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# International Journal of Innovative Trends in Multidisciplinary Research (IJITMR)

A Peer-Reviewed, Referred, Indexed Multidisciplinary Open-Access Research Journal

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# AWARENESS OF SOUTH AMERICAN TOMATO PINWORM (TUTA ABSOLUTA) AMONG TOMATO GROWING FARMERS OF NASHIK DISTRICT, MAHARASHTRA, INDIA.

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## ABSTRACT

A field survey was conducted during 2023–24 to assess the awareness, perception and management practices of tomato farmers regarding tomato pinworm, Tuta absoluta (Meyrick), in Nashik district of Maharashtra. A structured questionnaire was administered to 140 tomato growers selected from seven major tomato-growing talukas, Nashik, Niphad, Dindori, Sinnar, Chandwad, Trimbakeshwar and Igatpuri (20 farmers per taluka). The study revealed that although a majority of farmers were aware of the pest's leaf-mining and fruit-boring nature, gaps existed in correct identification of life stages, economic threshold level and scientific management practices. Chemical control dominated pest management decisions, while adoption of integrated pest management (IPM) components such as pheromone traps, biological control and cultural practices was comparatively low. Different reasons behind the unknowingness about the insect pest Tuta absoluta are studied. The tomato crop is taken to a great extent in Nashik district and also the loss due to this pest is at its peak. The awareness about the life cycle of experimental pest and the managing tools was made among some of the farmers. With the management of experimental pest, the awareness of the pest is also necessary. The findings highlight the need for location-specific extension programmes and farmer-oriented training to promote sustainable management of T. absoluta in the district.

## KEYWORDS

Tomato pinworm, survey, farmer knowledge, IPM, unknowingness, awareness, questionnaire

## INTRODUCTION

Tomato is a remunerative vegetable crop which is very popular in the world for its taste, nutritive value and diversified use. Tomato (Solanum lycopersicum L.) is one of the most important vegetable crops cultivated in Maharashtra, with Nashik district emerging as a major production hub supplying both fresh

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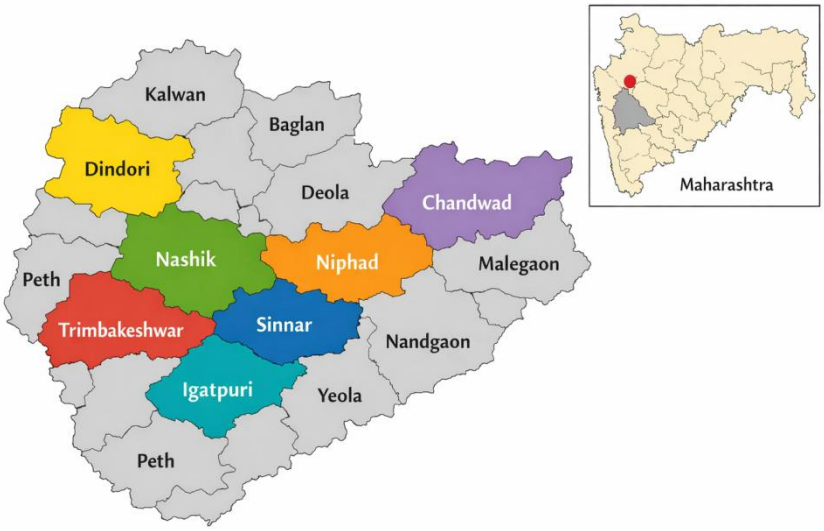
markets and processing industries. In recent years, tomato production has been severely constrained by the invasion and rapid spread of tomato pinworm, Tuta absoluta (Meyrick) (Lepidoptera: Gelechiidae). The larvae feeds voraciously upon tomato plants, producing large galleries in leaves, burrowing in stalks, and consuming apical buds and green and ripe fruits. It is capable of causing a yield loss of 100%.




NASHIK DISTRICT

**Major tomato growing Talukas from Nashik District**

Effective management of *T. absoluta* requires timely identification, knowledge of its biology and application of integrated pest management strategies by the farmers. However, farmers decisions are often influenced by their level of awareness, access to information and perception of control measures. Understanding the existing knowledge and practices of farmers is therefore needful for designing effective ways of management tools. The present investigation was undertaken to document taluka-wise knowledge, awareness, perception and management practices of tomato growing farmers regarding T. absoluta in Nashik district.

**MATERIALS AND METHODS**

**Study area**

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The survey was conducted in Nashik district of Maharashtra, India. Seven major tomato-growing talukas, namely Nashik, Niphad, Dindori, Sinnar, Chandwad, Trimbakeshwar and Igatpuri, were selected for the study.

**Sampling and sample size**

A total of 140 tomato growers farmers were selected using purposive random sampling, comprising 20 farmers from each taluka.

**Survey questionnaire and data collection**

Data were collected using a pre-tested structured questionnaire covering aspects as following:

1. Awareness and identification of *T. absoluta*
2. Awareness about damage symptoms in tomato crops and crop stage affected.
3. Perception of severity and yield loss
4. Management practices adopted (chemical, biological, cultural and mechanical)

Personal interviews of tomato growing farmers were conducted during field visits in these seven Talukas.

**Data analysis**

Responses were compiled, tabulated and expressed as frequencies and percentages. Taluka-wise comparison of all the aspects of study was carried out.

## RESULTS AND DISCUSSION

**Awareness and identification of *Tuta absoluta***

A majority of farmers across all talukas were aware of *T. absoluta* as a serious pest of tomato (Table 1). Awareness was highest in Dindori (90%) and Nashik (85%), possibly due to higher tomato acreage and frequent pest outbreaks. However, correct identification of different life stages was relatively poor, indicating partial knowledge. Shows unknowingness of biology or the different life stages such as egg, larval stages, pupa and adult moth stage of the tomato pinworm.

