Green Synthesis of Copper Nanoparticles Using *Ricinus communis*

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ABSTRACT :

Green synthesis of nanoparticles has emerged as an environmentally friendly and cost-effective alternative to conventional chemical methods. Utilizing plant extracts as reducing and stabilizing agents, this approach eliminates the need for hazardous reagents while leveraging the inherent bioactivity of plant compounds. This study focuses on synthesizing copper nanoparticles (CuNPs) using the leaf extracts of *Ricinus communis*. Copper nanoparticles, ranging in size from 30 to 100 nm, are known for their antimicrobial, antioxidant, and anticancer properties, as well as applications in agriculture, medicine, and environmental sustainability. The study highlights the preparation of aqueous and methanol-based leaf extracts, followed by the synthesis of CuNPs through bioreduction, confirmed by UV-Vis spectroscopy and FTIR analysis. UV-Vis spectral analysis showed characteristic absorbance peaks at 350–580 nm, indicative of surface plasmon resonance. FTIR spectra revealed the presence of functional groups such as phenols, amides, and carbohydrates, essential for stabilizing CuNPs. Results demonstrated effective antimicrobial and antioxidant activity, validating the potential of *Ricinus communis* in sustainable nanoparticle synthesis. This work underscores the significance of plant-mediated green synthesis in developing cost-effective, eco-friendly nanoparticles with versatile industrial and biomedical applications. Future research should explore large-scale production and enhanced characterization techniques.

Key words : Green synthesis, copper nanoparticles (CuNPs), sustainable nanoparticle synthesis.

INTRODUCTION: - A Green synthesis method is employed to produce nanoparticle by utilizing extract obtained from various plant parts, microbial cells, and biopolymers. These

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methods are classified as green due to their environmentally friendly nature. the size range of 1-100 nm are considered as nanoparticles (NPs) the term Nano originated from Greek word Nanons meaning dwarf Nano particles are very small sized particles. Concept of nanotechnology was introduced by scientist Richard Feymen (Nobel Laureate in Physics) about 50 years back. Eric Dexter put forth a theory of nanotechnological world, according to him in coming years world will be completely transformed by nanoscale robot assemblers. (Chung M, *et al*., 2016).

Green synthesis is defined as the use of environmentally compatible materials such as bacteria, fungi and plants in the synthesis of nanoparticles. Nano particles have many applications in electronics, optic al communication, medical and biological systems. Manipulated for the desired applications, is the study of a well-known field called nanotechnology. NPs receive attention for their positive impact in improving consumer products, cosmetics, pharmaceuticals, antimicrobial agents, energy, transportation, agriculture, etc. (Shobha G, *et al*. 2024). Copper is transition metal with atomic no 29. Important properties of Cu are its antibacterial activity and charge conduction capacity in the electronic world. Cu NPs are particularly more investigated because of their high natural abundance, low cost and good conducting properties. Cu NPs also show potential applications in sensing, photo and electro catalysis etc. (Mittal *et al.,*2013). Cu NPs are used in agriculture, consumer products, cosmetics, transportation, and pharmaceuticals as antimicrobial agent (Park,B.K *et al* ., 2007). of the original uses of copper nanoparticles was to colour glass and ceramics during the ninth century in Mesopotamia. Copper founded nanoparticles are orbicular blackish-brownish metallic nanoparticles with size ranges from 30 to 70 nanometres, dispersed or carbon Copper nanoparticles are being given significant attention as of late due to their fascinating properties and potential applications in numerous areas of industry (Das,R *et al* ., 1999). Copper nanoparticles treated drugs are extensively used to undermine cancerous and tumorous cells .and along with Copper nanoparticles also known to yield fluorescence, causing dye deposit accretion thus making them suitable for bio – sensing and bio labeling (Patel *et al*., 2011). Particles in the nano range are of great interest and importance due to their extremely small size and having large surface area to volume ratio, which lead to both chemical and physical differences in their properties (yedurkar, S *et al*. 2016). The field of Nanotechnology is growing day by day due to the increased applications of NPs in the routine of human life in medicine etc. nanotechnology is mainly concerned with the synthesis of nanoparticles of variable sizes, shapes, chemical compositions, and controlled disparity and their potential use for human benefits. Although chemical and physical methods may successfully produce pure, well-defined nanoparticles, these are quite expensive and potentially dangerous to the environment. The use of biological organisms such as microorganisms, plant extracts, or plant biomass could be an alternative to chemical and physical methods for the production of nanoparticles in an eco-friendly manner (shankar SS *et al*.,2004).

