INTERNATIONAL RESEARCH JOURNAL OF HUMANITIES AND INTERDISCIPLINARY STUDIES
(Peer-reviewed, Refereed, Indexed & Open Access Journal)
DOI : 03.2021-11278686 ISSN : 2582-8568 IMPACT FACTOR : 7.560 (SJIF 2024)

Silver nanoparticles from *Cordia sebestena* leavesin nano-phytoremediation of lead contaminated water

Sunita Manik Chauhan, Taufiq Shaikh, Nitin M. Labhane, Asmita Mestry*

**Bhartiya Vidya Bhavan's M.M. College Of Arts, N.M Institute of Science, H.R.J College Of Commerce,Department of Botany, Bhavans College (Autonomous), Andheri (West), Mumbai- 400058*

Corresponding E-mail: taufiq.shaikh@bhavans.ac.in

DOI No. 03.2021-11278686 **DOI Link ::** https://doi-ds.org/doilink/02.2024-71594835/IRJHIS2402021

ABSTRACT:

The application of nanoparticles in environmental biotechnology for effective and sustainable development is very well documented in the literature. Nanoparticles are extensively employed in a broad spectrum of applications due to their distinctive characteristics and extremely small size. The current investigation focuses on the green process for creating silver nanoparticles (AgNPs) employing Cordia sebestena leaves extract and their characterisation using techniques such as scanning electron microscopy (SEM) for surface analysis, UV-visible spectroscopyand transmission electron microscopy (TEM) for Morphology. One of the principal objectives is to study the efficacy of the AgNPs to remediate the lead-contaminated water. Experimental results showedC. sebestena AgNPs are effective at removing lead from contaminated water by nano-phytoremediation.

Keywords: *Cordia sebestena, Green synthesis, Lead, Nano-phytoremediation.*

1.0 INTRODUCTION:

The application of nanotechnology is growing in every field, including agriculture, pharmaceuticals, cosmetics, the environment, etc. (Sahu& Hayes 2017). The smaller nanoparticles exhibit unique features such as surface binding capacity, cellular uptake, larger surface area, increased stability and strength, etc**(Modena *et al.*,2019).** The size of nanoparticles ranges from 1-100 nm **(Banala *et al.*,2015)**. Nanoparticles can be obtained from various methods such as biological, chemical, and physical synthesis **(Iravani *et al.*, 2014 and Kalainila *et al.*,2017).** Mostly, the physical and chemical method is responsible for the different size and shapes of nanoparticles

(Ankamwar *et al.*,2005). Green synthesis of AgNPs has gained importance and can be considered as a better alternative method over conventional methods due to their distinctive properties such as cost-effectiveness, ease of availability and less harmful to the environment **(Phanjom*et al.*,2012).** The AgNPs are reported to have the capability to absorb/adsorb and minimize pollutants in the environment, which shows the effective remediation of contaminated water by nano-phytoremediation process **(G** Palani*et al*., 2021**).**The acronym nano-phytoremediation refers to the approach for eliminating contaminants from the environment by leveraging both nanotechnology and phytotechnology (Srivastav*et al.*, 2018). Nano remediation and phytoremediation are compatible,while nano-remediation is a quick and efficient method but involves a high cost whereas phyto-remediation is a low-costand sustainable techniquewhich requires appropriate plant selection (Bhati and Rai 2018).

C. sebestena is a dicotyledonous, evergreen treefound in tropical and sub- tropical regions. (Bokhari *et al.,* 2022). This plant belonging to the Boraginaceae family, commonly known as Geiger tree, Lal lasora, etc. and native to the American tropics and can grow up to 25 feet tall in summer. The leaves are dark green and ovalwith wavy margins Fig. 2(C). Flowers are orangish - red in color Fig. 1(A)and grow in clusters at the ends of branches (Hanani *et al*., 2019).According to Osho et al., (2016), the phytochemicals found in *C. sebestena* L. are flavonoids, triterpenoids, alkaloids, tannins, phenols, and saponins. The *C. sebestena* extract contains hepatoprotective, anti-inflammatory, analgesic, antioxidant, antibacterial, and diabetic effects.(MJ Oza *et al.,* 2017 and Sunaryo et al., 2019).

