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Green Synthesis of Silver Nanoparticles From *Moringa oleifera* Seeds And It's Application In Water Purification

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1. ABSTRACT

Water purification using plant extracts like *Moringa oleifera* is a natural and sustainable method due to their coagulant and antimicrobial properties. It is found that crushed *Moringa* seeds are used to purify water due to their natural coagulant properties. The crushed seed powder exhibit a remarkable reduction in turbidity and coliform count. In this study, the green synthesis of silver nanoparticles utilizing *Moringa oleifera* seeds and its antibacterial property followed by application in water purification was investigated. Phytochemical analysis of *Moringa oleifera* seed powder was done to know the phytochemical constituent which act as reducing agent in the green synthesis of silver nanoparticles. The UV visible spectroscopy , Fourier transform infrared spectroscopy, X-ray diffraction, and scanning electron microscopy were used to characterize synthesis nanoparticle. From this study it is clear that silver nanoparticles have the ability to inhibit the growth of E. coli, one of the common contaminant present in the drinking water. A concentration of 5mg is enough to treat 100ml of water sample and make it contaminant free. The concentration of silver nanoparticle came to conclusion by comparison method using treated and untreated water followed by streak plate method.

Key Words: Moringa oleifera, Silver nanoparticles, E. coli, Water purification, antibacterial property

2. INTRODUCTION

Medicinal plants have been used for centuries across cultures for their therapeutic properties. In ancient days treatment of disease and healing of wound was mainly done by using medicinal plants. Even now, most commercial goods, such as those used in healthcare and pharmaceuticals, food and drink, textiles, cosmetics, and fragrances, originate from plants (Khanuja, 2012). *Moringa oleifera* is one of them which is very important due to its medicinal and nutritional value. Different parts of the plant such as leaves, roots, seed, bark, fruit, flowers, and immature pod has a different types of biological activities such as antioxidant property, anti-inflammatory property, antimicrobial property, antifungal, antihypertensive, antidiabetic potential, anti - cancer properties etc. Health benefits of *Moringa* plant include inflammation reduction, improve immunity, removes toxins, aids digestion, fight cell damage and so on (Dillard *et al.*, 2000). *Moringa oleifera* is one of the plant which belongs to moringaceae family which have rich source of natural compounds and can be used in a wide range of industrial and pharmaceutical applications. The phytochemicals are commonly produced by the metabolic pathway in plants and they are responsible for the pharmacological activities (Arora *et al.*, 2013). Apart from this, it is also used for the purification of water. The anti coagulant property of seed powder helps to clarify the turbid water (Borin *et al.*, 2005).The coagulant proteins present in the form of water soluble substances can be used for the water purification purposes (Ghebremichael *et al.*, 2005).The crude seed extract as well as seed oil shows antibacterial activity towards gram negative and gram positive bacteria. In contaminated water the presence of *E. Coli* can be seen in great amount. The presence of *E. coli* is not suitable for potable water. By using the *Moringa oleifera* seeds, it is possible to remove negatively charged particles present in the water. The membrane fusion of pathogens was facilitated by cationic protein found in seeds, which enhanced *Moringa oleifera*'s antibacterial efficacy against *Escherichia coli.* Not only microorganisms the seeds have the ability to remove benzene, toluene, ethylbenzene and cumene which are considered as organic pollutants present in water (Akthar *et al*., 2007).

Phytochemical rich *Moringa oleifera* plant, are used in the green synthesis of silver nanoparticle. Silver nanoparticles (AgNPs) are one type of metal nanoparticle that have the ability to show strong antioxidant, antibacterial, and photocatalytic properties (Lopez-Quintela.,2003).Antibacterial property of silver nanoparticles helps to inhibit or kill wide range of Gram positive and Gram negative bacteria (M. Moulin *et al.*, 2019). AgNPs thus synthesized by using green method have demonstrated outstanding antibacterial efficacy against *Staphylococcus aureus* and *E. coli* (Dubey *et al.*, 2013). Although *Moringa oleifera* seeds lacks antibacterial activity, it is a great coagulant for purifying water. Without additional disinfection, water treated with *M. oleifera* seeds is not fit for human consumption. Thus, the anticoagulant properties and effectiveness of the silver nanoparticles produced by green methods are enhanced by the extract of *Moringa oleifera* seeds.