**Table 1. Taluka-wise awareness of tomato pinworm among tomato growers of Nashik district**

| Taluka | Farmers aware (%) | Farmers unaware (%) |
|---|---|---|
| **Nashik** | 85 | 15 |

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| | | |
|---|---|---|
| **Niphad** | 80 | 20 |
| **Dindori** | 90 | 10 |
| **Sinnar** | 80 | 20 |
| **Chandwad** | 70 | 30 |
| **Trimbakeshwar** | 60 | 40 |
| **Igatpuri** | 40 | 60 |

Figures in parentheses indicate percentage of respondents (n = 20 per taluka).

**Awareness about the damage symptoms of tomato crop and crop stage affected**

Most respondents (farmers) correctly identified leaf mining as a common symptom, while fewer farmers associated fruit damage with *T. absoluta* infestation (Table 2). The vegetative and fruiting stages were perceived as most vulnerable.The farmers are totally unaware about the secondary infections like bacterial and fungal, after the tunneling of fruits by the tomato pinworm. Similar observations have been reported from other tomato-growing regions of India.

**Perception of pest severity and yield loss**

More than half of the farmers perceived *T. absoluta* as a high-severity pest causing significant yield losses (>30%). Farmers from Nashik and Dindori

**Table 2. Knowledge of damage symptoms caused by *Tuta absoluta***

| Damage symptom | Respondents (%) |
|---|---|
| **Leaf mining** | 78 |
| **Stem tunneling** | 42 |
| **Fruit boring** | 55 |

Talukas which have been reported comparatively higher losses, those attributed to continuous tomato cultivation and favorable climatic conditions.

**Management practices adopted by farmers**

Chemical control was the most commonly adopted practice near about in all talukas (Table 3). Frequent use of broad-spectrum insecticides was reported. Adoption of pheromone traps and biological control agents was limited. It clearly indicates low awareness of IPM components among the farmers.

**Table 3. Taluka-wise application of different management practices against *Tuta absoluta***

| Taluka | Chemical control (%) | Pheromone traps (%) | Biological control (%) |
|---|---|---|---|

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| | | | |
|---|---|---|---|
| **Chandwad** | 80 | 30 | 10 |
| **Dindori** | 95 | 50 | 30 |
| **Igatpuri** | 85 | 20 | 2 |
| **Nashik** | 85 | 50 | 25 |
| **Niphad** | 80 | 40 | 5 |
| **Sinnar** | 75 | 30 | 5 |
| **Tryambakeshwar** | 80 | 25 | 2 |

The dominance of chemical control shows immediate effectiveness and easy availability, but it may increases the threats regarding resistance development in the *Tuta absoluta* and environmental safety issues in the future. Also the health issues among the farmers and society via the food chain and the water cycle also.

Chart -1

Table- 1 Taluka-wise Awareness of Tomato moth (*Tuta absoluta*)