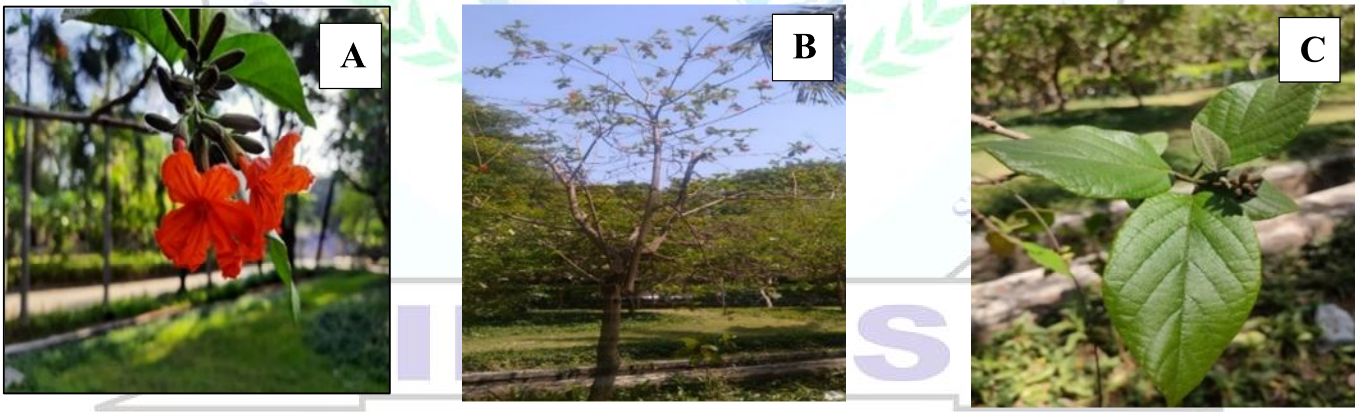


fig I:*(A)Flowers of C. sebestena(B)C. sebestena tree from Bhavan's college campus (C) Leaves of C.sebestena*

3.0 MATERIALS AND METHODS:

3.1 Plant materials collection:

Fresh *Cordia sebestena* leaves were gathered from the campus ofBhavans College (Autonomous), Andheri (West), Mumbai, location which lies in between 72°50'07.6"E and 19°07'28.6"N district Mumbai of Maharashtra, India which were carefully examined and identified through regional flora. The voucher specimen is deposited in the herbaria of Botany department of Bhavan's College, Andheri.

3.2 Preparation of leaf extract:

25 g of fresh *C. sebestena* leaves were minced into small chunks before being placed in 200mlof D/W. It was heated up to 60ºC for 10 minutes.The concentrate was filtered, and the filtrate was collected and kept for 30 minutes in a sand bath for 30 min. For future usage, the filtrate was securely stored at 4^{o}C.

3.3 Synthesis of silver nitrate solution:

1mM solution of silver nitrate ($AgNO_3$) were prepared.To prevent autoxidation of silver nitrate, the solution was stored in an amber-colored bottle.

3.4 *Silver Nanoparticles Synthesis:*

The Nanoparticle were synthesized using method describe by Banala *et al.,*(2015), but with slight modification.*C. sebestena* leaf aqueous extract and 1mM AgNO3 were combined in a 1:4 ratio.It was subsequently left to incubate for 30 minutes in a 60°C water bath until the colour changed.When AgNO3 was introduced into the solution, its appearance of solution changed from brown to blackish-grey, demonstrating that AgNPs were synthesized.Then the resultant solution was then centrifuged at 10,000 rpm keeping temperature at 4^{o}C for 10 mins.