Therefore, the goal of current study was to investigate the green synthesis of silver nanoparticle from *Moringa oleifera* seeds and its application in water purification.

3. MATERIALS AND METHODS :

3.1 Collection of the seeds :

The dried *Moringa oleifera* seeds (250g) were collected from the local market of Coimbatore.

3.2 Preparation of aqueous seed extract

The seeds were dried under hot air oven at a temperature of 45°C. The shells and wings of the seeds were removed and the kernel alone was ground to powder by using an electric blender. Twenty gram (20g) of the powdered seed was weighed and transferred in to a beaker.250ml of distilled water was added to the powder and stirred well to make them to Fine mixture. Allow that mix to boil until the bubbles were formed. Then the decoction Obtained has allowed for over night incubation. After a period of incubation the contents were Filtered using What man no. 1 filter paper (Ali-Shtayeh and S. I. Abu-Ghdeib 1999).

3.3 Phytochemical analysis of *Moringa oleifera* aqueous extract :

Qualitative phytochemical screening of aqueous extract of *Moringa oleifera* was carried out to identify the presence of secondary metabolite including alkaloids, flavonoids, proteins, saponins, tannins, phenols, steroids, and carbohydrates.

3.3.1 Test for alkaloids [Mayer's Test]:

2 ml of crude extract was treated with 2 drops of Mayer's reagent and observed for the formation of white precipitate (or creamy) which shows the presence of alkaloids.

3.3.2 Test for alkaloids [Wagner's Test]:

2 ml of crude extract was treated with 3-5 drops of Wagner's reagent and observed for the formation of reddish brown precipitate (or coloration) which shows the presence of alkaloids.

3.3.3 Test for flavonoids [Ammonium Test]:

4 ml of sample was treated with Few drops of 10% ammonium solution and heated for about 2mins.

Appearance of fluorescence yellow colour indicates the presence of flavonoids.

3.3.4 Test for flavonoids [Lead acetate Test]:

2 ml of crude extract was treated with few drops of 10% lead acetate solution. Formation of milky White precipitate indicates the presence of flavonoids.

3.3.5 Test for steroids:

2 ml of crude extract was treated with 2 ml of chloroform and 2 ml of concentrated sulphuric acid and observed for the formation of red or yellowish green which shows the presence of steroids.

3.3.6 Test for phenol [Ferric chloride test]:

2 ml of crude extract was mixed with few drops of 5% ferric chloride solution. Formation of green colour indicates the presence of phenol.

3.3.7 Test for protein [Millon's test]:

1ml of crude extract was treated with 2 ml of Millon's reagent. Formation of white precipitate turns red when heating indicates the presence of protein.

3.3.8 Test for protein [Ninhydrin test]:

1ml of crude extract was treated with 2 ml of 0.2% ninhydrin solution. Boiling it turns into violet colour that indicates the presence of protein.

3.3.9 Test for carbohydrates [Fehling's test]:

1ml crude extract was treated with 2-3 drops of Fehling's reagent. Keep the test tube in a water bath about 1-2 minutes. A reddish-brown precipitate appearance indicates a positive result.

3.3.10 Test for tannin [Ferric chloride test]:

1 ml of crude extract was mixed with ferric chloride solution which give dark green Color indicates the presence of tannins.

3.4 Green synthesis of silver nanoparticle (AgNO3):

100 ml of 0.1 mM concentration of silver nitrate was prepared. To this solution 10 ml of *Moringa oleifera* aqueous seed extract was added. A continuous mixing was ensured by placing it in a magnetic stirrer at 80°C. The synthesis of silver nanoparticle was qualitatively visually analysed by the colour change from pale yellow colour to brown colour. The colour of the solution got darker about 2-3 hours which confirmed the reduction of silver ions into silver nanoparticle (Kero jemal *et al.*,2017).

3.5 Characterization of silver nanoparticle :

3.5.1 UV- Visible spectroscopy analysis :

UV-Vis spectral analysis of synthesized silver nanoparticles was measured by using UV-Visible spectrophotometer with a resolution of 1 nm to investigate the reduction of Ag+ to Ag0 by crude seed extract. The spectra were taken between 300 and 800 nm after 24 Hrs incubation of the mixtures of AgNO3 solution. Double distilled water was used as blank reference for the background correction of experiments.