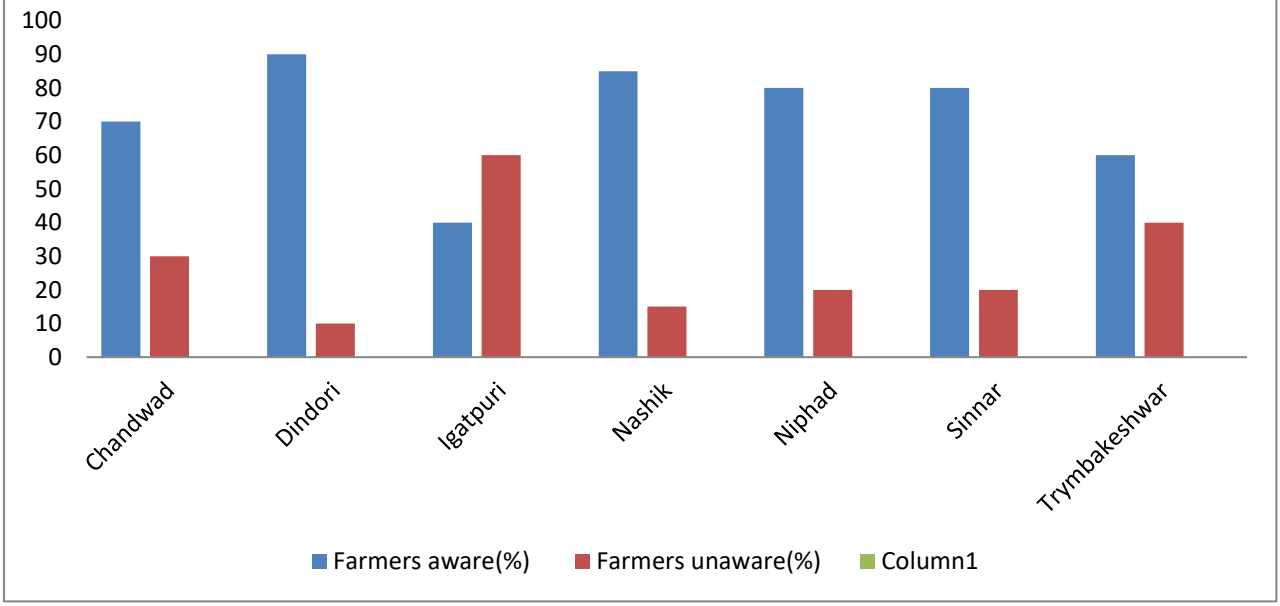


Chart -2

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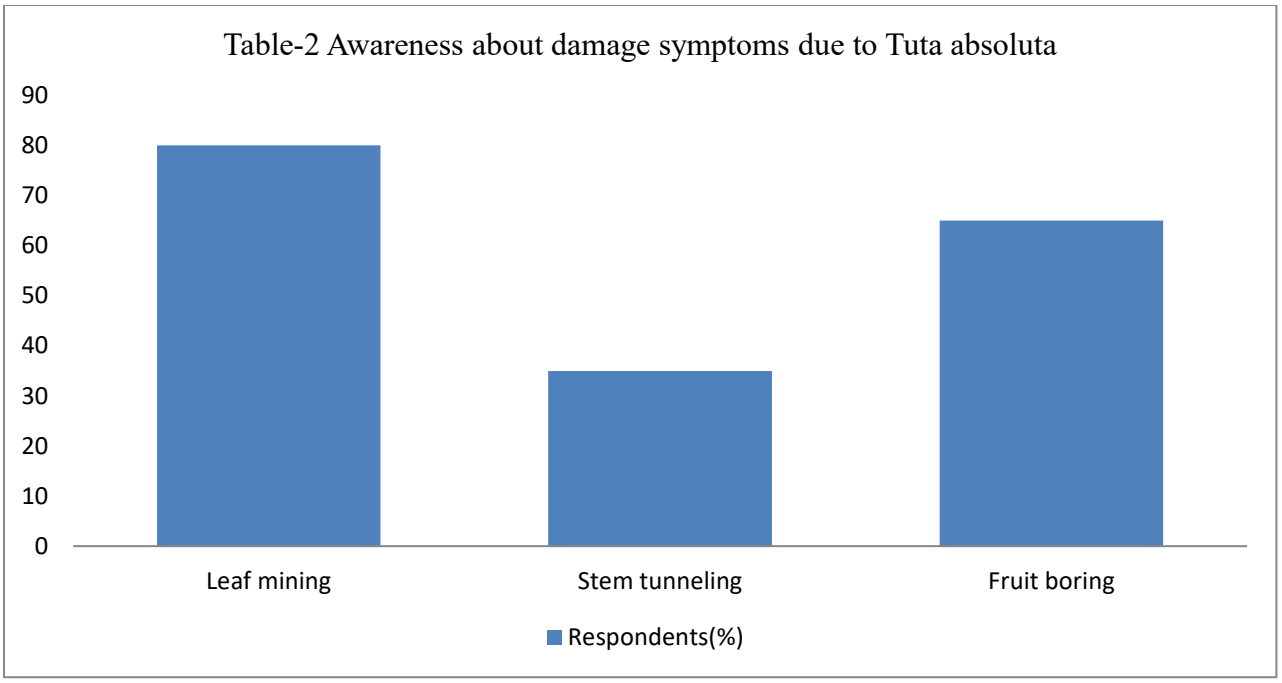
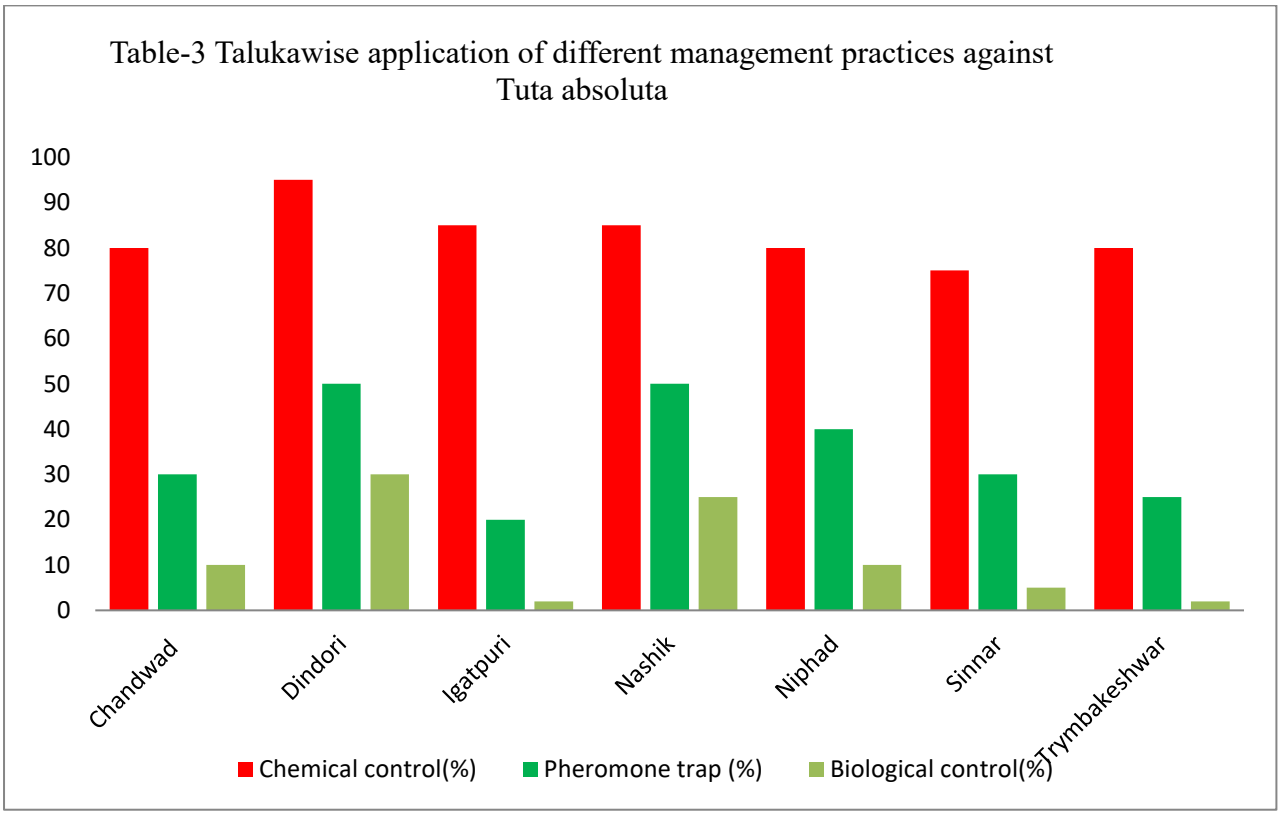