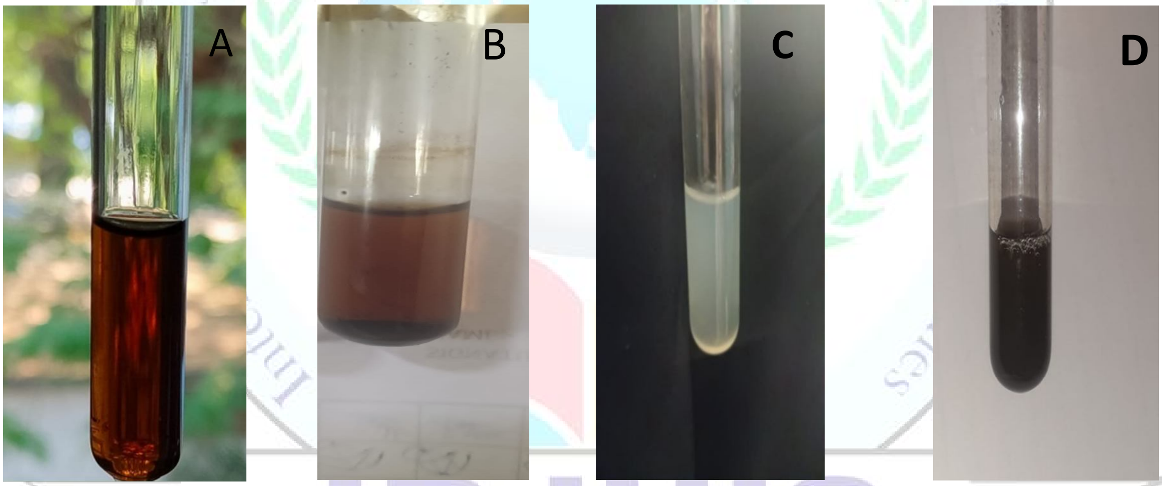


Fig II: *(A) C. sebestena leaf extract (B)) Leaf extract with 1mM $AgNO_3$ solution (C) $AgNO_3$ solutionand (D) Synthesised nanoparticles of AgNPs*

3.5 Characterization of silver nanoparticles (AgNPs):

The initial validation of AgNPs was performed using UV spectral analysis at wavelengths ranging from 200 to 600 nm using a Cary 100 UV-visible spectrophotometer..SEM analysis was done to characterize the surface morphology, using a Quanta 200 – EDAX machine. The Elemental composition study was examined through an Energy-Dispersive Spectroscopy (EDAX) instrument coupled with SEM.Using the TEM JEM 2100F model, the AgNPs were further analyzed to assess their geometry, size, and shape.

4.0 RESULTS AND DISCUSSION:

This study investigated the green synthesis of *C. sebestena* AgNPs as well as their efficiency in nano- phyto-remediation.

4.1 UV- visible spectroscopy analysis:

The addition of *C. sebestena* leaf extract to AgNO3 induced a change in colour due to AgNPs triggering surface plasmon resonance (SPR) (Mulvancy, 1996). *C. sebestena* AgNPs exhibit an absorption peak that can be measured between 200 and 600 nm. The UV absorption spectrometric investigation of *C. sebestena* AgNPs revealed maximal absorption spectra at 220 nm depending on size, shape, and distribution pattern, confirming the bioreduction of silver nitrate $AgNO_3$ into silver nanoparticles (AgNPs), which was consistent with that of *Amaranthus tricolour L.* AgNPs. (Fatimah & Afrid 2019).The absorbance peaks seen in **Fig. III**