3.5.2 Fourier transform infrared spectroscopy (FTIR) analysis :

Fourier Transform Infrared Spectrophotometer (FT-IR) is perhaps the most powerful tool for identifying the types of chemical bond/functional groups present in the phytochemicals. An FTIR spectral study was conducted to determine the potential interaction between silver and biologically active molecules, which may be responsible for the synthesis of AgNPs and stability.

3.5.3 X-Ray diffraction (XRD) analysis :

Further characterization of green synthesized silver nanoparticle was done by using X-ray diffraction technique. It was carried out in a X-ray diffractometer operated at 45kV voltage and 30Ma current. The XRD (X-Ray Diffraction) data table provides valuable information about the crystalline structure of the analysed material. The table lists the peak positions (2θ), peak intensities (heights), peak widths (FWHM), interplanar spacings (d-spacing), and Relative intensities for the observed diffraction peaks.

3.5.4 Scanning electron microscopy (SEM) analysis :

The morphological features of synthesized nanoparticles using the aqueous extract of *M.oleifera* seeds were studied by Scanning Electron Microscope .After 24 hours of addition of AgNo3 the SEM slides were prepared by making smear of the solutions on slides .A thin layer of platinum was coated to make the samples conductive. Samples for SEM were

prepared by drop coating the Ag nanoparticles solutions onto carbon copper grid. The films on the grids were allowed to dry prior to SEM measurement.

3.6 Antibacterial activity of silver nanoparticle :

The antibacterial activity of the green synthesized silver nanoparticle can be checked by using turbidimetric assay. The Minimum Inhibitory concentration (MIC) of silver nanoparticle can be determined by checking the OD value of bacterial culture after the incubation period. To check the MIC of silver nanoparticle, a loop full of *E. coli* inoculum was inoculated in to 100ml of nutrient broth. For the proper growth and development of the inoculum, the incubation period was set to be an overnight at 37°C. After the incubation period the bacterial culture was ready for next stage of inoculation. A series of 7 conical flask were taken and marked as control, standard, T1, T2, T3, T4 and T5 respectively. 20 ml of nutrient broth was taken as control. 20 ml of nutrient broth which was inoculated with a loop of *E. coli* was used as standard. Whereas in another 5 conical flask (T1T5), 20 ml of nutrient broth with one loop full of *E. coli* was added with 2 mg, 4 mg, 6 mg, 8 mg and 10 mg of silver nanoparticles synthesized by using *Moringa oleifera* seed aqueous extract. All these conical flasks were allowed for an overnight incubation along with continuous shaking on a shaker. After the overnight incubation the OD reading of all the flasks were taken at 600nm. The reading was noted and a graph is plotted according to the obtained OD values against the concentration (Tótoli and Salgado 2013).

3.7 Testing of water potability by MPN technique:

The potability of water can be checked by Most Probable Number or MPN technique. It involves the primary presumption for the presence of *E.coli* in the collected water sample. For the presumptive test a set of 15 test tubes containing lactose broth were prepared. Of these 15 test tubes, 10 of the test tubes contain Double strength (2X) lactose broth and the remaining 5 test tubes contain Single strength (1X) lactose broth. For this multiple tube fermentation technique water sample was collected from the tap placed in our laboratory. Wipe the portion of tip through which sample is to be collected with ethanol. The water samples were taken and inoculated to 5 tubes of Lactose broth of double strength (10 ml) with 10ml of sample. 5 tubes of double strength (9 ml) with 1ml and other 5 tubes of single strength of Lactose broth (9.9 ml) with 0.1 ml sample. Total numbers of 15 tubes were prepared and make sure to put Durham's tube in each of these 15 tubes. All tubes were incubated at 37°C for an overnight. After incubation, the tubes were observed for colour change and gas production. The number of positive tubes and negative tubes were noted for each set of test tubes. The most probable number of organism per test sample was determined by using McCardy's table. The final procedure for the confirmatory test was done by preparing EMB agar plate by inoculating a loopful of inoculum from the positive presumptive test. The plats were observed after an incubation period at 37°C for 24 hours (Ahmed, T *et al*,. 2013).