Chart -3




## CONCLUSION

*Tuta absoluta* is one of the most harmful insect pests of several cultivated and non cultivated host plants, particularly tomato plant (*Solanum lycopersicum* L). Chemical insecticides are mainly used to manage The tomato leaf miner. However, their excessive use has led to several problems. Biological managment remains an eco-friendly alternative for management of this pest. It relies on using bacteria, entomopathogenic fungi, animals and plants. Plant extracts are easy to applicate and have low costs. Several species, plant parts and extracts forms are used. Biological effects of these extracts are due probably to their major components that affect vital physiological functions such as neurophysiology and and respiration of the pest. The survey clearly indicates that tomato growers in Nashik district possess moderate knowledge about *Tuta absoluta* and mostly rely on chemical control measures. Adoption of eco-friendly and integrated pest management practices remains limited due to various technical and economic problems. Specific targeted action plans, capacity-building programmes and promotion of IPM strategies are essential for sustainable management of *T. absoluta* in the region.

**Acknowledgement-**

Iam thankful to the tomato growing farmers of Nashik district for their cooperation and valuable information provided during the field visits. I express my profound sense of gratitude and sincere thanks to the funding agency ‘ Chhatrapati Shahu Maharaj Research Training and Human Development Institute ‘ (SARTHI) for providing me the financial assistance. I would like to express my deep and heartfelt gratitude to my family, research guide, HOD of Zoology , Principal of Maulana Azad College Chhatrapati Sambhajinagar.

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# ETHNO – BOTANICAL KNOWLEDGE OF MEDICINAL PLANTS USED FOR LEUCORRHOEA IN RAHURI TEHSIL, AHILYANAGAR (MAHARASHTRA), INDIA

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## ABSTRACT

The paper provides information on the use of plant crude drugs for Leucorrhea diseases prevalent in tribal communities of Rahuri tehsil Ahmednagar district, Maharashtra. The local inhabitants in the region have inherited rich traditional knowledge of the use of many plant or plant parts for treatment of common diseases. They often have the information on how to use the plants and to take or to apply the medicines for different diseases, fodder and health care. Leucorrhoea is an abnormal excessive vaginal discharge commonly observed among women of reproductive age. Ethno-botanical surveys were conducted during 2024 and 2025 in villages. This paper explores its various types and causes, cultural perceptions, and ethno – botanical medicinal plant based treatments. In this paper 12 plant taxa belonging to 12 genera and 11 families. This research paper also gives some comparative studies with modern medicine, Pharmacogonosy used for Leucorrhoea with hygienic tips & risk factors in women. The tribal communities of the area depend on the herbal drug for their primary health care that is attributed partly to their socio-economic and cultural background.

## KEYWORDS

Ethno – botanical knowledge, Medicinal Plants, Leucorrhoea, Rahuri Tehsil

## INTRODUCTION

India is a treasure of biodiversity which hosts a large variety of plants and ranks 10$^{th}$ among plant rich countries of the world and 4$^{th}$ among the Asian countries. Medicinal plants are nature's gift to mankind and are rich heritage of India. According to WHO, 2008; the term "traditional medicine" is to be understood as the sum total of the knowledge, skills and practices based on theories, beliefs and experiences indigenous of different cultures that are used to maintain and improve health, as well as,

to prevent, diagnose and treat physical and mental illness. The WHO has a keen interest in documenting the use of medicinal plants by native peoples from different parts of the world (Buragohain, 2011). Folk knowledge of the people in a given community has developed over time and is based on experience, often tested over centuries of use, adopted to the local culture & environment and held by individuals or communities (Martin GJ, 1995). Leucorrhoea, commonly described as an excessive vaginal discharge, is a widespread gynecological concern affecting women of various age groups, particularly those in their reproductive years. While mild vaginal discharge can be physiological, excessive or abnormal discharge often indicates underlying infections, hormonal imbalances, or reproductive tract disorders. Leucorrhoea refers to the excessive or abnormal discharge from the female genital tract, typically white or slight yellowish. It may be benign or indicative of infection, inflammation, or systemic disorders. In India, where rural and tribal communities heavily rely on traditional healthcare knowledge, medicinal plants have played a significant role in managing female reproductive health issues, including Leucorrhoea. This paper explores the traditional wisdom associated with medicinal plants used for treating leucorrhoea, analyzing their phytochemical properties, therapeutic mechanisms, and relevance in contemporary healthcare systems. Traditional knowledge refers to the wisdom, practices, and skills developed by indigenous and local communities over generations. In healthcare, it includes herbal remedies, diagnostic methods, spiritual healing, and holistic approaches. Traditional medicine has historically addressed women's reproductive health, offering remedies for menstrual disorders, infertility, pregnancy-related care, and vaginal infections. Many herbal formulations for leucorrhoea still form a part of rural healthcare practices in India.

