its potential in the field of pharmaceuticals. These findings explore *Scytonema* sp. as an eco-friendly natural resource for the synthesis of versatile molecule AgNPs.

References

1. Bauer AW, Kirby WM, Sherris JC, Turck M. Antibiotic susceptibility testing by a standardized single disc method. *Am J Clin Pathol.* 1966;45(4 Suppl):493-496.
2. Bedlovičová Z, Strapáč I, Baláž M, Salayová A. A brief overview on antioxidant activity determination of silver nanoparticles. *Molecules.* 2020;25(14):3191.
3. Bhardwaj AK, Naraian R. Cyanobacteria as biochemical energy source for the synthesis of inorganic nanoparticles: mechanism and potential applications. *3 Biotech.* 2021;11(10):445.
4. Bhardwaj H, Khute S, Sahu RK, Jangde RK. Emerging trends in hybrid nanoparticles: revolutionary advances and promising biomedical applications. *Curr Drug Metab.* 2024;25(4):248-265.
5. Harutyunyan A, Hambardzumyan A, Gabrielyan L, Aghajanyan A, Kocharyan M, Avtandilyan N, *et al.* Silver nanoparticles fabricated using phycocyanin from *Arthrospira platensis*: green synthesis, physicochemical characterization, and biological activities. *Microb Cell Fact.* 2025;24(1):249.
6. Huang X, Pang Y, Liu Y, Zhou Y, Wang Z, Hu Q. Green synthesis of silver nanoparticles with high antimicrobial activity and low cytotoxicity using catechol-conjugated chitosan. *RSC Adv.* 2016;6:64357-64363.
7. Husain S, Sardar M, Fatma T. Screening of cyanobacterial extracts for synthesis of silver nanoparticles. *World J Microbiol Biotechnol.* 2015;31(8):1279-1283.
8. San Keskin NO, Kılıç NK, Dönmez G, Tekinay T. Green synthesis of silver nanoparticles using cyanobacteria and evaluation of their photocatalytic and antimicrobial activity. *J Nano Res.* 2016;40:120-127.
9. Li H, Yang Z, Khan SA, Walsh LJ, Seneviratne CJ, Ziora ZM. Characteristics of metallic nanoparticles, especially silver nanoparticles, as anti-biofilm agents. *Antibiotics.* 2024;13(9):819.
10. Michailidu J, Miškovská A, Jarošová I, Čejková A, Maťátková O. Antibacterial properties of silver and gold nanoparticles synthesized using *Cannabis sativa* waste extract against *Pseudomonas aeruginosa*. *J Cannabis Res.* 2025;7(1):20.
11. Nowruzi B, Sarvari G, Blanco S. The cosmetic application of cyanobacterial secondary metabolites. *Algal Res.* 2020;49:101959.
12. Park J, Lim DH, Lim HJ, Kwon T, Choi JS, Jeong S, *et al.* Size-dependent macrophage responses and toxicological effects of Ag nanoparticles. *Chem Commun.* 2011;47:4382-4384.
13. Parmar S, Kaur H, Singh J, Matharu AS, Ramakrishna S, Bechelany M. Recent advances in green synthesis of Ag NPs for extenuating antimicrobial resistance. *Nanomaterials.* 2022;12(7):1115.
14. Patel V, Berthold D, Puranik P, Gantar M. Screening of cyanobacteria for their ability to synthesize silver nanoparticles with antibacterial activity. *Biotechnol Rep.* 2014;5:112-119.
15. Pathak J, Ahmed H, Singh DK, Pandey A, Singh SP, Sinha RP. Recent developments in green synthesis of metal nanoparticles utilizing cyanobacterial cell factories. In: Tripathi DK, Ahmad P, Sharma S, Chauhan DK, Dubey NK, editors. *Nanomaterials in plants, algae, and microorganisms.* Academic Press; 2019. p. 237-265.
16. Pathak J, Sonker AS, Singh RV, Kumar D, Sinha RP. Synthesis of silver nanoparticles from extracts of *Scytonema geitleri* HKAR-12 and their *in vitro* antibacterial and antitumor potentials. *Lett Appl Nanobio Sci.* 2019;8(3):576-585.
17. Porra RJ. The chequered history of the development and use of simultaneous equations for the accurate determination of chlorophylls a and b. *Photosynth Res.* 2002;73:149-156.
18. Re R, Pellegrini N, Proteggente A, Pannala A, Yang M. Antioxidant activity applying an improved ABTS radical cation decolorization assay. *Free Radic Biol Med.* 1999;26(9-10):1231-1237.
19. Rippka R, Deruelles J, Waterbury JB, Herdman M, Stanier RY. Generic assignments, strain histories and properties of pure cultures of cyanobacteria. *J Gen Microbiol.* 1979;111:1-61.

20. Shen Q, Zhang B, Xu R, Wang Y, Ding X, Li P. Antioxidant activity *in vitro* of the selenium-contained protein from the Se-enriched *Bifidobacterium animalis* 01. *Anaerobe*. 2010;16:380-386.
21. Singh G, Babele PK, Shahi SK, Sinha RP, Tyagi MB, Kumar A. Green synthesis of silver nanoparticles using cell extracts of *Anabaena doliolum* and screening of its antibacterial and antitumor activity. *J Microbiol Biotechnol*. 2014;24:1354-1367.
22. Sondi I, Salopek-Sondi B. Silver nanoparticles as antimicrobial agent: a case study on *Escherichia coli*. *J Colloid Interface Sci*. 2004;275:177-182.
23. Sonker AS, Pathak J, Kannaujiya VK, Sinha RP. Characterization and *in vitro* antitumor, antibacterial and antifungal activities of green synthesized silver nanoparticles using cell extract of *Nostoc* sp. strain HKAR-2. *Can J Biotechnol*. 2017;1:26-37.
24. Takci DK, Ozdenefe MS, Genc S. Green synthesis of silver nanoparticles with antibacterial activity using *Salvia officinalis* aqueous extract. *J Cryst Growth*. 2023;614:127239.
25. Tang S, Zheng J. Antibacterial activity of silver nanoparticles: structural effects. *Adv Healthc Mater*. 2018;7:1701503.
26. Yiblet Y, Mintessnot M. Application of silver nanoparticles synthesized from species of green algae: a review. *Disc Appl Sci*. 2025;7(10):1215.