Plant extracts may act both as reducing agents and stabilizing agents in the synthesis of nanoparticles. The source of the plant extract is known to influence the characteristics of the nanoparticles. This is because different extracts contain different concentrations and combinations of organic reducing agents typically a, plant extract-mediated bio reduction involves mixing the aqueous extract with an aqueous solution of the relevant metal salt. Nanoparticle bound drugs have an extended half-life in vivo, longer circulation times and can convey a high concentration of a potent drug to where it is needed. (Kumar yadav *et al*.,2009).

The size of the drug nanoparticle and its surface characteristics can be modified to achieve the desired delivery characteristics. As the nanoparticle-bound drug is not able to circulate broadly, its side effects are reduced and a high localized concentration can be achieved where it is needed. In view of the large surface area per unit mass of nanoparticles, the drug loading can be relatively high. Nanoparticle-bound drugs are easily suspended in liquids and are able to penetrate deep in organs and tissues. (Sahoo Sk *et al* .,2007).Human beings have been using copper (Cu) and Cu complexes for various purposes for centuries, such as water purifiers, algaecides, fungicides, and antibacterial and antifouling agents, The application of nanoparticles expresses superior antibacterial activity against bacteria and fungi (Virkutyte S *et al*.,2007).

Taxonomical details of the studied Vegetative species :-

Kingdom - plantae
Order: - Malpighiales
Family: - Euphorbiacea
Subfamily. - Acalyphoideae
Tribe: - Acalypheae
Subtribe - Ricininae
Genus: - Ricinus
Species: - communis

Fig 1. - *Ricinus communis*

Ricinus communis, commonly known as castor oil plant, is a versatile medicinal plant that possesses various pharmacological properties, It has a long history of traditional use in different cultures for its therapeutic benefits. *Ricinus communis* is rich in bioactive compounds, such as ricinoleic acid, flavonoids, alkaloids, and phenolic compounds, which contribute to its pharmacological effects. One of the primary pharmacological properties of *Ricinus communis* is its laxative effect. The oil extracted from the plants seeds, known as castor oil, has been used for conturses as a natural laxative. The main consituent responsible for this effort is ncinoleic acid. Which stimulates intestinal motility and enhances the secretion of water and electrolyses into the unicatines. Castor oil is commonly used to relieve constipation and promote bowel movements in addition to its laxative propertios, *R. Communis* exhibits anti-inflammatory acuviny. The plant's extracts have been shown to reduce inflammation and alleviate pain. This effect can be attributed to the presence of flavonoids and phenolic compounds that possess anti-inflammatory properties. *Ricinus Communis* extracts have been used topically to soothe inflamed skin, reduce swelling, and promote wound healing Another notable pharmacological property of *Ricinus communis* is its antimicrobial activity. Several studies have demonstrated its effectiveness against various bacterial and fungal pathogens. The plant extracts inhibit the growth of microorganisms and can be used as natural alternatives to conventional antimicrobial agents. The antimicrobial properties are attributed to the presence of bioactive compounds, including alkaloids and flavonoids. Furthermore, *Ricinus communis* exhibits analgesic (pain-relieving) effects.

The plant extracts have been reported to possess analgesic properties, reducing pain and discomfort. This effect can be beneficial for managing conditions associated with pain, such as arthritis of post- operative pain. *Ricinus communis* also shows potential anticancer properties. Some studies have demonstrated its ability to inhibit the growth and proliferation of cancer cells. The presence of bioactive compounds, including ricinoleic acid and flavonoids, contributes to its anticancer effects. However, further research is needed to fully understand its mechanisms and potential applications in cancer treatment (Pinto NCC *et al*. 2013; Dos Santos *et al*.,2013).