3.8 Antibacterial property of silver nanoparticle towards collected water sample:

100 ml of sample was collected from the tap water. To the collected sample 5mg of silver nanoparticle was added and placed in a shaker for an overnight incubation. On the next day, the water treated with silver nanoparticle were carried for serial dilution. The dilution procedure was carried out from the dilution of 10-2 to 10-6 .After serial dilution each tube is

carried out for pour plate technique by using EMB agar. Total numbers of 5 plates were poured at a dilution of 10-2, 103, 10-4, 10-5, 10-6. After plating it is allowed for an incubation period of 37°C for 24 hrs. For the comparison and analysis the same procedure was carried out with the contaminated water.

3.9 Water potability test using *Moringa oleifera* seed aqueous extract mediated silver nanoparticle

100 ml of sample water was collected from the tap in the laboratory. Then into the collected 100 ml water sample, about 5mg of silver nanoparticle was weighed and added into it. Allow the water sample for an overnight incubation for proper mixing by placing it in a shaker. After the period of incubation, the water sample was carried out for MPN technique. Presumptive test, confirmatory test were done to check the water potability of treated water.15 test tubes were kept for an incubation at 37°C for over night. The results were observed after the incubation period by observing the changes in the tubes such as its turbidity and the gas formation inside the Durham's tube.

4. RESULTS AND DISCUSSION :

4.1 Preparation of *Moringa oleifera* seed aqueous extract

After drying and grinding 250g of *M.oleifera* seeds, about 200g of seed powder was obtained.200ml of seed extract was collected after the decoction procedure using 200g of seed powder in 250ml of water and it was stored in a reagent bottle for further use.

4.2 Phytochemical analysis of crude extract

Phytochemical screening of *Moringa oleifera* seeds showed the presence of alkaloids, flavonoids ,proteins, carbohydrates, where as the steroids, phenols and tannins were e absent. A significant variation in the contents like alkaloids, flavonoids, phenol and carbohydrates can be seen when compared to the *Moringa oleifera* seeds collected from different location. These variations are due to number of environmental factors such as climate, altitude, rainfall etc. as mentioned (Kokate *et al.*, 2004)

Table 4.1 : Phytochemical analysis of *Moringa oleifera* seeds

PHYTOCHEMICAL TEST	RESULTS
Alkaloids Mayer's test Wagner's test	 + +
Flavonoids Lead acetate test Ammonium test	 + +
Steroids	-
Phenols Ferric chloride test	-
Proteins Millons test Ninhydrin test	 + +
Carbohydrate Fehlings test	 +
Tannin	-

4.3 Synthesis of silver nanoparticle using *M. oleifera* seed aqueous extract

The visible colour change from light yellow to brownish yellow indicated the fast formation and nucleation of silver nanoparticles. Gradually the colour get intensed from light brown to dark brown which confirmed the presence of silver nanoparticles. After adding *M. oleifera* seed cold water extract to the AgNO3 solution and allowing it to incubate, the mixture's colour quickly changed from transparent to pale-purple as a result of the AgNPs' production. The activation of AgNO3's surface plasmon vibrations caused the formation of a pale-purple tint, which indicates that plants have potent reducing abilities (Elisa Kalugendo and Kousalya P., 2018). The synthesized silver nanoparticle solution was centrifuged for 20 min at 10,000 rpm. The resulting pellet was washed with distilled water to wash off impurities. The remaining solution was transferred into a petriplate and allowed to dry in a hot air oven at a temperature of 60°C. Finally powdered silver nanoparticles were obtained.

4.4 Characterisation of silver nanoparticle

4.4.1 UV VIS Spectrometry

UV-visible spectrum of silver nanoparticle synthesized from *Moringa oleifera* of the reaction mixture exhibited peaks at a range between 300 to 800 nm. The UV-visible absorption spectra of silver nanoparticles synthesized by using 1 mM AgNO3 with *Moringa oleifera* seed extracts revealed a Surface Plasmon Resonance band at 440 nm in the spectrum, respectively, which clearly indicated the presence of spherical silver nanoparticles. The UV-visible absorption spectra of silver nanoparticles synthesized by using 1 mM AgNO3 with *Moringa oleifera* seed extracts

revealed a Surface Plasmon Resonance band at 440 nm in the spectrum, respectively, which clearly indicated the presence of spherical silver nanoparticles . Broadening of the peaks at the base indicated that the nanoparticles are poly dispersed (Prasad and Swamy, 2013).

