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GREEN SYNTHESIS AND COMPARATIVE STUDY OF SILVER AND IRON NANOPARTICLE FROM LEAF EXTRACT

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ABSTRACT

We report on rapid one-step green synthesis of silver and iron nanoparticles using leaf extract of ***Chenopodiastrum murale***, ***Magnolia champaca*** and ***Datura metel***. UV-Vis absorption spectroscopy was used to monitor the quantitative formation of silver and iron nanoparticles. The characteristics of the obtained silver and iron nanoparticles were studied using UV-Vis absorption spectroscopy (UV/Vis), pH analysis, Fourier transform infrared spectroscopy (FTIR), Scanning electron microscopy (SEM), and Energy-dispersive spectroscopy (EDX). The EDX spectrum of the solution containing silver and iron nanoparticles confirmed the presence of elemental silver and iron signals. The average diameter of the prepared nanoparticles in solution was about 20–150nm. Synthesized particles were spherical in shape. This synthesis approach silver and iron nanoparticles is cost effective and can be widely used in biological systems.

1. INTRODUCTION

Nanoparticles are particles of less than 100nm in diameter that exhibit new or enhanced size-dependent properties compared with larger particles of the same material. Nano is greatest building block for health care, structural material, in electronics, automation, and etc. This new science will become the platform for launching new cutting-edge technologies for the better living of mankind. The application of nanotechnology to the day to day living scenario is growing in the world. Biological systems such as plants microorganisms produce inorganic materials and most of these are present in Nanoscale dimensions. Biosynthesis of silver and iron nanoparticles is a bottom-up approach that mostly involves reduction or oxidation reactions. The components involved in biological method of nanoparticle synthesis are solvent medium for synthesis, the environmental friendly reducing agent and a nontoxic stabilizing agent. The advantage of biological method of silver production is less expensive and non toxic. Green synthesis of silver and iron nanoparticle can be carried out in a very cheap manner within a short period of time and with minimum labour. In this method of green synthesis there is no requirement for high pressure, energy, temperature or toxic chemicals. Silver nanoparticles have found applications in catalysis, optics, electronics and other areas due to their unique size-dependent optical, electrical and magnetic properties. Iron nanoparticle is used for removal of organic and inorganic pollutants from aqueous solutions. Iron nanoparticle contains iron oxides and zero valent iron (ZVI), which can be used as FENTON-like catalyst. Fenton's reagent is a solution of hydrogen peroxide and an iron catalyst which is used to oxidize contaminants in water. Fenton's reagent can be used to destroy organic compounds such as trichloroethylene and tetrachloroethylene.

In this study, we have synthesized silver and iron nanoparticles using some leaf extract for reduction of Ag^{+} ions to Ag^{0} nanoparticles from silver nitrate solution and Fe^{+} ions to Fe^{0} nanoparticles from ferric chloride solution within 2min of reaction time at ambient temperature.

Here, we have described the synthesis of silver and iron nanoparticles based upon the change in color, change in pH, change in absorbance and the particle size formed after reduction.

2. MATERIALS AND METHODS

2.1 Materials

For the synthesis of silver and iron naoparticle, we used leaf extract of three different plants which includes *Chenopodiastrum murale*, *Magnolia champaca* and *Datura metel*.

1. Bionomial name-*Magnolia champaca*

Common Name –Joy Perfume Tree,champa

Plant part taken-Leaves

Family Name- Magnoliaceae

(a)*Magnolia champaca*

Description: *Magnolia champaca* is a large evergreen tree. The flowers are used in Southeast Asia for several purposes. It is rarer and has a strong perfume, and is not that commonly or plentifully used. *Magnolia champaca* is cultivated and used as an ornamental tree in temperate climate gardens.

2. Binomial name- *Datura metel*

Common Name – Kamkamawlaw

Plant part taken-Leaves

Family Name- Solanaceae

(b) *Datura metel*

Description: *D.metal* is a shrub-like perennial herb, commonly known as angel's trumpet and devil's trumpet. *D.metal* grows in all warmer parts of the world. It is cultivated for its chemical and ornamental properties. It is a medicinal plant widely used in phytomedicine to cure diseases such as asthma, cough, convulsion and insanity.

3. Binomial name-*Chenopodiastrum murale*

Common Name – *Amaranthus viridis*

Plant part taken-Leaves

Family Name-Amaranthaceae

(c) *Amaranthus viridis*

Description: This is an annual herb reaching 70 centimeters in height with an erect stem which is usually red or red-streaked green and leafy with green foliage. The oval to triangular leaves is toothed and broad, smooth on the upper surface and powdery on the undersides. The seeds are edible, and the shoots, stalks, and leaves can be eaten as greens.

2.2 Preparation of leaf extract:

Leaf extract was prepared by taking 20gm of leaves and washed thoroughly with double distilled water, dried at room temperature and cut into fine pieces. Fine pieces are boiled in 100ml double distilled water for 20minutes at 60^0 C in a glass beaker.After boiling the extract was filtered using Watmann No.1 (25µm pore size) filter paper. The filtered leaf extract act as a reducing agent.