It is important to note that white *Ricinus communis* has several pharmacological properties, as use should be approached with caution. Castor oil, in particular, should be used in moderation and under the guidance of a healthcare professional, as excessive consumption can lead to advene effects Additionally, some individuals may be allergic to the plant or its extracts, so it is important to perform a patch test before using topically. The castor oil plant is a fast growing Sukching perennial shrub or occasionally a soft wooded small tree up to 6 meter or more, but it is not hardy in nature. This plant was caltivated for leaf and flower oil production (jitendra kumar and ashish kumar gupta, 2012) Leaves are alternate, cylindrical purplish petiole sub peltate drooping sepals large ovate.Sepals large ovate Yellowish united into cap enclosing the buds deciduous, blade 3 inches across pulmately cut for three quarters of its depth into 7.11 lanceolate, acute coarsely serratc segments smooth blue green paler beneath red and shining when young (manpreet rana *et al* ., 2012) Well developmem tap mot which can reach several feet in length and has sub tantial laterals and secondary roots (Saliha bolajiz et al 2014) The stem are varying in pigmentation The flow are monoecious and about 30-60 cm^{-1} . Long the fruit is a three celled thorny capsule (Jitendra jena and asish kumar gupta 2012).

Literature Review :The application of green synthesis techniques for producing copper nanoparticles (CuNPs) has gained prominence due to its environmental and cost benefits. The following studies provide a comprehensive overview of advancements in this field, particularly focusing on the use of natural plant extracts for nanoparticle synthesis and their biological applications.

Applications of *Ricinus communis* in Copper Nanoparticle Synthesis

1. **Nadla Ghaffar et al. (2021)** evaluated the role of *Ricinus communis* in synthesizing CuNPs and their ability to reduce metal ions. Their study revealed that these nanoparticles could enhance the efficacy of streptomycin against multidrug-resistant *Staphylococcus aureus*, addressing antibiotic resistance challenges.

2. **Fernando Lopez Ubaldo et al. (2019)** synthesized copper bimetallic nanoparticles using *Ricinus communis* extract. Their work demonstrated the nanoparticles' antibacterial and antifungal properties, indicating their potential in addressing microbial infections.

3. **Bolaji Z et al. (2014)** and **Jena and Gupta (2012)** conducted detailed studies on the castor oil plant (*Ricinus communis L.*), highlighting its botany, ecology, and pharmaceutical uses. They identified bioactive compounds with unique chemical structures and pharmacological properties, supporting the plant's suitability for green nanoparticle synthesis.

Comprehensive Perspectives on Copper Nanoparticles

4. **Michaela Corina Crisan et al. (2022)** presented a detailed review of CuNPs, addressing their synthesis, characterization, physiological properties, toxicity, and antimicrobial applications. Their work provided a holistic understanding of the potential applications of CuNPs across various fields.

5. **Dayo Felix Latone et al. (2021)** emphasized the importance of green chemistry approaches for synthesizing CuNPs. Their study explored the nanoparticles' therapeutic and environmental applications, positioning them as sustainable and multifunctional agents.

MATERIAL AND METHOD:-

1. **Collection of plant materials :-** Based on the ethnobotanical records, an important Indian traditional medicinal plant *Ricinus communis* selected for the study. The plant was collected from Government V.YT. PG. Autonomous College, Durg. Chhattisgarh, Identified the plant material. and double distilled water used for the prepration of aqueous extract.

2. **Plant extract prepration :-** The pant leaves of were washed under tap water to remove dust and other particles. The well clean leaves were cut into small. Then shade dried for 15 – 20 days. dried leaves were grinded to fine powder. the aqueous extract was prepared by refluxing 20 gm of leave power and two solvents like methanol and distilled water aqueous (300ml) by using soxhlet apparatus at 100°C at

6 to 10 hours, The extract were collected in an airtight bottle and were kept in deep freezer for further use.

3. **Synthesis of copper nanoparticle from leave extract: -** 5 ml of leaf extract plant and added into 25 ml of 1% aqueous copper sulfate in two different conical flasks and stirred for constant mixing. It was incubated for 24 h at room temperature. A color change of the solutions was noted by visual inspection confirming the synthesis of CuNPs.

4. **Characterization of copper nanoparticles :-** NPs are generally characterized by investing their size, shape and surface area. A homogeneity in these properties result in the advancement in applications of NPs. The characterization will be done by using UV-visible spectroscopy and FTIR analysis.

5. **UV-Visible Spectroscopy analysis of synthesized nanoparticle :** UV-Vis spectroscopy is an easily available and most effective technique that allows fast identification of nanoparticles formation. Bio reduction of metal ions in the solution was monitored by UV-Visible spectroscopy The mixture of a metal salt with different volumes of plant extract was analyzed for its spectra for this purpose small amount of sample was taken in a quartz cuvette and distilled water was used as a reference UV-Visible spectrophotometer was used to identify the synthesis of CuNPs.

   synthesis of *Ricinus communis* nanoparticles was confirmed using UV-Visible Spectrophotometer with a resolution between 200 and 700 nm(Supraja *et al.,* 2017).