4.4.2 XRD

The XRD analysis of green synthesized silver nanoparticle from *Moringa oleifera* seed extract show diffraction peaks at 2θ = 28.0°, 32.4°, 46.4°, 54.9°, 57.6°, 67.7°,74.6°,76.8° respectively. When compared with the standard, the obtained XRD spectrum confirmed that the synthesized silver nanoparticles were in nanocrystal form and crystalline in nature (Roy *et al.*,2015).The most intense peak is observed at a 2θ angle of 76.8517°, with a height of 58.31 counts and a relative intensity of 9.29%. This peak corresponds to an interplanar spacing (d-spacing) of 1.24044 Å. The second most intense peak is located at 74.6518° (2θ) with a relative intensity of 2.37% and a spacing of 1.27144 Å. These two peaks are likely related to the primary crystalline phase present in the material. Other significant peaks are observed at 2θ values of 67.7046° (d-spacing = 1.38395 Å, relative intensity = 3.49%), 57.6631° (d-spacing = 1.59867 Å, relative intensity = 11.97%), and 54.9949° (d-spacing = 1.66975 Å, relative intensity = 14.21%). *Moringa* seed extract contains phenols, carboxylic acid, proteins, and terpenoids, which are probably responsible for the synthesis and reduction of nanoparticles (Chougule *et al.*,2020)

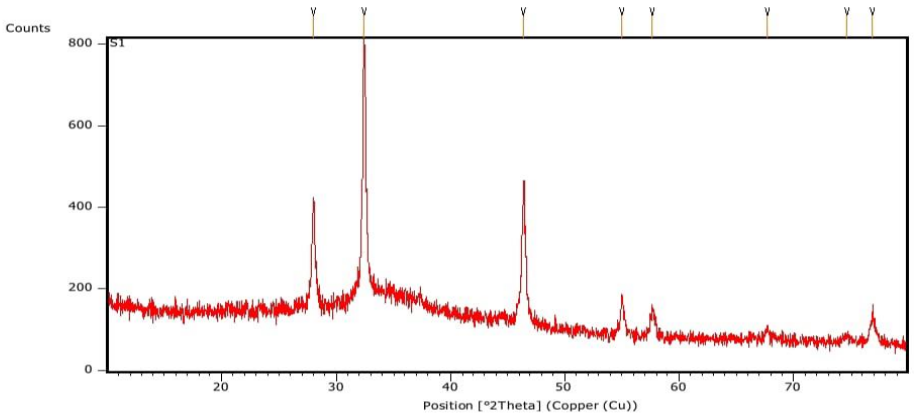

Fig 4.1 : XRD Graph of silver nanoparticles synthesized from *Moringa oleifera* seed extract

Pos. [°2Th.]	Height [cts]	FWHM Left [°2Th.]	d-spacing [Å]	Rel. Int. [%]
28.0279	264.95	0.2676	3.18362	42.20
32.4490	627.81	0.1338	2.75924	100.00
46.4235	333.05	0.3011	1.95605	53.05
54.9949	89.23	0.2007	1.66975	14.21
57.6631	75.16	0.2676	1.59867	11.97
67.7046	21.89	0.8029	1.38395	3.49
74.6518	14.91	0.8029	1.27144	2.37
76.8517	58.31	0.4015	1.24044	9.29

Fig 4.2 : XRD Result of silver nanoparticles synthesized from *Moringa oleifera* seed extract

4.4.3 FTIR

The FTIR spectra of obtained nanoparticles showed different absorption bands ranging from 3973 to 416 cm^{-1} which indicated the presence of some active functional groups. The absorption spectrum of synthesized silver nanoparticle showed peaks at 3973 cm^{-1},3865 cm^{-1}, 725 cm^{-1}, 686 cm^{-1}, 648 cm^{-1}, 594 cm^{-1},516 cm^{-1} ,470 cm^{-1},432 cm^{-1},416 cm^{-1}. The peak that appear in 3800 – 4000 range referred to phenol and alcohol functional group which belongs to O-H stretching vibrations. The peak between 500-730 refers to the halogen compound . The peak between 400-480 referred to cycloalkane functional group, which is the organic acid that contain C-C bond. The presence of phenols and proteins does not only work as a reducing factor but also can act as a stabilizing factor and may prevent clustering by linking to AgNPs through free amino groups or cysteine residues.