2.3 Preparation of precursors:

(a) For Silver - Precursor for preparing silver nanoparticle was 0.001M of silver nitrate using double distilled water.
(b) For Iron – Precursor for preparing iron nanoparticle was 0.001M of ferric chloride using double distilled water.

2.4 Preparation of silver and iron nanoparticles:

(a) For Silver nanoparticles – Precursor and reducing agent was added in 1:1 proportion (i.e.) 20ml of 0.001M silver nitrate solution was added with 20ml of leaf extract in a clean sterilized flask at room temperature.
(b) For Iron nanoparticles – Iron nanoparticle was reduced from 0.001M ferric chloride by adding 20ml of leaf extract with 20ml of $FeCl_3$ at room temperature.

4. EXPERIMENTAL METHODS

3.1 pH analysis:

pH is defined as negative logarithm of hydrogen-ion activity. It is a measure of the relative amount of free hydrogen and hydroxyl ions. The pH was determined by using Digital pH meter Systronics. The pH of the reduced solution with Nanoparticle synthesized was found to be acidic. After reduction the pH of every sample was found to decrease and move towards acidic range.

3.2 UV-Vis Spectra analysis:

Ultraviolet-visible spectroscopy (UV-Vis) refers to absorption spectroscopy in the UV-Visible spectral region. This means it uses light in the visible and adjacent (near-UV and near-infrared (NIR)) ranges. The absorption in the visible range directly affects the perceived color of the chemicals involved. In this region of the electromagnetic spectrum, molecules undergo electronic transitions.

3.3 FTIR:

Fourier transform infrared spectroscopy is a technique which is used to obtainan infrared spectrum of absorption, emission, photoconductivity or Raman scattering of a solid, liquid or gas. An FTIR spectrometer simultaneously collects spectral data in a wide spectral range. The goal of any absorption spectroscopy is to measure how well a sample absorbs light at each wavelength.

3.4 SEM:

A scanning electron microscope (SEM) is a type of electron microscope that produces images of a sample by scanning it with a focused beam of electrons. Thin film coating of sample is made on a glass plate and dried in a room temperature for one day.

3.5 EDAX:

Energy dispersive X-ray analysis (EDXA) or energy dispersive is an analytical technique used for the elemental analysis or chemical characterization of a sample.

5. RESULTS AND DISCUSSION

4.1 Synthesis of Silver and Iron Nanoparticles

Three plants extracts were used to produce silver and iron nanoparticles (Table. I and II), the reduction of silver ions into silver particles and iron ions into iron particles occurred after mixing silver nitrate and ferric chloride solution with different plant and spices extract, followed by colour change and change in pH of solutions. As the plant extract was mixed in the aqueous solution of the silver ion complex abd iron ion complex, it started to change the color due to reduction of silver ion and iron ion, which may be the indication of formation silver and iron nanoparticles.

I. Change in color of the solution during Silver and Iron nanoparticle synthesis

Solution	pH change			C
	A	B Silver	B Iron	
Magnolia	**4.94**	**4.29**	**3.52**	+
Amarant hus	**5.12**	**4.69**	**3.56**	+
Datura	**4.52**	**3.85**	**3.20**	+

A. **Before reduction**
B. **After reduction**
C. **Result**

II.Indication of change in pH during green synthesis of silver and iron nanoparticles

A) **Before reduction**
B) **After reduction**
C) **Result**

Solution	Color change			Time
	A	B Silver	B Iron	
Magnolia champaca	Turbid Brown	Grey	Black	Immediate
Amaranthus viridis	Dark Brown	Grey	Light Brown	24 hours
Datura metel	Honey yellow	Grey	Brown	12 hours

5.2 UV-Vis Spectra analysis:

The bioreduction of Ag^{+3} and Fe^{+3} in aqueous solutions was monitored by periodic sampling of aliquots of the mixture and subsequently measuring UV–Vis spectra. UV-Vis spectral analysis was done by using UV-Vis spectrophotometer at the range of 300-500 nm and observed the **absorption peaks for each samples** due to the excitation of surface plasmon vibrations in the iron nanoparticles, which are identical to the characteristics UV visible spectrum of metallic iron and it was recorded.