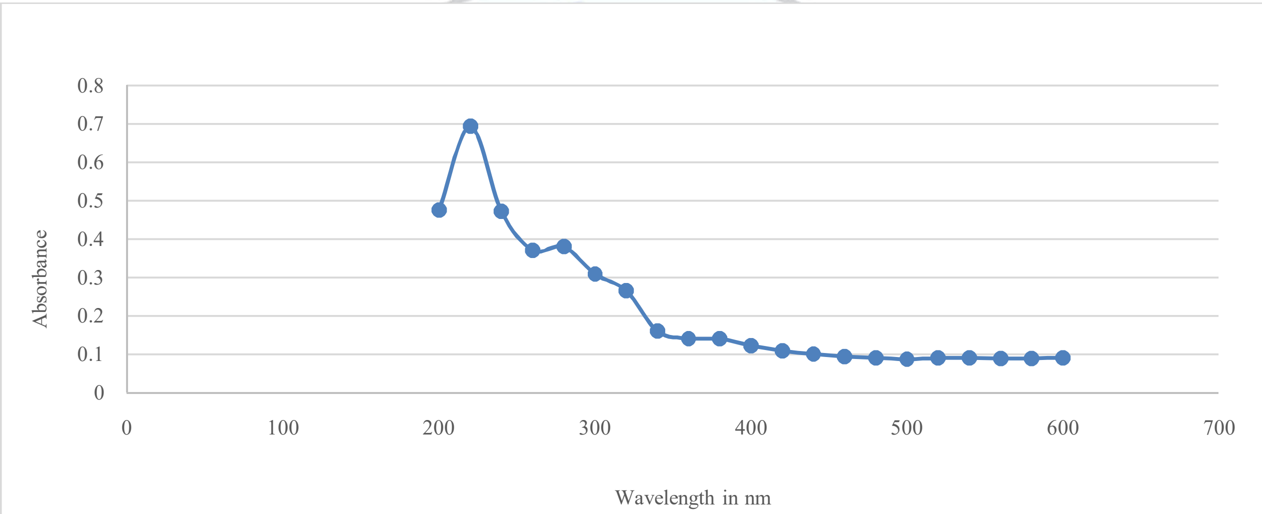


Fig. III: *Absorbance spectra of C. sebestena leaves extract AgNPs*

4.2 Scanning Electron Microscopy (SEM) Analysis:

The external morphology of AgNPs of *C. sebestena*, was observed underhigher magnification showed that the AgNPs were spherical in shape with an average size of 50 nm to 75 nm.The presence of phytochemicals found in the C. sebestena leaves such as tannins, phenols, flavonoids,etc act as a reducing agents during the formation of AgNPs(Devaraj *et al.*, 2013 & M. Juvekar*et al.*, 2009).

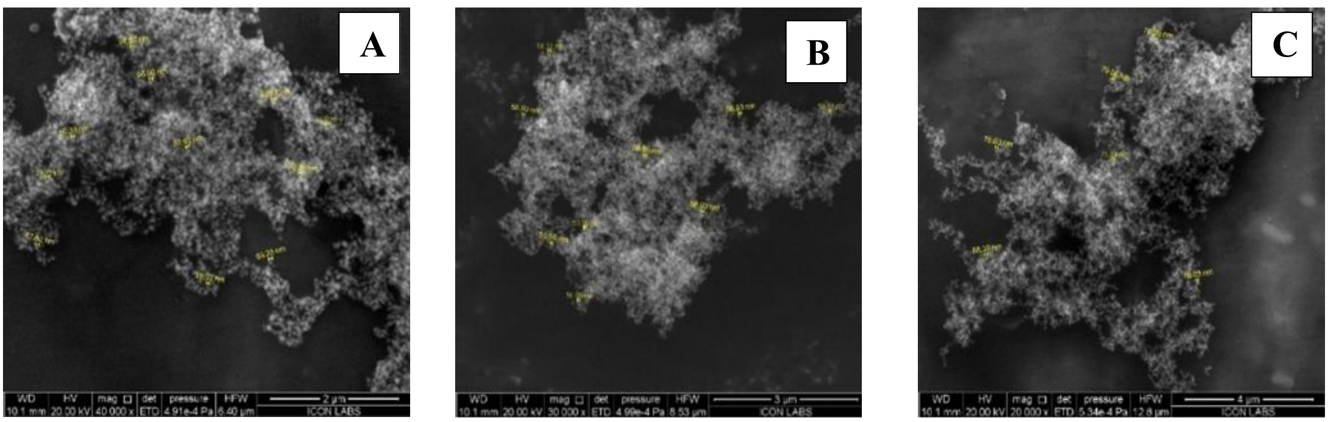
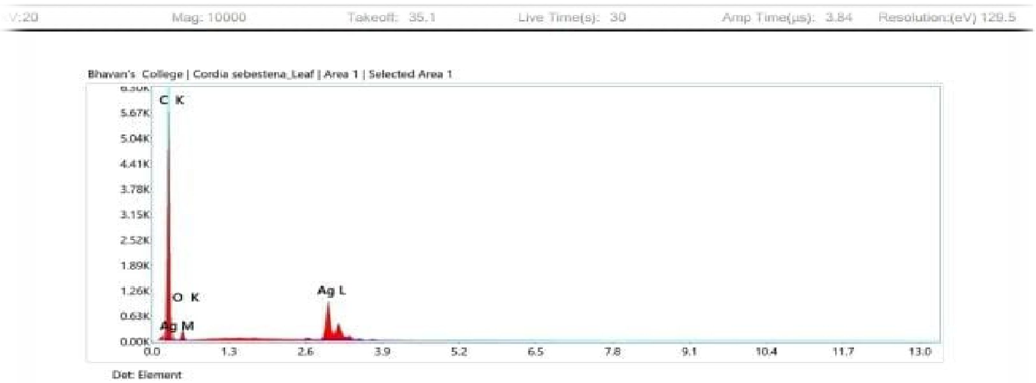