6. **FTIR analysis for synthesized nanoparticles:** Fourier transforms infrared (FTIR) spectroscopy is a chemical analytical tool used to detect the possible functional groups present in Plant. Copper nanoparticles based on the peak value in the region of infrared radiation. FTIR spectroscopy is an analytical technique in which the sample is irradiated with Infra-Red radiations due to which various functional groups of

compounds present in sample show absorbance in range from 4000 to 400 cm^3. FTIR spectroscopy was carried out to recognize biological molecules that are tangled in phenomenon of bio-capping and reduction of copper NPs. FTIR is sensitive to small absorbance variations, which leads separation of even weak absorption peaks of active compounds from those of the whole extract. The major function of FTIR spectroscopy was to determine the nature of the association of Phyto-molecules or Phytoextracts with nanoparticles. Infra-red (IR) analysis of *Ricinus communis* copper nanoparticles was done with the help of infra-red Spectrophotometer (BRUKER, ALPHA, ECO ATR) at the Department of Chemistry, Govt. VYT PG Autonomous College. Durg, Chhattisgarh, India

RESULT AND DISCUSSION: Synthesis of copper nanoparticles from *Ricinus communis* nanoparticles were synthesized using an aqueous extract of leaf *Ricinus communis* UV-Visible spectral analysis showed an absorbance peak at 580nm (distilled water) 500(methanol)with special reference to the excitation of surface plasmon vibration by copper nanoparticle.FTIR analysis of nanoparticles revealed the presence of molecular functional groups sach as amides, phenolic compounds, and alkenes. These phytochemicals act capping and stabilizing agents for nanoparticles.

UV-visible spectrophotometer analysis of CuNPs

UV- Visible analysis of synthesize *parthenium hysterophorus* CuNPs (solvent methanol). UV-visible spectrophotometer was used to identify the synthesis of CuNP's. The reduction of copper ions into CuNPs in the presence of *Parthenium hysterophorus* leaf extracts was observed as a result of the colour change. The colour change is due to the surface plasmon resonance (SPR) phenomenon Color transformation in CuSO4 aqueous solution from blue to dark greenish coloration and formation of brownish precipitates in reaction container indicates successful creation of Cu NPs subsequent to addition of suitable quantity of leaf extract of *Parthenium hysterophorus*. . The sharp bands of CuNPs were observed around **500 nm**(solvent – methanol) for fresh and dry samples of *P. pysterophorus* leaf extract .

UV- Visible analysis of synthesize *Ricinus communis* CuNPs-

UV-Vis spectroscopy is one of the well-known techniques that are widely used for the characterization of synthesized nanoparticles. It is the simplest way to confirm the formation of nanoparticles. In the present study CuNPs (*R.communis*) showed maximum abrorbance 350 nm ,(solvent methanol and distilled water)- UV -Visible spectroscopy (UV-Vis) measures the extinction (scatter + absorption) of light passing through a sample. Due to the

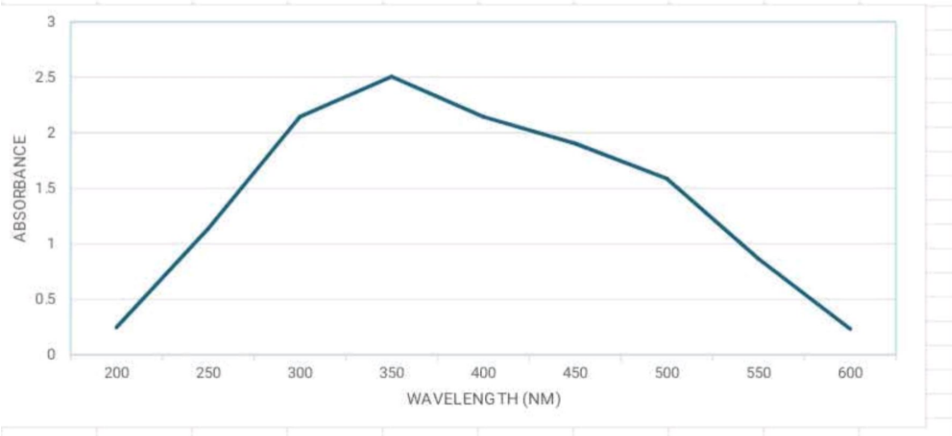


Fig 2.UV-Visible spectra of synthesised CuNPs of the studied species

unique optical properties of NPs, their UV-visible spectra are sensitive to concentration, shape, size, and refractive indices near the surface of NPs, which makes UV-Vis a valuable tool for studying, identifying, and characterizing nanomaterials (Zook JM, *et al* ., 2001)