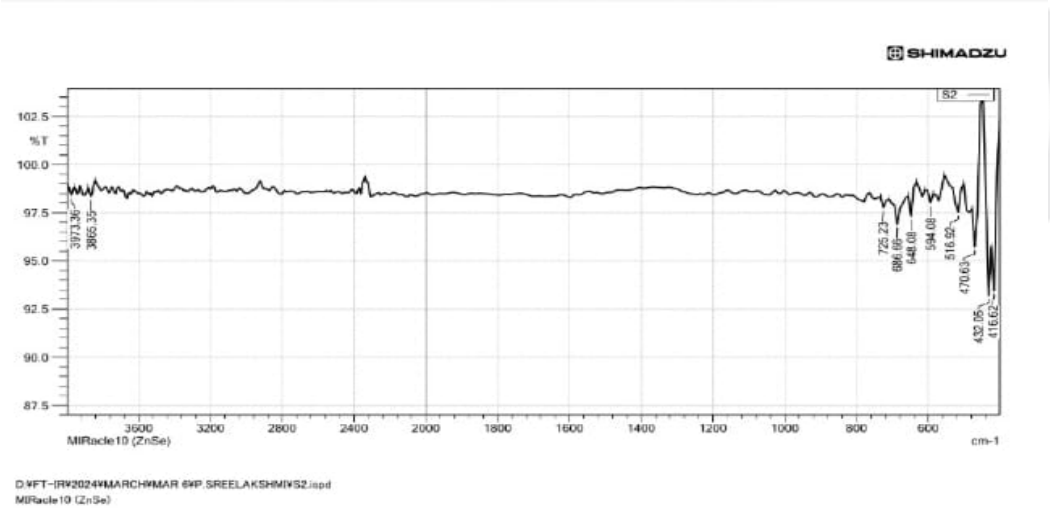

Fig 4.3 : FTIR Spectrum of silver nanoparticle synthesized from *Moringa oleifera* seed extract

4.4.4 SEM ANALYSIS

The SEM images showed individual silver nanoparticles which were predominantly aggregates with no defined morphology. The formation of amorphous crystalline structures of silver nanoparticles are obtained by SEM analysis which ranges from 1µm to 50µm by using scanning electron microscopy. Total number of 6 images having different dimensions were obtained through the SEM analysis. The SEM analysis was performed to identify the uniformity and surface morphology of AgNPs. The average size of the silver nanoparticles synthesized from *M. oleifera* seed cake extracts was 127 ± 24 nm, with diameters ranging from 90 nm to 180 nm. AgNPs were confirmed to be present by the detection of intense peaks between 3 and 3.5 keV (Moodly *et al.*, 2018)

