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Comparison of *Millettia pinnata* and *Justicia adhatoda* as eco-sustainable extraction of silver nanoparticles for sewage water treatment

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ABSTRACT

The main objective of this project is to find an efficient, reasonably-priced adsorbent to remove contaminants from wastewater. Plant extracts can be used to produce silver nanoparticles (Ag NPs) more efficiently and inexpensively than traditional processes, and silver nanoparticles are evaluated by UV-visible spectroscopy. When silver nanoparticles are added to the solution, it is observed that there is a notable absorption peak in the UV-visible spectrum between 280 and 320 nm; with a higher concentration of plant extract, silver nanoparticles' size increases. In this investigation a batch study method was used, in which the reaction of PLE and Ag NPs reduces the amount of many contaminants found in wastewater, including pH, total dissolved solids, hardness (TH), BOD, and COD, in a laboratory. According to a recent study, both *Millettia pinnata* and *Justicia adhatoda* have the capacity to bio reduce and increase Ag ions on silver nanoparticles. This paper describes a simple and environmentally friendly technique for producing silver nanoparticles that uses water-soluble plant leaf extract as a powerful biodegrading agent for wastewater treatment. The current study finds that treated sewage water is used to create silver nanoparticles that are collected from *J. adhatoda* and *M. pinnata* leaves. According to a comparison of the amount of nanoparticles extracted from *J. adhatoda* and *M. pinnata* leaves in waste water, *M. pinnata* could reduce TDS, TH, and BOD levels by 40%, 16%, and 30%, respectively. As a result of the investigation, it is discovered that *M. pinnata* is the most effective adsorbent, with the influence of various experimental conditions leading to different absorbance intensities. The results show that *M. pinnata* reduces TDS, TH, and BOD more effectively than *J. adhatoda*.

Keywords: Sewage water treatment; Plant leaf extract (PLE); Bio adsorbent; UV-visible spectroscopy; Silver nano particles; Plant extracts; Wastewater treatment

1. Introduction

The principle source of waste water for years was sewage, where 70% of the toxicity is found in aquatic habitats. Water pollution and inadequate sanitation are among the major causes of child mortality. Children under the age of five are especially susceptible to the harmful effects of drinking polluted water, and it is estimated that 1.5 million children die each year from consuming polluted water. The majority of young children are under the age of five, so everyone should know how important sewage water treatment is [1]. Silver's bactericidal potential increases when it is contained in particles, which more efficiently release Ag ions. Silver nanoparticles can be used to clean materials by

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eliminating bacteria and other contaminants when they are deposited on solid surfaces. Silver nano particles in various forms have also been used to purify drinking water, which is coated on materials and substrates. Sand, zeolite, and fibre glass mixed with silver are all examples of highly effective silver ion combinations used in waste treatment. Silver nano particles are the most effective antibacterial agent against bacteria, viruses, and other eukaryotic organisms, according to research [2]. Silver nano particle and a natural adsorbent could be an on-demand source to efficiently filter wastewater in the next few years. Aqueous plant leaf extracts can be used to make silver nanoparticles, which is more economical, energy-efficient, and less dependent on chemicals as the reducing and capping agent [3].