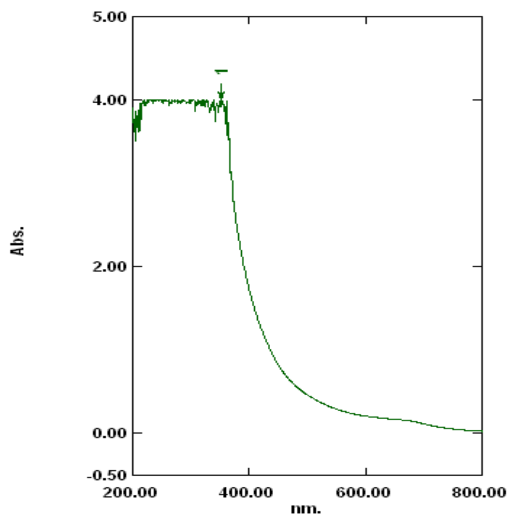

Fig.4.2(a)UV vis of AgNP's for *Amaranthus viridis*

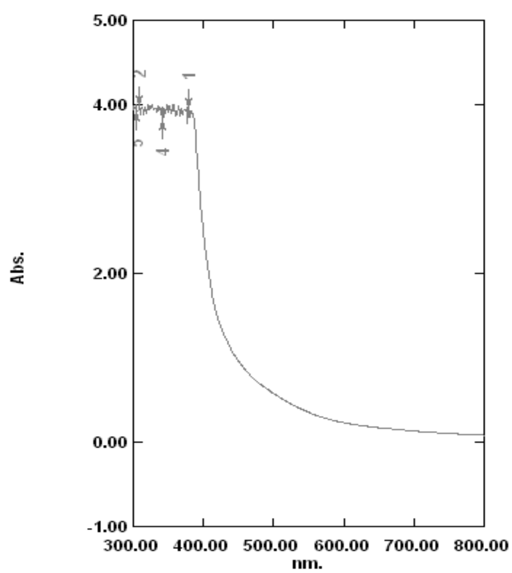

Fig.4.2(b)UV vis of AgNP's for *Magnolia champaca*

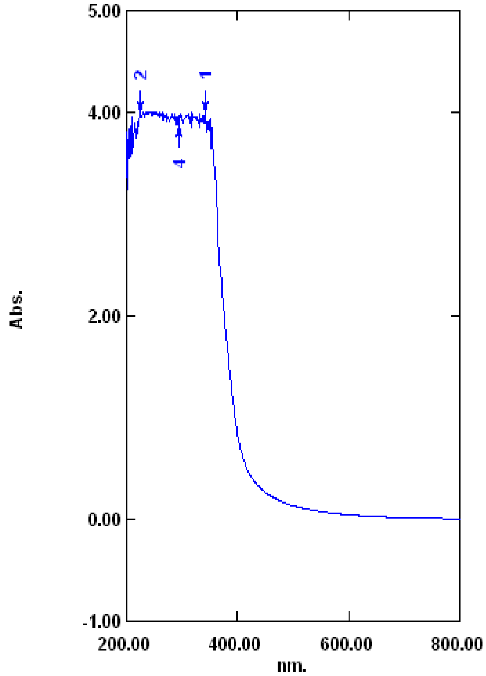

Fig.4.2(c)UV vis of AgNP's for *Datura metel*

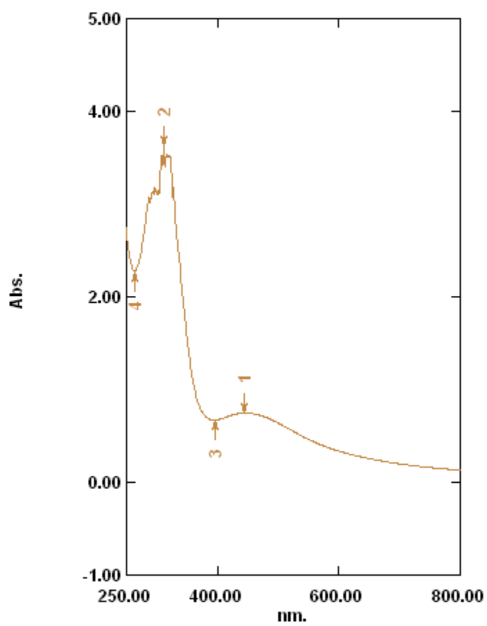

Fig.4.2(d)UV vis of AgNP's for Curry leaves

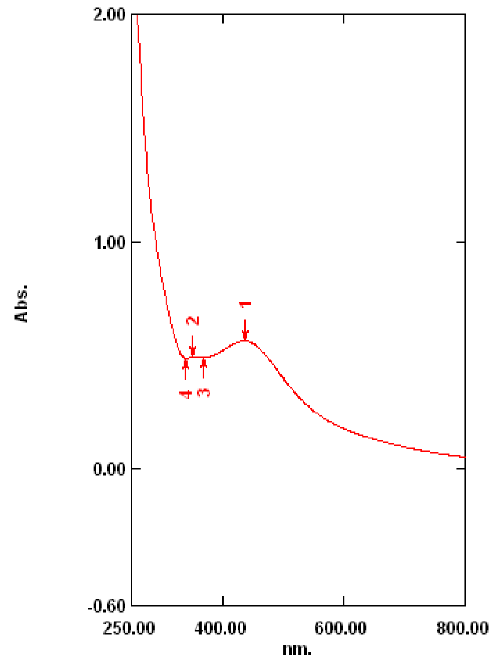

Fig.4.2(e)UV vis of AgNP's for Neem leaves

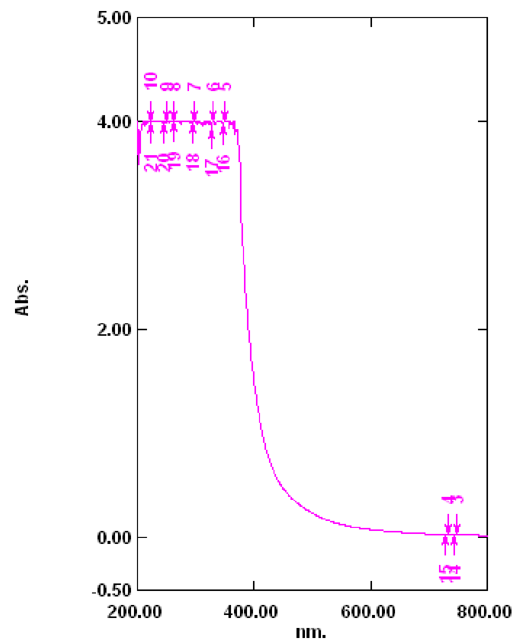

Fig.4.2(f)UV vis of FeNP's for *Amaranthus viridis*

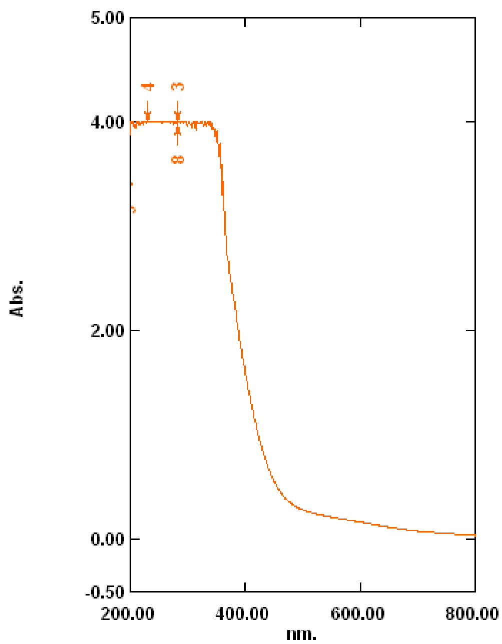