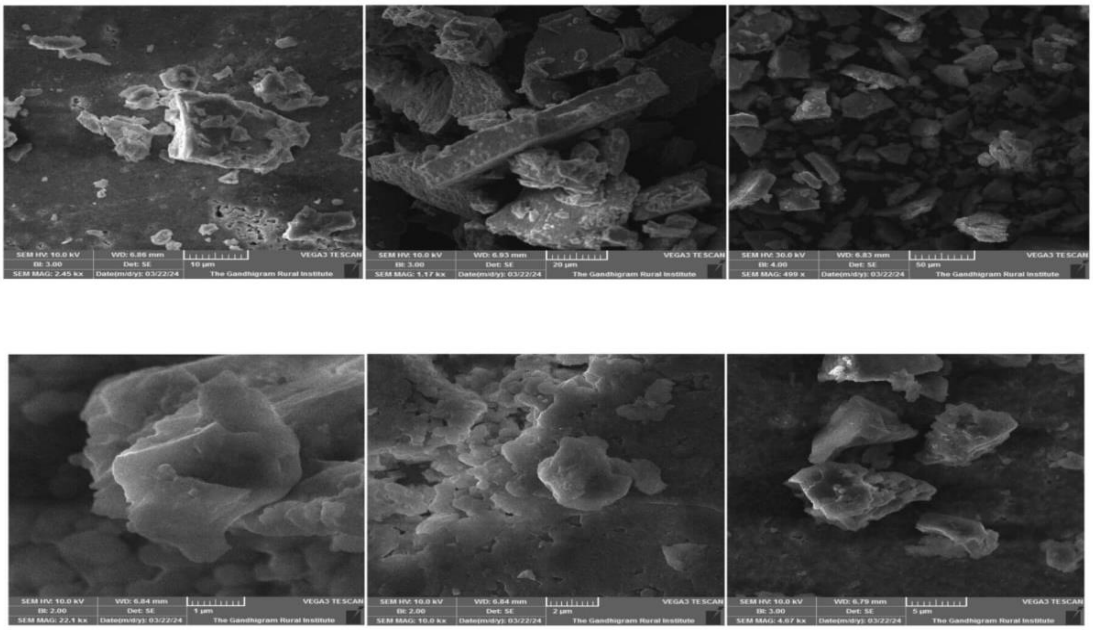

Fig 4.4 : SEM Analysis of silver nanoparticles synthesized from *Moringa oleifera* seed extract

4.5 Antibacterial activity of silver nanoparticle :

The antibacterial activity of silver nanoparticles was done by taking seven conical flask containing nutrient broth along with different concentration of silver nanoparticles. They were placed in a shaker for proper mixing overnight. After the incubation period OD reading was taken at 600 nm. By taking nutrient broth as blank , the reading was taken for all the samples .The obtained OD values were 0.490, 0.351, 0.249, 0.183,0.137 at a concentration range of 2mg, 4mg, 6mg, 8mg, 10mg respectively. From the reading, it was clear that there was decrease in the absorbance value. The OD reading is based on the absorbance and the amount of particles present in it. The turbidity of the broth decreased as the concentration of the nanoparticle increased. From this it was clear that the synthesized silver nanoparticles have the antibacterial property which inhibited the growth of *E.coli* present in it.

4.6 Checking of water potability by mpn technique :

MPN technique was carried out in a total number of 15 test tubes, of these 5 tubes of Double strength (2X) which contains 10ml broth and 10ml sample showed positive results. The increase in turbidity of the broth as well as the gas formation inside the tubes indicated the Positive results. 5 tubes of Double strength (2X) which contain 9ml broth and 1ml sample gave a positive result. In remaining 5 tubes of Single strength (1X) which contain 9.9ml of broth and 0.1 ml of sample gave 3 positive tubes. The presence of bacteria can be determined by comparing the positive tubes with McCardy's table. The confirmatory test was done by using the EMB agar plates which have colonies with a green metallic sheen. The presumptive, confirmatory and completed test indicate the presence of coliform bacteria in the collected sample. The positive tubes which have high turbidity and the gas formation in Durham's tube confirmed the presence of bacteria. Furthermore the completed test also gave positive result by forming green metallic sheen on the EMB agar plate. So from these tests it was clear that the collected water is not suitable for drinking purpose.

4.7 Antibacterial activity of synthesized silver nanoparticle by using mpn technique :

Total number of 15 tubes were used for the MPN technique of treated water. Of these 3 tubes of Double strength 2X (10 ml sample +10ml broth) were given positive results. Next 5 set of Double strength tubes containing 9ml broth plus 1ml sample showed negative results. The remaining 5 Single strength tubes (9.9 ml broth + 0.1 ml sample) also show negative Result. All the 15 test tubes showed less turbidity and show no gas formation except the 3 test tubes of double strength. From this result it is clear that the water sample which is treated with silver nanoparticle is free from contaminants. The antibacterial property of silver nanoparticle prevent the growth and multiplication of E. Coli present in the collected Sample. By observing the tubes it is clear that only 3 tubes show positive result. And left of the tubes show negative result. Absence of gas formation and less turbidity of the broth is due to the absence of contaminants. Antimicrobial activity of AgNPs against *Escherichia coli*, leading to cell death because of the accumulation of AgNPs in the cell wall. The extent of AgNPs' antibacterial activity largely depends on their size and shape (Haque *et al.*,2017)