Fig- showing UV- visible spectrum of leaf extract CuNPs *R.communis*(distilled water)350nm

UV -visible analysis of synthesize *Ricinus communis* CuNPs(methanol)

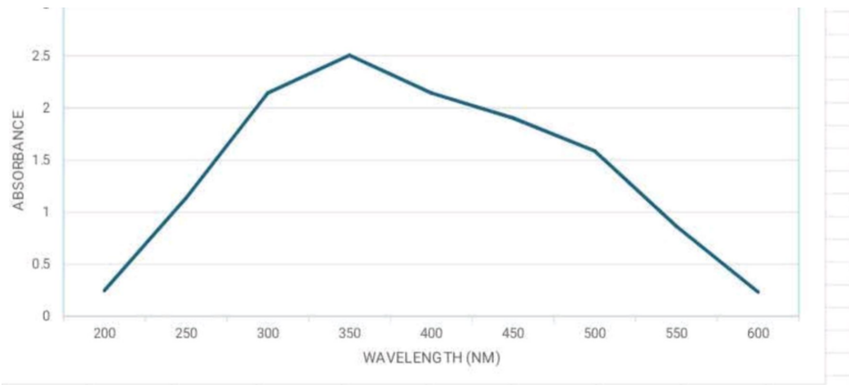
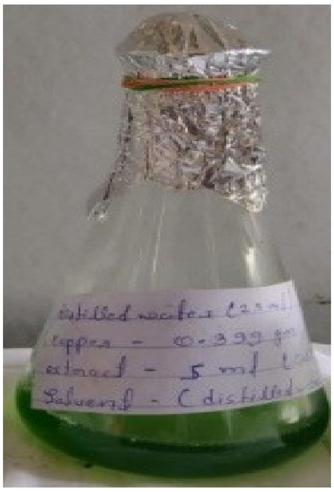


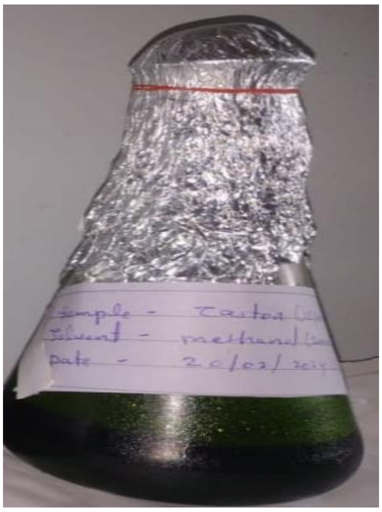
Fig 3.- UV- visible spectrum of leaf extract CuNPs *R.communis* (methanol) 350n

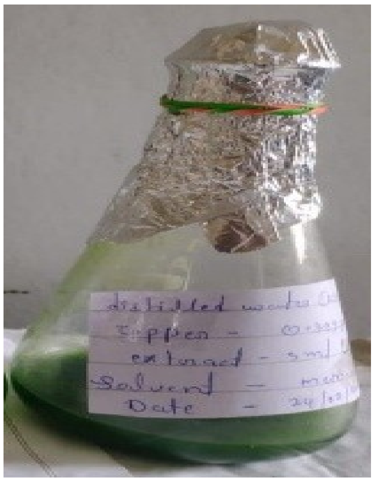
UV-**SPECTRAL ANALYSIS OF SYNTHESIZED RICINUS COMMUNIS IN VARIOUS SOLVENT**



Extract of *R.communis* synthesised nanoparticle

(i)STUDY IN DISTILLED WATER





Extract of *R.communis. &* prepared nanoparticle

(ii) Study of Plant 2- *Ricinus communis* in Methanol (300ml0

FTIR spectral analysis of *Ricinus communis* CuNPs (solvent methanol,)

FTIR measurements were carried out to identify the possible functional group present in The Plant extract (*Ricinus communis*)which are responsible for capping and efficient stabilization of the Synthesize Nanoparticle (1) 3353.49 cm-[1] for carbohydrates proteins and polyphenols (O-H stretching) (2) 1557.08 cm-[1] for Diketones (3) 1397.08 cm-[1]for aliphatic bending group (C-H stretching) (4) 1019.60 cm-[1] for aliphatic amines or to alcohol / phenol functional group (C-N stretching)