Fig IV: *Scanning Electron Microscope (SEM) micrographs of synthesized C. sebestena leaf AgNPs, (A) Showing the morphology of AgNPs on 2 µm scale, (B) on 3 µm scale (C) on 4 µm scale*

4.3 Energy-Dispersive X-ray Spectroscopy (EDAX) Analysis:

The physio-chemical characterization of the *C. sebestena* AgNPs were studied utilizing the EDAX-analysis. The presence of elemental silver, oxygen, and carbon dioxide compounds in the examined materials was indicated by the EDAX spectrum. EDAX's quantitative investigation revealed a high silver level of 9.6%. Oxygen (O) and carbon (C) were also detected in the spectra. As Ag+ is totally depleted during the synthesis, there is no nitrogen (N) signal, verifying the absence of AgNO3 (Fatimah & Afrid 2019).



eZAF Quant Result

Element	Weight %	MDL	Atomic %	Net Int.	R	A	F
C K	83.9	0.29	93.4	1204.9	0.9207	0.2380	1.0000
O K	6.5	0.47	5.4	52.2	0.9301	0.0524	1.0000
Ag L	9.6	0.18	1.2	327.6	0.9608	0.9332	1.0048

Fig V:*EDAX characterization spectrum obtained for C. sebestena AgNPs.*

4.4 Transmission Electron Microscopy (TEM) Analysis:

To visualize the morphology of *C. sebestena* leaf AgNPs, a JEM 2100F model of TEM was utilized. The TEM investigation revealed the AgNPs' spherical form and average size ranging from 17 nm to 70 nm at various magnification setting.