**Types of Leucorrhoea**

1. **Physiological Leucorrhoea** – is normal, healthy vaginal discharge that occurs due to hormonal fluctuations / activity, emotional stress or anxiety, puberty (estrogen production), active cervical and vaginal glands, ovulation, or pregnancy. It caused by Kapha predominance condition, It is not a disease and not indicate infection. It is the body's way of cleaning and lubricating vagina. It is white or clear and smell is mild or without smell. During physiological Leucorrhoea there is Painless.
2. **Pathological Leucorrhoea** – It's an Abnormal, excessive, foul smelling white / yellow / green vaginal discharge caused by microbial infections [bacterial (thin, grey – white), fungal (thick white, curdy discharge), or parasitic (frothy, yellow – green discharge)], poor genital hygiene,

sexually transmitted infections, or cervical erosions. It causes genital itching or irritation, backache, lower abdominal pain, dysuria, dyspareunia (painful intercourse), fever in severe infection (PID).

3. **Inflammatory Leucorrhea**: Caused by inflammation or congestion of the vaginal mucosa. In cases where it is yellowish or gives off an odor, a doctor should be consulted since it could be a sign of several disease processes, including an organic bacterial infection (aerobic vaginitis) or STD. After delivery, Leucorrhea accompanied by backache and foul-smelling lochia (post-partum vaginal discharge, containing blood, mucus & placental tissue may suggest the failure of involution (the uterus returning to pre-pregnancy size) due to infection. A number of investigations such as wet smear, Gram stain, culture, pap smear and biopsy are suggested to diagnose the condition.

**Study Area:**

Rahuri tehsil is situated in the Ahilyanagar district, Maharashtra state, India. Rahuri Taluka of Ahilyanagar district has a **total population of 322,823** as per the Census 2011. Out of which 166,952 are males while 155,871 are females. In 2011, there were a total 64,707 families residing in Rahuri Taluka. The **Average Sex Ratio of Rahuri Taluka is 934.** As per Population Census 2011 data, **Schedule Caste (SC) constitutes 13.5%** while **Schedule Tribe (ST) where 10.5%** of total population in Rahuri Taluka of Maharashtra (Table 1).

**(Table 1): Social Category wise sex ratio According to Census 2011.**

| Social Category | Total | Male | Female |
|---|---|---|---|
| **Schedule Caste** | 43619 | 22320 | 21299 |
| **Schedule Tribe** | 34036 | 17177 | 16859 |

## MATERIALS AND METHODS

**Medicinal Plant Survey and Data Collection:** Ethno – botanical exploration trips were carried out in primitive tribal people dominated villages during 2023 – 2025.The area under study was thoroughly covered and people were interrogated for information. After selecting the people, knowledge about their interests and skills in identification and utilization were obtained through informal interviews and discussion was made with the informants in their local language. A total of 30 informants (Mahadeo

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Koli 5, Ramoshi 3 and Dhangar 7) between the age group 25 to 80 years were interviewed with questionaries. Out of 30 informants, 25 are male and 05 are female. At the end of the each interview, specimens of plants mentioned for medicinal uses were collected and identified. Identification of species was made with the help of Floras ( Flora of Maharashtra, Flora of Bombay Presidency, Flora of Ahmednagar district). The species and family names are mentioned according to APG III, systems of classification. The list of medicinal plants were depicted in a tabular form along with their botanical names followed by family, their local names in Marathi if any and the parts used for medicinal purpose.

**Table 2: Ethno – botanical Medicinal Plants Used for Leucorrhoea**

| Sr. No. | Botanical Name, Family, Common Name | Habit& Plant Parts used | Disease & mode of usage | Pharmacogonosy |
|---|---|---|---|---|
| 1 | *Saraca asoca* (Roxb.) D. Willd. Fabaceae, Ashoka | Bark | Bark powder consumed with honey, two times a day. | Anti-diabetic, anti-inflammatory, and antimicrobial Uterine tonic. |
| 2 | *Azadirechta indica* A. Juss., Meliaceae, Neem | Leaves & Bark | Decoction of leaves or bark used for washing genital area. | Antifungal, antibacterial and detoxifying effects |
| 3 | *Asparagus recemosus* Willd., Asparagaceae, Shatavari | Roots | Prepare decoction of fresh root powder, administered twice a day. | Astringent, anti-septic, Tonic, Balance female hormones |
| 4 | *Curcuma longa* L., Zingiberaceae, Halad | Rhizome | Rhizome powder mixed with water and administered internally. | Antimicrobial, anti-inflammatory and healing effect |
| 5 | *Trigonella foenum-graecum* L., Fabaceae, Methi (Fenugreek) | Seeds | Boil 1 teaspoon seeds in a 1 glass of water for 5 -7 minutes, strain and drink warm once day. | Anti-oxidant, anti-inflammatory, Digestive and Reproductive |
| 6 | *Punica granatum* L., Lytharaceae, Dalimb (pomegranate). | Peel | Dry the outer peel of pomegranate fruit and make a fine powder. Mix 1tablesppon powder in 1 glass warm water and drink once daily. | Antioxidant, anti-inflammatory, anti-microbial anti-diabetic, cardioprotective and anti-cancer |
| 7 | *Abelmoschus esculentus* (L.) Moench., Malvaceae, Bhendi (Lady's finger) | Fruit | Cut 4-5 pieces of lady finger, boil in 2 cups of water until it becomes half, drink once daily. | Antidiabetic, antioxidant, anticancer, cardioprotective, anti-inflammatory |