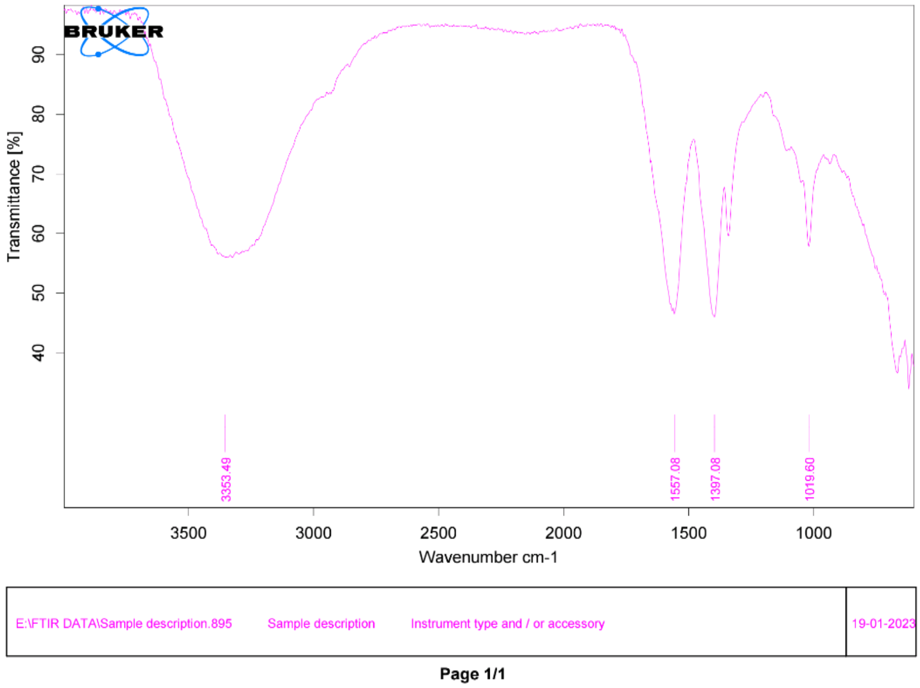


Fig 5 - showing FTIR spectrum of leaf extract CuNPs o*f R.communis*

FTIR analysis of <u>*Ricinus*</u>*.communis* CuNPs (solvent- distilled water)

FTIR Spectrum is a very useful tool for the discovery of the possible bio-molecules interactions in the copper nanoparticles of leaf extract of FTIR spectrum applied in the range of 400 4000cm-[1] The wide-ranging infrared spectrum of leaf extract of *Ricinus communis* presented in Characteristic absorption bands were exhibited at Fig 2- is presenting the FTIR spectrum of CuNPs the absorbance peak absorbed at (1) 1388.03 cm-[1] for aliphatic bending group (C-H stretching) (2) 679.90 cm-[1] for Halogen compound chloro,compound (C-CI stretching) (3) 663.67cm-[1] for Halogen compound Chloro compound (C-Cl stretching) (5) 644.13 cm-[1] for Halogen Compound chlora compound (C -CL stretching).