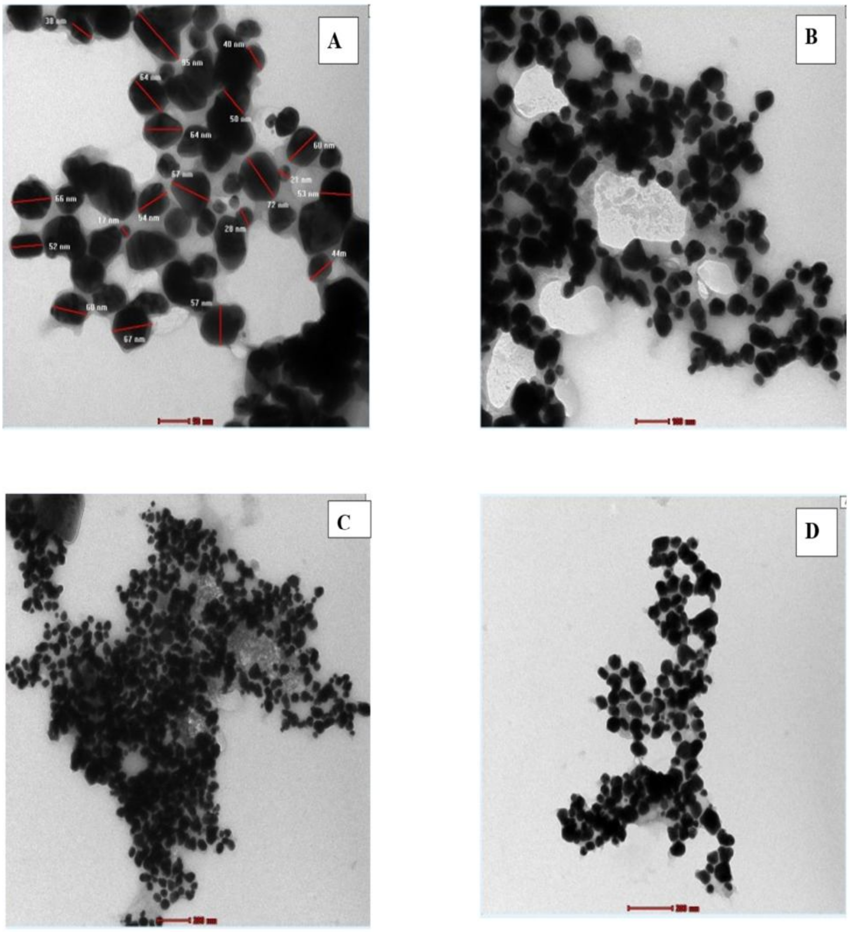


Fig VI: *Transmission Electron Microscopy (TEM) micrographs of green synthesized AgNPs at different magnification levels (A) Morphologyand particle size of AgNPs at 50 nm, (B) at 100 nm, (C) at 200 nm (D) at 200 nm*

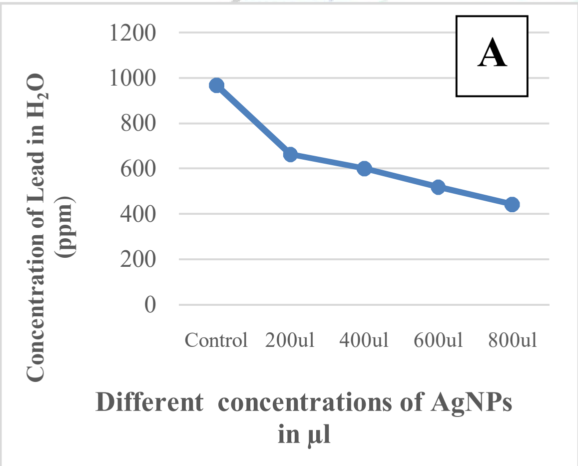
4.5 Nano-phyto-remediation of lead contaminated water by C. sebestena AgNPs:

The obtained AgNPs using *C. sebestena* leaf extract was used for nano-phyto-remediation of lead- contaminated water. In this process, the effect of AgNPs on the lead contaminated water were examined by changing the concentration of AgNPs and by changing in time period which can be determined by (ICP-AES) analysis. The results obtained from AES analysis in setup one where the time is kept constant and the concentration of nanoparticles are increased shows that with rise in concentration of AgNPsthe rate of lead contaminated in water decreases.

In the second analysis, the result suggestedthat by maintaining the concentration of AgNPs constant i.e., 200 µl, and varying the time period of experimental setup, It was observed that the AgNPs show greater remediation of lead from contaminated water in12 and 24 hrs. However, as the time period increase to 36 and 48 hrs, the ability of the AgNPs to absorb lead was seen to reduced,releasing lead ions backinto the water and this can be attributed to the instability of AgNPs. The instability of AgNPs is due to change in temperature, whichallowsthe AgNPs to change its structure (Liu *et al;* 2020), and affected the binding capacity of AgNPs which resulting in decreasein the absorption rate of lead from contaminated water. This demonstrates the gradual decrease in the ability of AgNPs' to bind metal ions as timeincreases.

	Analysis 1 (Change in concentration of AgNPs)			Analysis 2 (Time variation)		
Test No.	**Concentration of AgNPs (µl)**	**Time (hrs)**	**Concentration of lead in H_2O (ppm)**	**Concentration of AgNPs (µl)**	**Time (hrs)**	**Concentration of lead in H_2O (ppm)**
	Control	12	969.23	Control	12	969.23
1	200 µl	12	662.97	200 µl	12	634.05
2	400 µl	12	601.64	200 µl	24	439.79
3	600 µl	12	518.63	200 µl	36	689.68
4	800 µl	12	442.21	200 µl	48	721.77

Table 1. *Study the absorbance of lead (ppm) by varying the concentration of AgNPs and time*



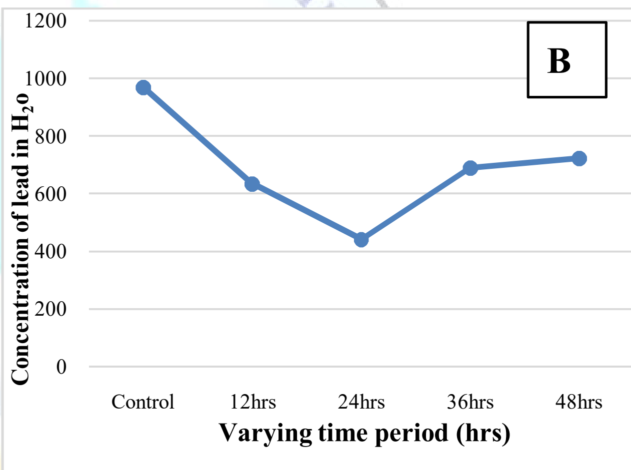


Fig VII: Absorbance of lead (ppm) by (A) changing the concentration of AgNPs (µl) and (B) time (hrs)