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| **8** | *Musa paradisiaca* L., Musaceaea, keli (Banana) | Fruit | Eat 1 ripe banana with 1 teaspoon amla powder daily. | Anti-diabetic, anti-oxidant, anti-ulcer, anti-microbial and anti-diarrhoeal |
| **9** | *Ocimum tenuiflorum* L., Lamiaceae, Tulsi | Leaves | Take 1 teaspoon tulsi juice or paste, mix with 1 teaspoon honey. Take twice a day. | Analgesic, anti-asthamatic, anti-bacterial, anti-cancer, anti-helminthic |
| **10** | *Oryza saiva* L., Poaceae, Tandul (Rice) | Seeds | Cook rice in excess water, stain and drink the leftover rice water once daily. | Gastrointestinal, dermatological, cardiovascular, anti-inflammatory, anti-oxidant |
| **11** | *Piper betel* L., Piperaceae, Nagin pan (Betel) | Leaves | Chew 1 fresh betel leaf daily or make a mild wash by boiling betel leaves in water abd using externally when warm. | Gastroprotective, anti-microbial, anti-fungal, aphrodisiac, anti-platelet |
| **12** | *Ficus carica* L., Moraceae, Anjeer | Fruit | Soak 2-3 anjeer in water overnight, eat them in the morning. | Anti-carcinogenic, anti-oxidant, anti-fungal, Hypo-cholesterolemic, anti-anxiety, digestive |

## RESULTS AND DISCUSSION

The present paper gives detailed information on 12 plant species, from different 11 families were made which are used traditionally against Leucorrhea disorders. The present survey shows that the practice of ethno-botany is still a matter of cultural heritage of the area. People are making maximum use of the plant species for meeting their day to day household remedies. Traditional healers use their five senses to diagnose the diseases, which are remarkable because they live in remote areas and lack of the modern scientific equipment for diagnosis and treatment; however, they treat diseases using medicinal plants. Traditional knowledge of medicinal plants offers valuable insights into managing Leucorrhoea naturally. Many plants used for generations show scientific backing through phytochemical studies. However, standardization, dosage determination, and clinical trials are essential to ensure safety and efficacy. Preserving indigenous knowledge systems is crucial, particularly in rural communities where plant-based medicine remains the first line of treatment. The medicinal plants covered in the present study warrant extensive research work to exploit their full potential in the future.

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**Causes and Risk Factors for Leucorrhea:**There are some causes and risk factors enlisted below which are important in this study. Out of them poor personal health & hygiene, Prolonged use of strong antibiotics, stress and nutritional deficiencies, poor knowledge of cleanliness, clothing & wearing patterns etc. These will finally leads to Hormonal imbalance, Vaginal or cervical infections, Pelvic inflammatory disease & Sexually transmitted diseases (STD)

| | |
|---|---|
| *Ficus carica* Linn. | Punica granatum |
|  |  |
| Piper betle | *Ocimum tenuiflorum* L. Tulsi |
|  |  |
| *Saraca asoca* (Roxb.) Ashoka | *Azadirechta indica* Meliaceae, Neem |

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**Phytochemical Properties and Mechanisms of Action:** Medicinal plants with their therapeutic potential to diverse phytochemicals are flavonoids, tannins, alkaloids, Saponins and glycosides etc. **Flavonoids** Provide antioxidant and anti-inflammatory benefits. **Tannins** offer astringent action and reduces excessive discharge. **Alkaloids** Exhibit antimicrobial activity which prevents smelling and microbial infections. **Saponins** – Helps to regulate hormones and improve uterine health. While, **Glycosides** Support immune function and tissue healing. These compounds work through multiple mechanisms such as inhibiting pathogen growth, reducing inflammation, restoring vaginal pH balance, and strengthening reproductive tissues. Leucorrhoea, though common, can significantly affect women's quality of life. Traditional medicinal plants provide effective and culturally accepted solutions for managing this condition. Integrating traditional knowledge with modern scientific research can enhance women's healthcare while preserving valuable ethno-medical heritage. This study reveals the traditional uses of some medicinal plants for prohibition of abnormal Leucorrhea among the women. **Traditional medicine** emphasizes holistic care using readily available herbs, focusing on root causes, nutritional balance, and long-term wellbeing while **Modern medicine** uses antifungals, antibiotics, hormonal treatments, and probiotics for rapid relief. While modern treatments are effective for acute infections, traditional remedies offer long-term prevention with minimal side effects. Integrating both systems can provide comprehensive healthcare.

**Hygienic Tips & Suggestions:**

1. Wear cotton underwear only.
2. Keep area clean and dry.
3. Avoid tight jeans.
4. Change underwear twice a day if discharge is heavy.
5. Do not use harsh soaps, Dettol or perfumed washes.

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The authors are grateful to the local tribal and non-tribal people of Rahuri tehsil, Ahilyanagar district from the study sites for their support and help during the study.

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# EFFECT OF COPPER NANO PARTICLE AGAINST LEAF SPOT OF CAULIFLOWER

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## ABSTRACT

Alternaria leaf spot caused by *Alternaria brassicicola* (Schwein) Wiltshire is one of the most destructive disease of the cauliflower (*Brassica oleracea* var. *botrytis*), causing high losses. The present investigations were taken for management of Alternaria leaf spot of cauliflower with CuNP. Result revealed that all the treatments significantly reduced the leaf spot disease incidence over control. Experiment was taken for the evaluation of efficacy of CuNP against *A. brassicicola* in *in vitro*. CuNP @0.5% and 1% were evaluated in *In vitro* conditions against *A. brassicicola* using poisoned food technique. CuNP exhibited maximum inhibition in mycelial growth. Nanoparticles can play a major role in coming days for the management of plant diseases at large scale and protect the farmers from indebtedness by decreasing the cost of production.