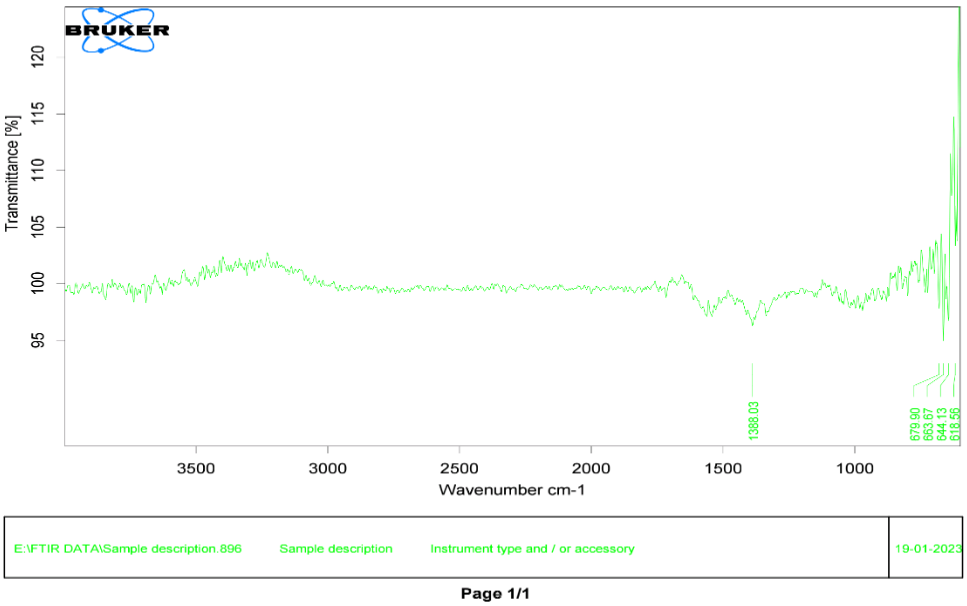


Fig- 6. showing FTIR spectram of leaf extract CuNPs of *R.communis*

LEAF EXTRACT

Fig 7. Synthesis of copper nanoparticle from leaf extract

CONCLUSION : Green synthesis of copper nanoparticles using *parthenium hysterophorus* and *Ricinus communis* leaves extract the biological synthesized copper nanoparticles using UV- Visible spectroscopy and FTIR analysis.The formation of copper nanoparticles was confirmed by color change.This greener approach toward the synthesis of CuNPs, using plant leaf material as reducing and capping agent, has many advantages such as easy with which the process can be scaled up, economic viability, environmentally benign, and renewable, there is no need to use high pressure, energy, temperature, and toxic chemicals. Applications of eco-friendly CuNPs in bactericidal, wound healing, and other medical and electronic applications are potentially exciting for their large-scale synthesis. Toxicity of CuNPs on human pathogen bacteria opens a door for a new range of antibacterial agents. Copper nanoparticles are synthesized from *Parthenium hysterophorus* extract. We reported here the excellent inhibitory potential Of the CuNPs against test microbial strains which are considered to be significant pharmacological targets for the treatment of Such microbial infections.Plant extract mediated copper Nanoparticles were typified by different spectroscopic Techniques. UV-Visible spectrum showed λmax at **580 nm** (solvent – distilled water) **500 nm (**solvent methanol nm Indicating the establishment of Cu NPs. FTIR spectral data Indicates the presence of residual bio molecules attached on Cu NPs surface.such as

Alkyl amine group,phenol ,alcohol,chloro compound, halogen compound, aliphatic amines, hydroxyl group etc. The synthetic method presents The advantages of a low-cost process that may have potential Applications in medicine and technological applications.

REFERENCES -

- Bajaj A.K.; 2001. Contact dermatitis. In: Valia RJ.Editor r. IADVL Textbook and Atlas of Dermatology. Bhalani Publishing House, Mumbai, India. 1:470.
- Berry MI. (1984). Feverfew faces the future. Pharmaceutical Journal. 232: 611–614
- B.S. Kim and J.Y. Song, "Biological synthesis of metal nanoparticles". In: C.T. Hou and J.-F. Shaw (ed), "Biocatalysis and Agricultural Biotechnology", CRC Press, pp 399-407, 2009.
- Chung, M.; Park, I.; Seunghyun, K.; Thiruvengadam, M.; Rajakumar, G. Plant-Mediated Synthesis Of copper Nanoparticles: Their Characteristic Properties and Therapeutic Applications. Nanoscale Res. Lett. 2016, 11, 1-14.
- Das, R.; Ali, M.E.; Hamid, S.B.A.: Ramakrishna, S.; Chowdhury, Z.Z. Carbon nanotube membranes for water purification with bright future in water desalination. Desalination. J. Nanotech Col. 2014, 336, 97-109.
- Fazal H, Ahmad N, Ullah 1, Inayat H. Khan LAbbasi B.H. (2011). Antibacterial potential in *parthenium hysterophorus*, Stevia rebaudiana an Ginkgo biloba. Pak. J Bot. 43: 1307-1313.
- Freitas ,R.A.; Austin, T.X. Nanomedicine Basic Capabilities. Nano. Med. 2007, 8, 374-399.
- J.R. Morones, J.L. Elechiguerra, A. Camacho, K. Holt, J.B. Kouri, J.T. Ramirez and M. Jose-Yacaman, "The bactericidal effect of copper nanoparticles", Nanotechnology 16, 2346-2353, 2005.
- Jones RN, Fritsche TR, Sader HS, Ross JE/Leader surveillance program results for 2006: an activity and spectrum analysis of linezolid using clinical isolates from the United States. Diag Microbiol and Infect Disease. 2007; 59: 309-317.
- Kumar V, Yadav SK. Plant-mediated synthesis of copp nanoparticles and their applications. J Chem Technol Biotechnol 2009;84:151-7.
- Mukunthan K, Balaji S. Cashew apple juice (Acarida occidentale L.) Speeds up the synthesis of copper nanoparticles. Int J Green Nanotechnol 2012;4:71-9.
- Mittal, A. K.; Chisti, Y.; Banerjee, U. C. Synthesis of Metallic Nanoparticles Using Plant Extracts. Biotechnol. Adv. 2013, 31, 346-356.
- Park, B.K.; Jeong. S.; Kim, D.; Moon, J.; Lim, S.; Kim, J.S. Synthesis and size control of monodisperse copper nanoparticles by polyol method. J. Int Colloid. Sci. 2007, 311, 417-424.
- Pauksch L, Sonja H, Marcus R, Gabor S, Volker, A. Biocompatibility of copper nanoparticles and copper ions in primary human mesenchymal stem cells and osteoblasts. Acta Biomaterialia. 2014, 10:437- 439.
- Pandey K, Sharma P.K, Dudhe R. (2012). Antioxidant and anti-inflammatory activity of Ethanolic extract of *Parthenium hysterophorus* L.Asian Journal of Pharmaceutical and Clinical Research. 5: 28–31