Fig.4.2(g)UV vis of FeNP's for *Magnolia champaca*

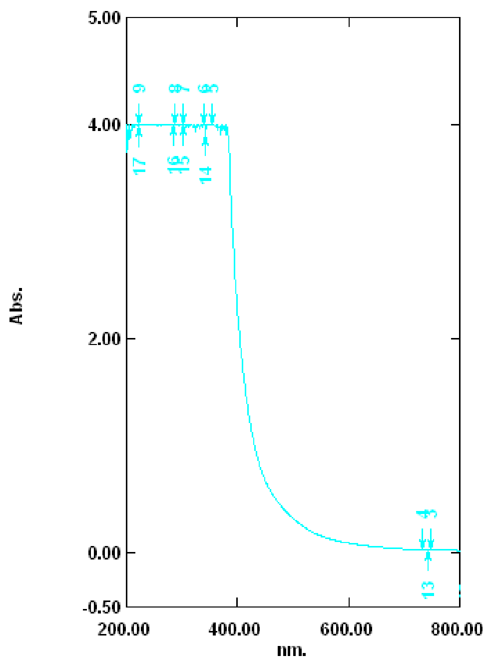

Fig.4.2(h)UV vis of FeNP's for *Datura metel*

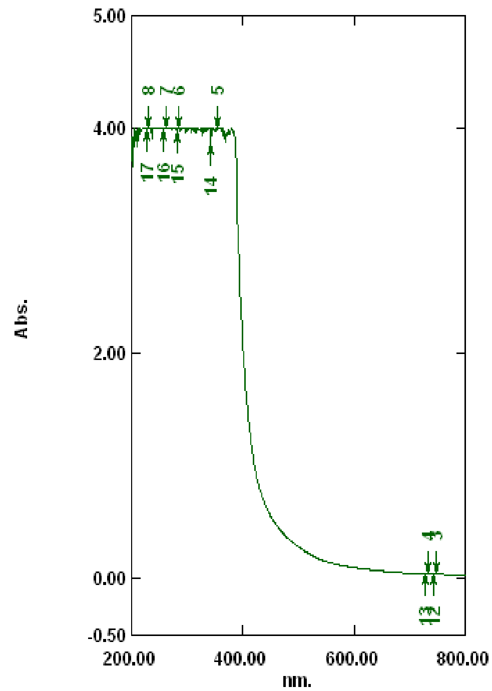

Fig.4.2(i)UV vis of FeNP's for Curry leaves

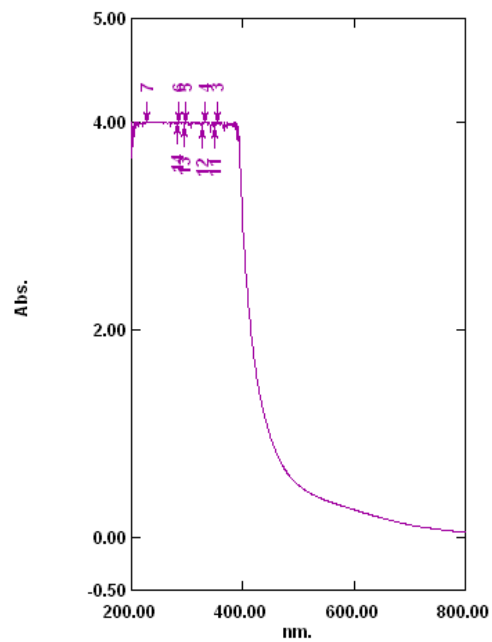

Fig.4.2(j)UV vis of FeNP's for Neem leaves

I.Comparative UV vis results for AgNp's and FeNP's

Solution	Wavelength (nm)		Absorbance	
	Silver	Iron	Silver	Iron
Amaranthus	351	296	4.00	4.00
Magnolia	379	282	3.97	4.00
Datura	342	286	3.99	4.00
Curry	445	292	0.75	4.00
Neem	436	296	0.56	4.00