The proposed experiment aims to reduce wastewater contamination by producing inexpensive adsorbent Ag nanoparticles, while the other treatment method, which uses land and energy, raises the overall cost of the treatment process. To reduce treatment costs, naturally occurring adsorbents are used. A reduction in pH, total hardness, BOD, and COD with plant leaf powder as adsorbents with silver nanoparticles may have an environmental benefit [4]. Eutrophic wastewater treatment uses green production of Fe nanoparticles using eucalyptus leaf extracts [5]. First, eucalyptus leaf extracts are used to create iron nanoparticles (EL-Fe NPs) in a single step at room temperature. The results clearly show that 84.5% and 71.7% of the COD and N are removed from wastewater, respectively. *Piliostigma thonningii* aqueous leaf extract-based green-generated silver nanoparticles are being used for the purification of simulated waste water. It is demonstrated that *Piliostigma thonningii* can convert silver nitrate into nanoparticle sizes that give different absorbance intensities at the same wavelength with the help of various experimental settings. Using medicinal plant leaf extract and pure flavonoids, silver nanoparticles with enhanced antibacterial properties were created [6]. The results of different characterisation techniques have also revealed striking similarities, proving that biomolecules such as quercetin are found in plant extracts such as Tulsi, Neem, etc. The produced AgNPs displayed high absorption based on the size, shape, and morphology of the final particles, with a maximum wavelength between 400 and 450 nm. On average, the synthetic AgNPs produced using the green approach had a size of 10 to 20 nm, which can easily be incorporated into the AgNPs by using the green approach, since environmental conditions can have a profound effect on these features [7].

The authors of this research paper have collected all the leaves in the Thanjavur district's Panayakkottai village during the morning time from 10:00 a.m. to 12:00 p.m.

A sample of sewage water was collected from Vallam, Thanjavur, by Periyar Maniammai Institute of Science and Technology. For further analysis, the collected water sample is kept in an appropriate container.

2. Biological production of silver nanoparticles

In order to produce silver nanoparticles, the first stage is to prepare leaves for extraction. Distilled water is used to clean *Millettia pinnata* and *Justicia adhatoda* leaves of dirt and other soluble substances in this village. Then the leaves are allowed to dry naturally at room temperature before being ground to make a fine powder at home, which is stored in tightly sealed bottles for use as an adsorbent [8]. After making the extraction powder, 150 mL of distilled water and 10 mg of *M. pinnata* powder are combined in a 250 mL beaker, and the mixture is heated to 550°C for 60 min using a magnetic stirrer. To gain new insights, the extract is further purified using Whatman No. 1 filter paper and stored at room temperature [9,10].

3. Batch study process

10 mL of 0.1 M $AgNO_3$ is thoroughly mixed with 3 mL of *J. adhatoda* plant leaf extract by hand shaking, and the mixture is refluxed for 2 h at 6,000°C. After reflux, the colour changes to reddish brown, indicating that Ag NPs are being produced. Diverse amounts of silver nitrate and leaf extract are extracted for the purpose of calibrating the synthesis of silver nanoparticles. The leaf extract concentrations are 3, 6, and 9 mL, while silver nitrate concentrations were 10, 15, and 25 mL. The same process was used to

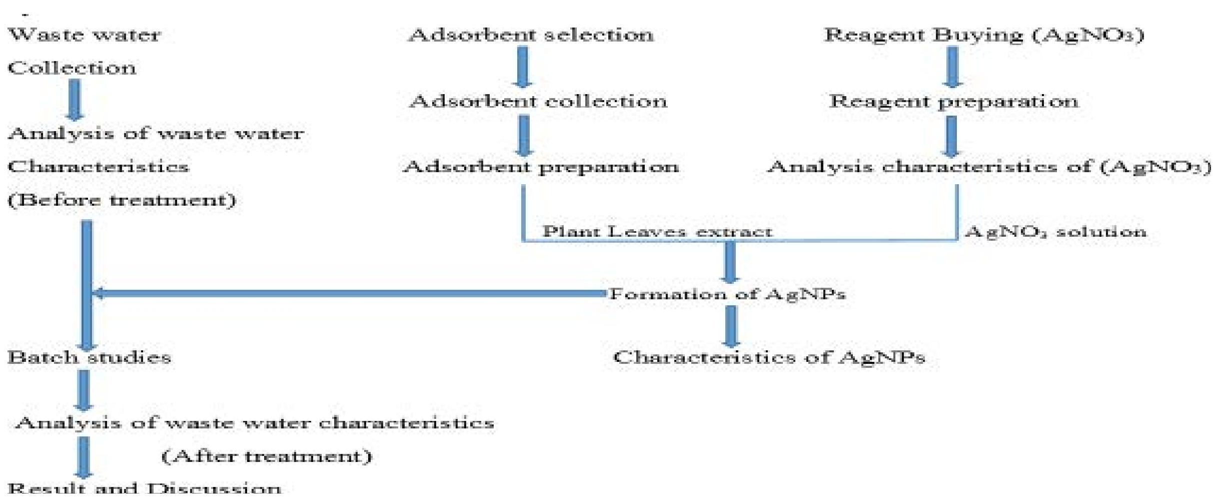

Fig. 1. Materials and techniques.