4.8 Antibacterial activity of silver nanoparticle on water by streak plate method :

Total number of 10 plates were kept for incubation. Of these 5 plates for treated water and other 5 plates for contaminated or untreated water. EMB agar is the selective media for E.coli. After a period of overnight incubation the colonies will be formed in plates were the E. coli is present. The plates which poured with treated water showed no colony formation. This indicates that the silver nanoparticles have the ability to inhibit the growth of coliform present in the water. The antibacterial activity of the silver nanoparticle kill the E.coli present in the water. At the same time colonies were appeared in plates having contaminated water with increase in dilution. The presence of E.coli can be seen in contaminated water by the appearance of colonies on the EMB agar plate. By observing these

plates, it is clear that the growth and reproduction of E.coli get inhibited by treating the water with silver nanoparticle. The antibacterial property of silver nanoparticle inhibit the growth of contaminants present in the water. As a result ,there is no formation of colonies in the plates poured with treated water. At the same time colonies are present in the EMB plates poured with contaminated water. By observing and comparing these two sets of plates ,it is clear that the silver nanoparticle synthesized from *Moringa oleifera* seeds have the potential for water purification. The sheets where AgNPs are deposited on the cellulose fibres have shown significant antibacterial properties against *E.coli* (Dankovich and Grey., 2011)

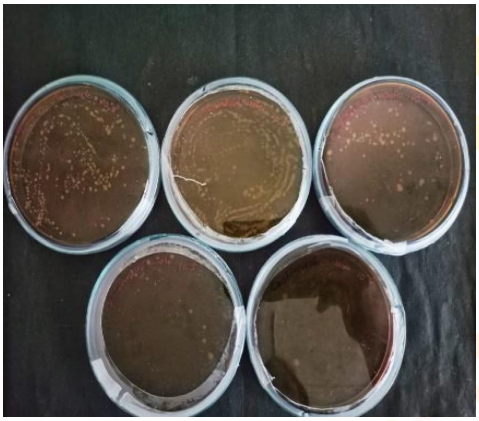

Fig 4.5 : Bacterial growth on EMB agar before treatment

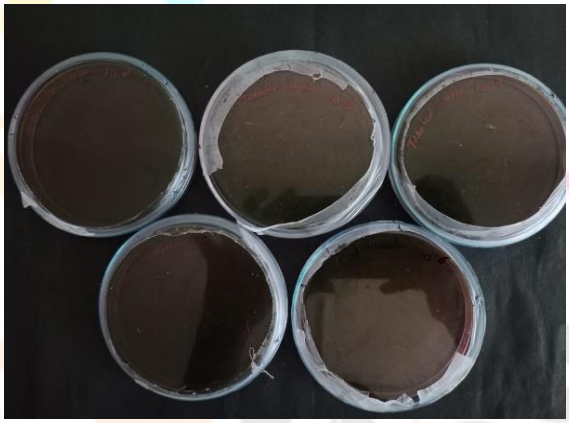

Fig 4.6 : Bacterial growth on EMB agar after treatment

5. CONCLUSION :

Silver nanoparticles have the potential for use in the treatment of contaminated water. The antibacterial property of silver nanoparticle make the water free from contaminants and make them suitable for drinking purpose. Coliforms are the common contaminants present in the drinking water. In the present study, stable silver nanoparticles were produced using *Moringa oleifera* seeds via a simple, economic and green synthesis method. The characterization of green synthesized silver nanoparticle was done by using techniques like UV-VIS SPECTROMETRY, FTIR, XRD, SEM. The developed method has numerous significant advantages over conventional methods. Specifically, the synthesis of silver nanoparticle using *Moringa oleifera* seed extract does not produce any toxic substances. In this study, powdered silver nanoparticles are directly used for the treatment of water. Many research studies are still going on with Moringa seeds due to its high potential in water purification. In future the silver nanoparticle synthesized from *Moringa oleifera* seed can be used either in a membranous filter form or else in a pellet form for the water purification. From this study it is clear that 5mg of AgNP is enough to purify 100ml of water. Several techniques that include chlorination, distillation and water sediment filters have been used to purify water however, some of these techniques

are expensive, toxic and have many limitations. The use of silver nanoparticles (AgNPs) for water purification has been found to be easier, nontoxic and cost effective.

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