4.3 FTIR spectroscopy

FTIR spectrum was used to analyse the functional group present in the synthesized silver and iron nanoparticles. FTIR spectrums of synthesized silver and iron nanoparticles were represented (Fig. 4.3). FTIR measurements were carried out to identify the possible biomolecules in the leaf extract responsible for the reduction of ions and also the capping agents responsible for the stability of the biogenic nanoparticle solution.

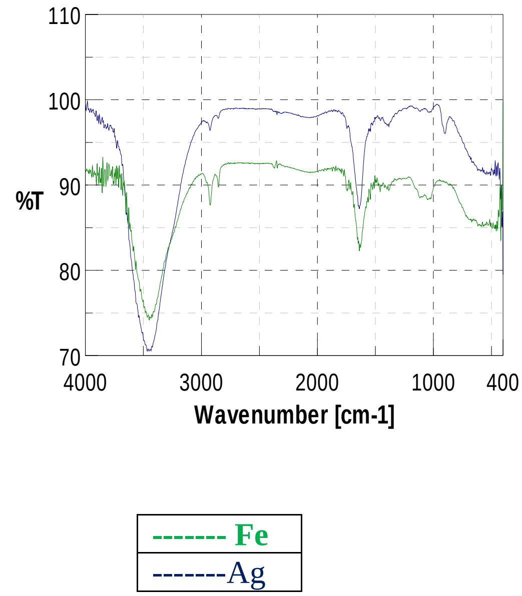

Fig. 4.3(a) FT-IR Spectra for a synthesized silver and iron nanoparticles from *Amaranthus viridis*

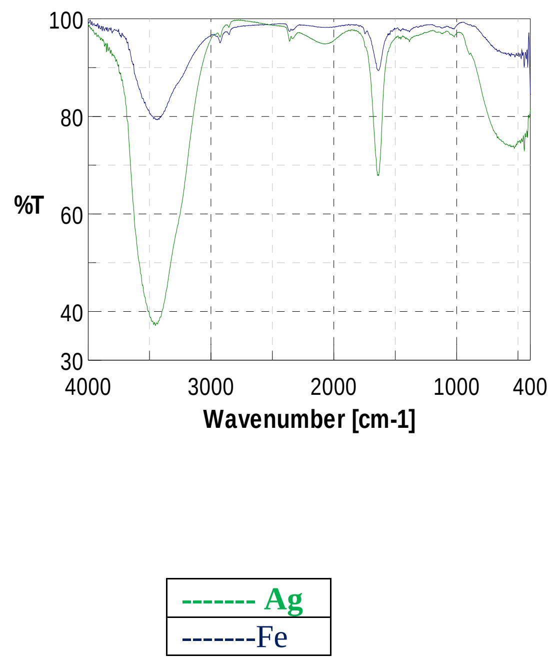

Fig. 4.3(b) FT-IR Spectra for a synthesized silver and iron nanoparticles from *Magnolia champaca*

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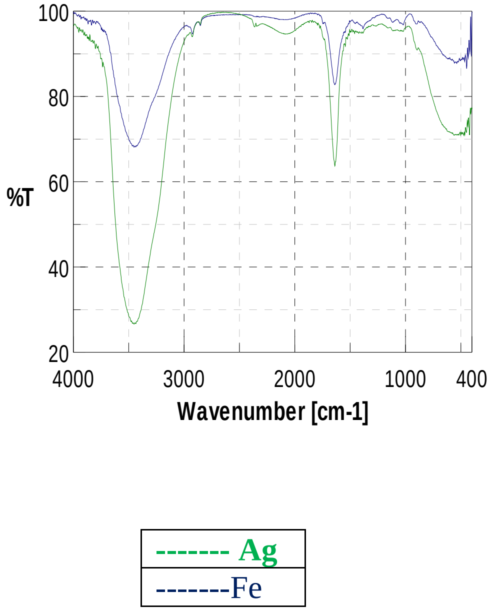

Fig. 4.3(c) FT-IR Spectra for a synthesized silver and iron nanoparticles from *Datura metel* leaves

4.4 SEM

SEM images provided information about the morphology and size of the biosynthesized silver and iron nanoparticles. The silver nanoparcticles were found to be spherical in shape. The iron nanoparticles are in the form of nanospheres, which exist in contact with each other and form chains having diameters of 0.12-0.44 µm. This linear orientation is nearly due to the magnetic properties of iron species. The diameter of synthesized silver nanoparticle was identified as 19 - 98 nm (Fig .4.4).