Fig. 2. Sample collection and preparation of extraction powder.

make nanoparticles from each leaf extract. The solution was then held at room temperature and kept in dark areas [11].

4. Ultraviolet spectroscopy

After a few hours of incubation in darkness, UV-VIS spectroscopy is used to get the UV-VIS spectra. The absorption peak of nanoparticles is around 300 nm, as shown in Fig. 3, and a lengthening of the curve indicates poly dispersed particles.

5. Treatment of sewage water using Ag nanoparticles

The experimentation is made easier with the use of a batch method. Leaf extracts and waste water are diluted in a round-bottom flask with a capacity of 250 mL to facilitate experimentation. In a round bottom flask, 5 mL of the Ag nanoparticles and 10 mL of waste water are kept. The sample is heated to 700°C for 45 min in a water bath while pellets stir it. After heating, a number of samples are collected and analyzed for BOD, COD, and pH levels in accordance with APHA guidelines. Results that are consistent across all three samples form the basis for statistical analyses.

6. Result and analysis

A batch adsorption study is conducted to test the viability of using bio-adsorbents to minimize contamination in sewage water. The leaf extract's effectiveness as an adsorbent is assessed using synthetic Ag nanoparticles. The main characteristics of sewage water are determined during a preliminary evaluation in order to judge its effectiveness as an adsorbent. In Table 1, the initial property of untreated sewage water (pH, TDS, TH, BOD_3, and COD) is illustrated. Table 2 illustrates the properties of treated sewage water, which helps to reduce pollution levels [12].

7. Ag nanoparticle diagnosis by UV spectroscopy

Fresh leaf extracts and silver nitrate solutions are examined using UV spectroscopy at concentrations of 3, 6, 9, and 12 mL. The Spectra 50 ANALYTIKJENA Spectrophotometer has a resolution of 1 nm to capture the UV-Visible spectra of this solution from 200 to 600 nm [13]. As well as UV-Vis spectroscopy, the Ag NPs' spectrum of absorption at different plant extract concentrations is examined.

Fig. 3. Sewage water collection.

Table 1
Properties of untreated raw sewage

Characteristics of water (mg/L)	Sewage water	Standard limits
pH	8.4	6.5–9.0
Temperature, °C	18	–
Total dissolved solids, ppm	6,850	3,500
Total hardness, ppm	600	300
BOD$_3$, ppm	400	30
COD, ppm	248	250

Table 2
Qualities of treated sewage water

Characteristics of wastewater (mg/L)	*Millettia pinnata*	*Justicia adhatoda*
pH	7.4	7.2
TDS, ppm	4,000	6,350
Total hardness, ppm	400	500
BOD$_3$, ppm	356	384
COD, ppm	228.8	251.2

Fig. 4. Biosynthesize of silver nanoparticles.

Fig. 5. Ag nanoparticle diagnosis by UV spectroscopy.