## KEYWORDS

Alternaria, CuNP, Cauliflower, disease

## INTRODUCTION

Cauliflower or Brassica oleracea, is a member of the Brassicaceae family. It is a winter vegetable that is grown all over the world. [1]. Its floral shape is reflected in the name, which is derived from the Latin words caulis (cabbage) and floris (flower). Through natural mutation and selection, it developed from wild cabbage. [2]. Cauliflower is cultivated in many countries like China, India, Italy, Mexico, France, Poland, U.S.A, Pakistan, Germany, Egypt etc. India is the world's second-largest producer of cauliflower after China. During 2021-22, national production reached 89.41 lakh metric tonnes [3]. In Chhattisgarh, the crop cultivated over 24,250 hectares, with a production of 483,565 metric tonnes and an average productivity of 19.94 t/ha [4]. Protein, vitamins B1, B2, B5, B6, and C, omega-3 fatty acids, folate, phosphorus, manganese, and dietary fiber are all abundant in cauliflower. Cauliflower has been

found to contain a number of phytochemicals, including isothiocyanates, glucosinolates, and indoles, which detoxify carcinogens and inhibit the enzymes that cause tumors and malignancies. [5].

Cauliflower [*Brassica oleracea* (L.) var. *botrytis*], *Alternaria brassicicola* (Schwein) Wiltshire is the dominant pathogen. All growth phases are impacted by the leaf spot disease, which goes by several names throughout the world, including curd blight, brown rot, and black spot. There have been reports of this disease in several nations, including India. [6]. It has reported 20-80 per cent loss in yield and 59 per cent loss in seed production. zlobally, the loss due to this disease is 30-47percent. In India, about 30 percent losses in terms of seed and yield was reported [7].

Nanoparticle research has attracted more attention because of their special qualities—such as electrical conductivity, toughness, and ductility; enhanced hardness and strength of metals and alloys; and luminous efficiency of semiconductor. [8]. Metal oxides such as Copper Oxides (CuO) have attracted attention mostly because of antimicrobial [9, 10] and biocide properties which can be used in many biomedical applications. Apart from the earlier mentioned applications Copper-based nanoparticles also showed advantageous usage in cancer detection [11], as nanofluids in heat transfer systems [12], and as catalyst [13], photocatalysts [14]. In general, copper-based nanoparticles are less costly than other extensively researched nanoparticles like gold and silver. Plant extract-based nanoparticle synthesis has many benefits, including readily available resources, a safer alternative, an eco-friendly approach, a straightforward technology, and low cost. [15].

Due to the limitation in use of fungicides as it causes the environmental pollution and health hazards, use of nanoparticles may be safer and least expensive. The present investigations were carried out to generate information on potentiality of some promising nanoparticles under *in vitro* as well as *in vivo* conditions against *Alternaria* leaf spot of cauliflower and its causal agent.

## MATERIALS AND METHODS

### Collection of the diseased samples.

Leaves of cauliflower with dark brown spots having characteristic concentric circumferences, often with a yellowish chlorotic halo were collected from farmer's field of nearby Loni and brought to the laboratory for isolation and further studies.

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**Isolation**

For isolation of pathogen, small pieces of the leaves were cut from the diseased portion and surface sterilized with 1% sodium hypochlorite solution for one minute followed by three consecutive washings with sterilized distilled water. The surface sterilized pieces were transferred to Petri plates containing Potato Dextrose Agar (PDA) and incubated at 25+1°C in BOD incubator.

**Preparation of Plant Extracts**

The extract was used to produce Copper oxide nanoparticles. 20g fine grounded powders of *Coriandrum Sativum* was weighed, separately added to 200 ml of double distilled water, and heated at around 80°C for 30 minutes in a water bath. The mixture was filtered separately. The filtrate was stored for further use in a refrigerator (in a cold condition).

**Synthesis of Copper Oxide Nanoparticles using *Coriandrum Sativum* Extract**

In 200 ml of *Coriandrum Sativum* extract were taken separately. 50 ml of 1M Copper Sulphate ($CuSO_4.5H_2O$) solution was added drop wise to extract while stirring on the magnetic stirrer. During the addition of the Copper Sulphate solution, the gradual change in the color of the solution was observed from brown to dark green visually indicating the formation of nanoparticles. The solutions were stirred for about 1 hour for completion of the reduction reaction and were kept aside for 24 hours. These solutions were then centrifuged at 4000 rpm with washings of double distilled water. The solid precipitate obtained was collected and oven dried for 2 hours at 50°C to 60°C. The dried powder was obtained from extracts and used for further analysis.

**In Vitro Antifungal Activity Assay**

The antifungal activity of Cu-NPs against *Alternaria brassicicola* was evaluated using the poisoned food method [16]. Briefly, PDA was mixed with different amounts of Cu-NPs to obtain the following final concentrations 0.5% and 1% and non-amended media were used as control. Spore suspensions ($1 \times 10^6$ CFU/mL) were inoculated at the center of each PDA plate and incubated in darkness at 28 °C for six days. All treatments were carried out in triplicate. Colony diameters were measured three and six days after inoculation (dai). The percentage of growth inhibition was calculated by measuring the average area of the fungal colonies in the treatments and compared to the negative control.