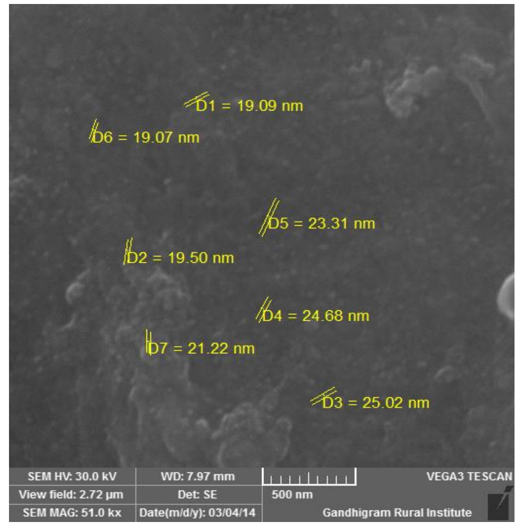

Fig. 4.4(a) SEM image of silver nanoparticles formed by *Amaranthus virid* leaves

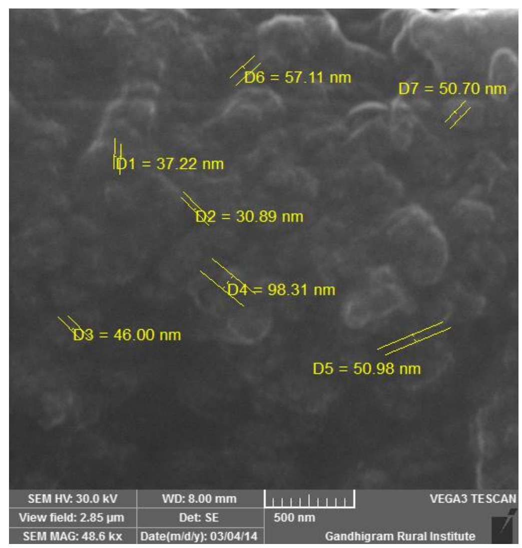

Fig. 4.4(b) SEM image of silver nanoparticles formed by *Magnolia champaca* leaves