4.6 Statistical Analysis:

The Pearson co- efficient co-relation has been carried out for both experimental setups to determine the efficacy of AgNPs of *C. sebestena* in nano phytoremediation of lead from the contaminated water.

The Pearson correlation coefficient between the change in the concentration of AgNPs and the absorbance of lead is negative and close to -1, indicating a strong negative correlation between the two variables. As the concentration of AgNPs increases, the concentration of lead in water decreases. The correlation coefficient (r) for second setup is -0.577, which indicates a negative correlation between the time period and the absorbance of lead. This means that as the time period increases, the absorbance of lead decreases.The negative correlation observed here could be due to other factors that were not controlled for in this experiment.

5.0 CONCLUSION:

A green approach for synthesizing AgNPs utilizing *C. sebestena* leaf extract was devised. It has been established that the leaf extract of *C. sebestena* contains a variety of phytochemicals. The characterization of AgNPs was done by UV-visible spectroscopy, SEM, and TEM examination. The UV-vis spectroscopy investigation of *C. sebestena* AgNPs revealed a typical broad peak with highest absorption at 220 nm. SEM and TEM studies revealed that the nanoparticles were spherical with sizes ranging from 15 to 70 nm. ICP-AES study findings showed that the effect of *C. sebestena* AgNPs on lead absorption from contaminated water was done by varying the concentration of AgNPs and time period. Lead absorption was increased via nano-phytoremediation. The structure of nanoparticles changes and impacts the stability of nanoparticles as time passes. This change in the stability of nanoparticles can be due to temperature changes, which result in a decrease in the absorption rate of lead from the contaminated water, which was evaluated using the ICP-AES technique. Due to the instability of AgNPs, AgNPs may release lead ions back into the water. Further research is needed to manage the composition and dimensions of AgNPs, as well as to improve their stability and binding capability over a longer period of time, in order to maximize their efficiency in remediation applications.

The aim was to show that the synthesis, characterization of AgNPs and the utilization of AgNPs in lead removal from the contaminated water was an effective approach and provides additional property in the application of nano-phyto-remediation that can be utilized for the research purposes in future. The current study of nano- phyto-remediation of lead- contaminated water by *C. sebestena* leaves is studied for the first time.

6.0 ACKNOWLEDGEMENT:

The authors are grateful to the principal, Bhartiya Vidya Bhavan's M.M. College Of Arts, N.M Institute Of Science, H.R.J College Of Commerce, and Department of Botany, Bhavans College (Autonomous), located in Andheri (West), Mumbai 400058, for providing laboratory facilities. We would also like to thank ICON'S LAB authorities who granted permission for SEM and TEM analysis and to SAIF (Sophisticated Analytical Instrument Facility) Department of IIT Bombay for providing ICP- AES analysis.

REFERENCES:

1. Ankamwar, B., Damle, C., Ahmad, A., & Sastry, M. (2005). Biosynthesis of gold and silver nanoparticles using *Emblica officinalis* fruit extract, their phase transfer and transmetallation in an organic solution. *Journal of nanoscience and nanotechnology*, *5*(10), 1665-1671.
2. Banala, R. R., Nagati, V. B., & Karnati, P. R. (2015). Green synthesis and characterization of *Carica papaya* leaf extract coated silver nanoparticles through X-ray diffraction, electron

microscopy and evaluation of bactericidal properties. *Saudi Journal of Biological Sciences*, *22*(5), 637-644.