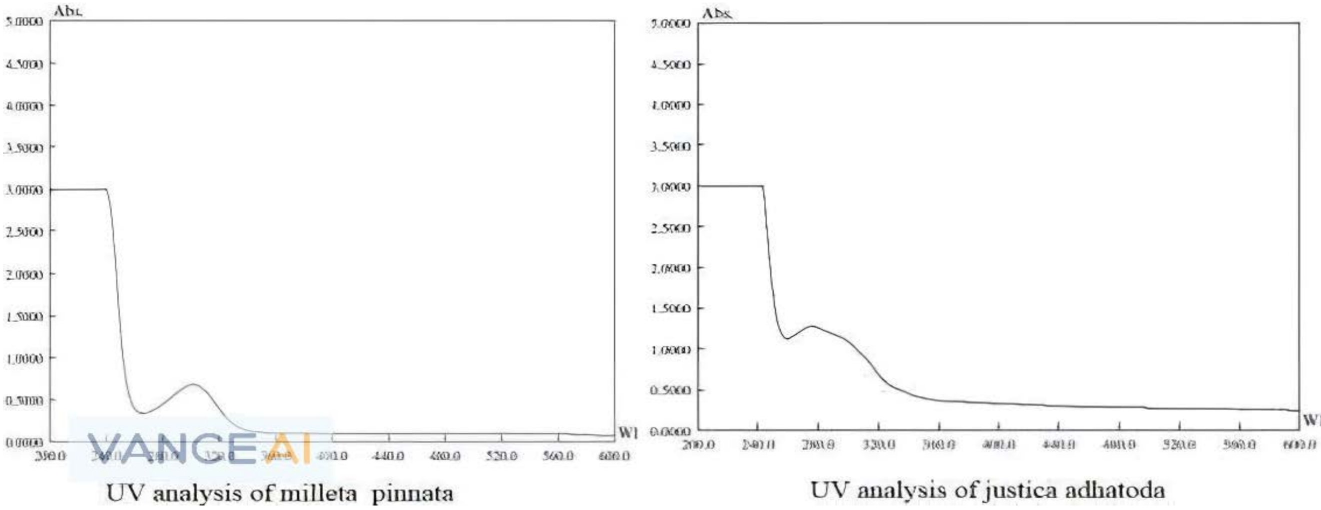

Fig. 6. Analyses of natural absorbents under UV.

In each test, equal volumes of *J. adhatoda* and *M. pinnata* leaf extracts are used, and the maintained temperature is 70°C (using 0.1 M $AgNO_3$) [14,15].

The pure Ag NP solution's light brown colour turn dark brown, when the amount of plant extract gets increased. Comparative analysis is employed to look at how the synthesis of Ag NPs is impacted by various $AgNO_3$ concentrations (3, 6, 9, and 12 mL, respectively).

In the present study, a course of treatment which includes adding 5 mL of leaf extract containing Ag nanoparticles to 10 mL of sewage water samples. The sample has a pH between 7.4 and 7.2 after treatment. A pH range of 6.5–9.0 is suggested for sewage water. The investigation's final findings demonstrated that both analyses successfully decreased pH within allowable bounds. According to the research, *M. pinnata* has given the best results, by reducing TDS up to 4,000 mg/L and COD up to 228 mg/L. By 251 mg/L, *J. adhatoda* is decreased BOD_3. The *M. pinnata* extract reduces sewage water's TDS, Total Hardness, BOD_3, and COD with the greatest absorption efficiency.

8. Conclusion

This research is aimed at assessing the effectiveness of bio-adsorbents in removing contaminants from wastewater water through a batch adsorption study. Leaf extracts from *M. pinnata* and *J. adhatoda* act as a natural adsorbent and can be used to produce silver nanoparticles for the treatment of sewage water at a reasonable cost. At room temperature, this method permits the production of Ag NPs without the use of any hazardous reducing or capping chemicals, such as the UV analysis method, 320 nm nanoparticles. Bioadsorbents containing different concentrations of Ag nanoparticles are allowed to interact with sewage water while monitoring pH, TDS, TH, BOD, and COD. *M. pinnata* can shrink TDS, BOD, and TH nanoparticle size under the influence of various experimental conditions that resulted in a diverse range of absorbance intensities, according to the study. *M. pinnata* is much more efficient at reducing TDS, TH, and BOD than *J. adhatoda*, and so the production of bio-adsorbent nanoparticles is a more environmentally friendly and pollution-free substitute for chemical synthesis.

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