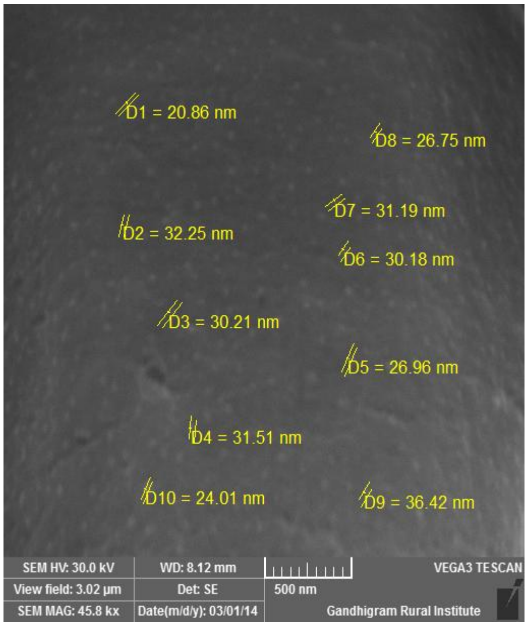

Fig. 4.4(c) SEM image of silver nanoparticles formed by *Datura metel* leaves

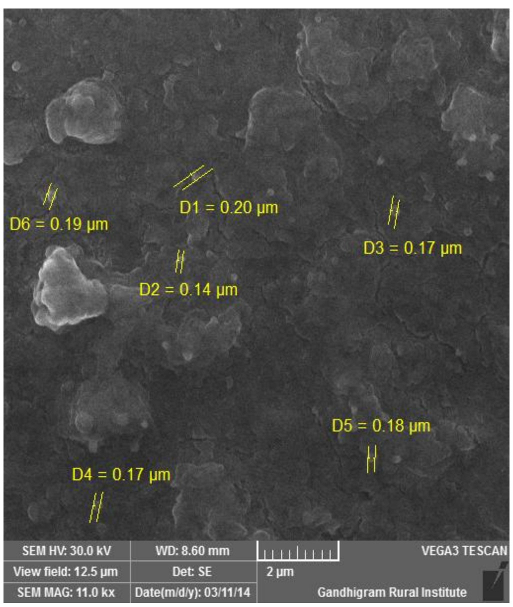

Fig. 4.4(d) SEM image of iron nanoparticles formed by *Amaranthus virid* leaves

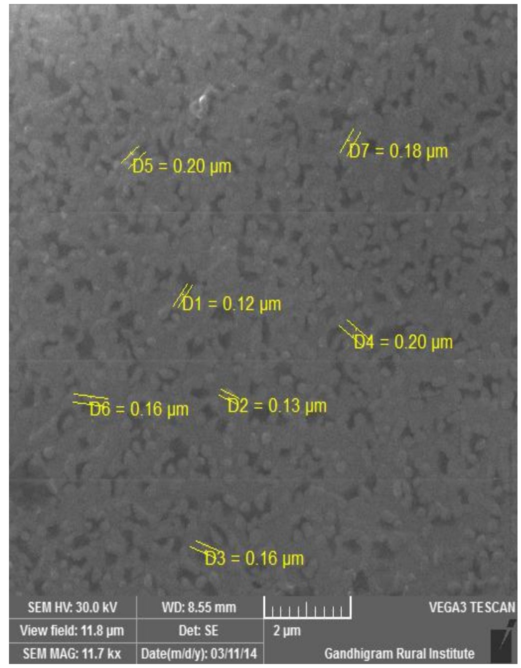

Fig. 4.4(e) SEM image of iron nanoparticles formed by *Magnolia champaca* leaves

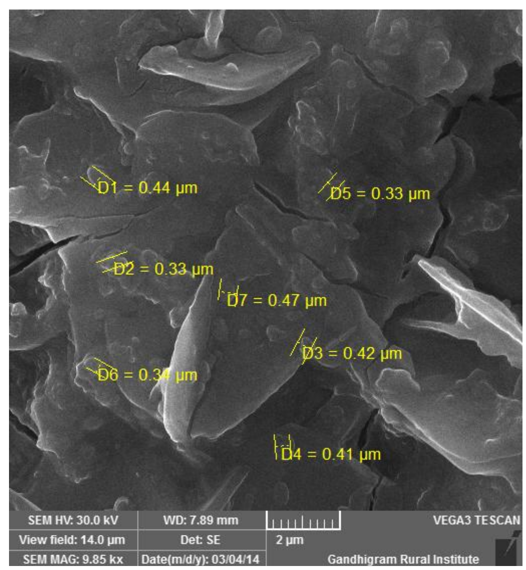

Fig. 4.4(f) SEM image of iron nanoparticles formed by *Datura metel* leaves

I. Diameter of the Synthesized Silver and Iron nanoparticles from Various plants leaves extract

Plant Leaves	Silver nanoparticles (nm)	Iron nanoparticles (nm)
Amaranthus viridis	**19-25**	**140-200**
Magnolia champaca	**30-57**	**120-200**
Datura metel	**20-36**	**330-440**

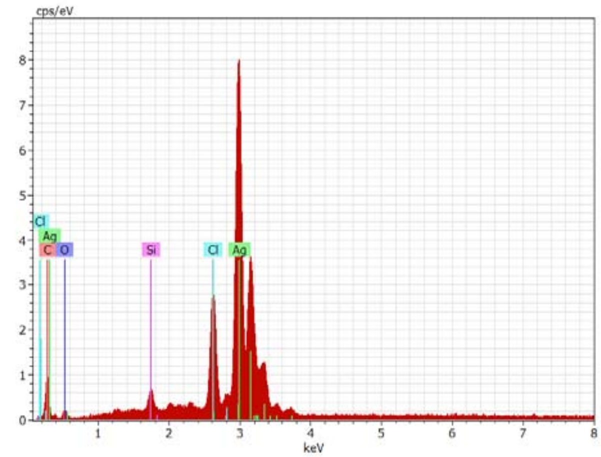

Fig. 4.5(a) EDAX spectra of silver nanoparticles for *Amaranthus viridis* leaves

4.5 EDAX

The presence of elemental silver and iron was determined. The samples were dried at room temperature and then analyzed for samples composition of the synthesized nanoparticles.

The presence of the elemental silver and iron can be seen in the graph presented by the EDX analysis, which indicate the reduction of silver and iron ions Figure(4.5). It has been reported that nanoparticles synthesized using plant extracts are surrounded by a thin layer of some capping organic materials from the plant leaf both that remains stable in the solution even after synthesis.