3. Bhati, M., & Rai, R. (2018). Nano-phytoremediation application for water contamination. *Phytoremediation: Management of Environmental Contaminants, Volume 6*, 441-452.
4. Bokhari, S. W. A., Sharif, H., Gilani, S. M. U., Ali, S. T., Ahmed, S., Siddiqui, M. U. A., & Hasan, M. M. (2022). Pharmacognostic and phytochemical study of the flowers of *Cordia sebestena* L. *Pakistan Journal of Pharmaceutical Sciences*, *35*(1).
5. Devaraj P., Kumari P., Aarti C., & Renganathan A. (2013). Synthesis and characterization of silver nanoparticles using cannonball leaves and their cytotoxicity activity against MCF- 7 cell line. *Journal of Nanotechnology*, 2013.
6. Fatimah, I., & Aftrid, Z. H. V. I. (2019). Characteristics and antibacterial activity of green synthesized silver nanoparticles using red spinach (*Amaranthus Tricolor L.*) leaf extract. *Green Chemistry Letters and Reviews*, *12*(1), 25-30.
7. Hanani, E., Soewandi, S. H. W., & Revita, N. (2019). Pharmacognostical and Preliminary Phytochemical Evaluation of *Cordia sebestena* L. *Pharmacognosy Journal*, *11*(5).
8. Iravani, S., Korbekandi, H., Mirmohammadi, S. V., & Zolfaghari, B. (2014). Synthesis of silver nanoparticles: chemical, physical and biological methods. *Research in pharmaceutical sciences*, *9*(6), 385.
9. JuvekarM., JuvekarA., Kulkarni M., WakadeA., Ambaye R., & Wankhede S. (2009). Phytochemical and pharmacological studies on the leaves of Couroupita guianensis Aubl. *Planta Medica*, *75*(09), PJ168.
10. Kalainila P., Ravindran R. E., Hemachandran V., & Renganathan S. (2017). Greener synthesis of silver nanoparticle from *Chordia dichotoma* leaf extract and its antimicrobial activity. *International Journal of Nanoparticles*, *9*(2), 132-142.
11. Liu H., Zhang H., Wang J., & Wei J. (2020). Effect of temperature on the size of biosynthesized silver nanoparticle: deep insight into microscopic kinetics analysis. *Arabian Journal of Chemistry,* 13(1), 1011-1019.
12. Modena M. M., Ruhle B., Burg T. P., & Wuttke, S. (2019). Nanoparticle characterization: what to measure? *Advanced Materials*, *31*(32), 1-26.
13. Mulvancy P. (1996). Surface plasmon spectroscopy of nano sized metal particles. *Langmulr,* 12(3), 788-800.
14. Osho A., Otuechere C. A., Adeosun C. B., Oluwagbemi T., & Atolani O. (2016). Phytochemical, sub-acute toxicity, and antibacterial evaluation of Cordia sebestena leaf extracts. *Journal of basic and clinical physiology and pharmacology*, *27*(2), 163-170.

15. Oza M. J.,& Kulkarni Y. A. (2017). Traditional uses, phytochemistry and pharmacology of the medicinal species of the genus Cordia (Boraginaceae). *Journal of Pharmacy and Pharmacology*, *69*(7), 755-789.
16. Palani G., Arputhalatha A., Kannan K., Lakkaboyana S. K., Hanafiah M. M., Kumar V., & Marella R. K. (2021). Current trends in the application of nanomaterials for the removal of pollutants from industrial wastewater treatment-a review. *Molecules*, 26(9), 2799.
17. Phanjom, P., Borthakur M., Das R., Dey S., & Bhuyan T. (2012). Green synthesis of silver nanoparticles using leaf extract of Amaranthus viridis. *Int J. Nanotechnol Appl,* 6, 53-59.
18. Sahu S. C.,& Hayes A. W. (2017). Toxicity of nanomaterials found in human environment: a literature review. *Toxicology Research and Application*, 1, 1-1.
19. Srivastav A., Yadav K.K., Yadav S., Gupta N., Singh J.K., Katiyar R., & Kumar V. (2018). Nano-phytoremediation of pollutants from contaminated soil environment: current scenario and future prospects. *Phytoremediation: Management of Environmental Contaminants,* 6, 383-40.
20. Sunaryo H., Siska S., Hanani E., Anindita R. S., & Yanti N. (2019). Evaluation of analgesic and anti- inflammatory activities of ethanolic extract of L. *European Pharmaceutical Journal, 66(2), 26-31.*