- Rai M.K, Upadhyay S.K. (1990). In vitro efficacy of different extract of *Parthenium hysterophorus* Linn. Against human pathogenic fungi using different techniques. Indian J. Pathol. And Microbiol. 33 (2):

- Radhey, M.; Bachhav, I.; Suvarna, N.; Deore. Environment and Green Nanotechnology. Int. J.Sci. 2013, 4, 2319-7064

- Sharma G.L., Bhutani K.K. (1988). Plant based Antiamoebic drugs part ii. Amoebicidal activity of parthenin isolated from *Parthenium hysterophorus* planta Medica. 54 (2): 120-122.

- Shobha, G.; Moses, V.; Ananda, S. Biological Synthesis of Copper Nanoparticles and its Impact A Review. Int. J. Pharm. Sci. Invent. 2014, 3. 28-38.

- Shankar SS, Rai A, Ahmad A, Sastry M. Rapid synthesis of Au, Ag. And bimetallic Au core-Ag shell nanoparticles using (*parthenium hysterophorus*) leaf broth. J Colloid Interface Sci 2004:275:496-502.

- Sohal S.K, Rup P.J, Kaur H, Kumari N, Kaur J.(2002). Evaluation of the pesticidal potential of the Congress grass, *Parthenium hysterophorus* Linn. On The mustard aphid, Lipaphis erysimi (Kalt.). Journal Of Environmental Biology / Academy of Environmental Biology, India.

- Sahoo SK, Parveen S, Panda JJ. The present and future of Nanotechnology in human health care. Nanomedicine 2007;3:20-31.

- Shruthi TS, Meghana MR, Medha MU, Sajana S, Navya PN. Streptomycin fictionalization on copper Nanoparticles for improved antibacterial activity. Materials Today: Proceedings, 2019, 10:5-15. 15.

- Shankar SS, Rai A, Ahmad A, Sastry M. Rapid synthesis of Au, Ag, and bimetallic Au core-Ag shell nanoparticles using (*parthenium hysterophorus*)leaf broth. J Colloid Interface Sci 2004;275:496-502.

- Valdés A.F.-C. Martinez J.M, Lizama R.S, Gaitén Y.G. Rodríguez DA, Payrol J.A. (2010). In vitro antimalarial activity and cytotoxicity of some selected cuban medicinal plants. Revista Do Instituto De Medicina Tropical De São Paulo. 52:

- Virkutyte J, Varma RS. Green synthesis of metal nanoparticles: Biodegradable polymers and enzymes in stabilization and surface Functionalization. J Chem Sci 2011;2:837.

- Yedurkar, S.; Maurya, C.; Mahanwar, P. Biosynthesis of vopp Nanoparticles Using *Ricinus communis* leaf Extract- A Green Approach. J.Synth. Theory Appl. 2016, 5, 1-14.

- Zhang, Y.; Ram, M. K.; Stefanakos, E. K.; Goswami, D. Y. Synthesis, Characterization, and Applications of ZnO Nanowires. J. Nanomater. 2012, 2012, 1-22.