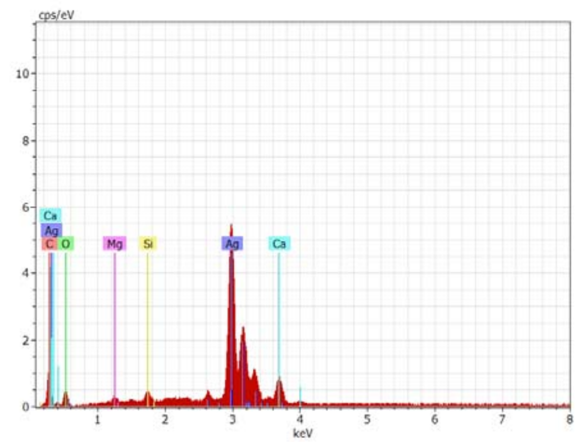

Fig. 4.5(b) EDAX spectra of silver nanoparticles for *Magnolia champaca* leaves

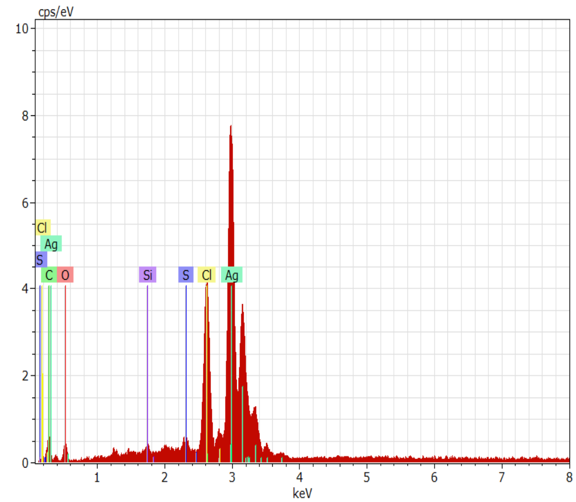

Fig.4.5(c) EDAX spectra of silver nanoparticles for *Datura metel* leaves

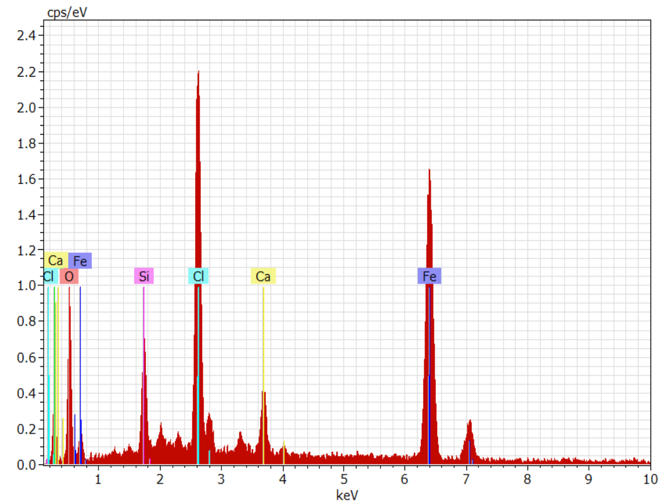

Fig. 4.5(e) EDAX spectra of iron nanoparticles for *Magnolia champaca* leaves

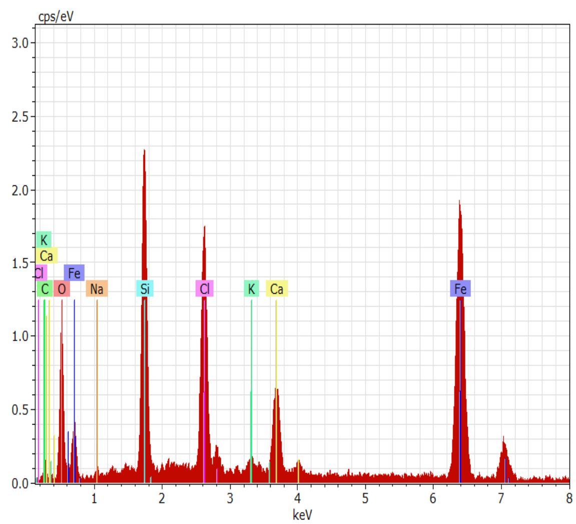

Fig .4.5(d) EDAX spectra of iron nanoparticles for *Amaranthus viridis* leaves

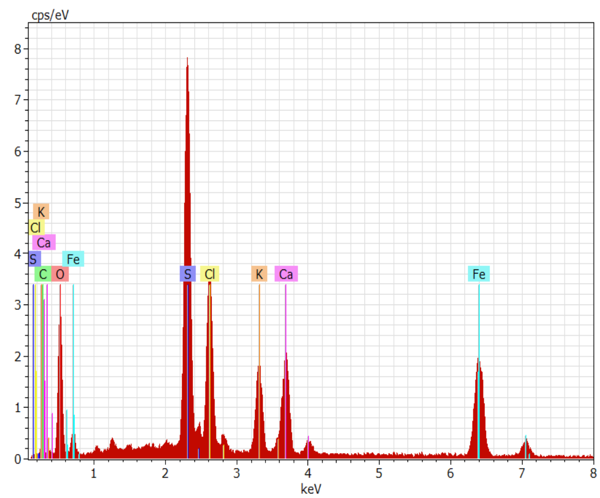

Fig. 4.5(f) EDAX spectra of iron nanoparticles for *Datura metel* leaves

5. CONCLUSION

In conclusion, the bio-reduction of aqueous Ag^+ and Fe^+ ions by the plant extract of the *Amaranthus viridis*, *Magnolia champaca*, *Datura metel*, Neem and Curry leaves extracts has been demonstrated. In this present study we found that this plant can be also good source for synthesis of silver and iron nanoparticles.

The reduction of Ag and Fe ions by the leaf extract resulted in the formation of stable nanoparticles with spherical morphologies which ranged from 19-98 nm for Ag and 0.12-0.44 µm for Fe in size. The concentration of leaf extract and metal ions play an important role in the green synthesis of Ag and Fe nanoparticles. The spectroscopic characterizations using UV-Vis, pH analysis, FTIR, SEM and EDAX were useful in proving the formation of nanoparticles and also in confirming their size, shape and composition.

From these results the traces of silver nanoparticles was more compared to iron nanoparticles.Therefore, this green chemistry approach towards the synthesis of silver nanoparticles has many advantages such as, ease with which the process can be scaled up, economic viability, etc. Applications of such eco-friendly nanoparticles in bactericidal, wound healing and other medical and electronic applications, makes this method potentially exciting for the large-scale synthesis of other inorganic materials (nanomaterials).

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