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## RESULTS AND DISCUSSION

**Isolation and identification-**

On potato dextrose agar medium, the pathogen was successfully isolated from diseased tissue. The inoculation plates were incubated in the BOD incubator for 5 to 7 days at a temperature of 25 to 20°C. After seven days of incubation, the fungus generated greenish-gray to black-colored, fluffy, lanose to loose cottony growth on potato dextrose agar medium. The pure culture of *Alternaria brassicicola* obtained by single spore isolation method was used for pathogenicity test. The test was carried out by spore suspension spray inoculation on the foliage of 35 days old. The symptoms appeared on inoculated leaves as brown, circular or oval necrotic spots with concentric rings and surrounded by yellow after twenty days after inoculation. The fungus was re-isolated and purified and compared for similarity to that of original culture.

**Nanoparticle synthesis by UV- Visible Spectroscopy Analysis [17]**

Nanoparticles in the reaction mixture were excited by light absorption at different wavelengths due to surface plasmon resonance (SPR) to give respective peaks in the wavelength range from 200 nm to 600 nm to determine the absorption. The synthesized nanoparticles from Coriandrum Sativum plant extracts showed broads peaks at 327 nm, which corresponds to Copper Oxide. Thus, it was confirmed that the Copper Oxide nanoparticles were formed using Coriandrum Sativum plant extracts.

**Antifungal Acivity-**

The radial growth of the fungal mycelium was recorded at 7 days after inoculation. Zone of growth of fungus of control plate is 4.2 cm whereas zone of growth of CuNp at 0.5% and 1% is 1.9 and 1.2 cm respectively.

## CONCLUSION

The presented work proves that using Cu-NPs could be considered as a highly efficient alternative with better antifungal properties. The study revealed that the disease can easily be identified by its characteristic's symptoms, and observing the asexual reproductive structures of the causal pathogen in aqueous medium that will help the farmers for selecting effective treatment against the disease easily. This method has merits over other reported methods are easily available starting materials, inexpensive process, easy to carry out in any college level laboratory, reaction condition are simple, avoid use of expensive, hazardous and toxic reagent and pollution free.

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# FORMULATION AND EVALUATION OF SUSTAINED RELEASE TABLET USING NATURAL POLYMER

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## ABSTRACT

Natural polymers have gained significant attention in pharmaceutical research due to their biocompatibility, biodegradability, low cost, and ability to control drug release. These materials, derived from plant, microbial, and animal sources, serve as retardant and controlled-release agents in oral dosage forms. Polymers such as carrageenan, pectin, and glucomannan exhibit excellent swelling, gel-forming, and diffusion-controlling properties that enable sustained drug delivery. Carrageenan, a sulfated polysaccharide from Chondrus crispus, exists in κ, ι, and λ forms, each differing in sulfate content and gelling capacity. It has been used in various matrix systems to modulate drug release up to 24 hours. Similarly, pectin, composed of α-(1,4)-linked D-galacturonate units, forms gels depending on its degree of methylation and pH, influencing solubility and drug release kinetics. Sustained release tablets aim to maintain steady plasma drug levels, reduce dosing frequency, minimize side effects, and improve patient compliance through mechanisms such as diffusion, erosion, and swelling. Natural polymers like cellulose, agar, and xanthan gum are widely used as binders, gelling agents, and stabilizers in these formulations. Their renewable nature and ease of modification make them ideal for designing advanced drug delivery systems. Future developments in polymeric drug delivery focus on responsive and biomimetic systems that allow targeted, controlled, and efficient release, particularly in cancer therapy. The integration of natural and synthetic polymers offers promising prospects for developing innovative, site-specific, and patient-friendly pharmaceutical formulations that enhance therapeutic efficacy while minimizing adverse effects.

## KEYWORDS

Polymers, delivery, Release, Specific, Effect, Tablet

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## INTRODUCTION

Polymers have been used in pharmaceutical applications, particularly as retardant release for oral controlled release formulations, because of their many benefits, including being inert, biocompatible, inexpensive, readily available in nature, convenient, and easy to manufacture. Depending on the polymers, they can also provide a desired drug release profile. Natural polymers and other hydrophilic polymers show promise as retardants and controlled release agents because they prolong drug release and trap the drug in a matrix to control its release by controlling swelling and diffusion through the polymer. This makes them especially well-suited for controlled release platforms. Controlled release formulations based on natural and hydrophilic polymer matrix have been thoroughly researched lately. The properties of natural polymers are crucial in determining the process in a number of situations. and the drug to polymer ratio, solubility, viscosity, and swelling capacity all affect the kinetics of drug release. Chondrus crispus (Rhodophiceace) is the source of carrageenan, a high molecular weight sulphated polysaccharide. Based on differences in the degree of sulfation, the carrageenan is separated into three groups: kappa (κ), iota (), and lambda (λ) with di, mono, and three sulfate, respectively. Ester sulfate is the basis for carrageenan's properties; a high ester sulfate content results in reduced solubility and gelation strength.

The ionic strength of carrageenans determines their gelling capabilities; κ-carrageenan produces stronger gel presences of K+, γ-carrageenan produces stronger gel presences of Ca2+, and λ-carrageenan has no gelling feature. High ratios of either ¾ or κ carrageenan blended with λ-carrageenan have been investigated, given that zero order release and burst release happened in blend γ/κ-Tolterodine is used as a drug model for carrageenan, a medication that is somewhat soluble in water. A blend of carrageenan and hydroxyl-propyl methylcellulose has been used in gastro-retentive drug delivery systems to improve their floating capability and delay the drug for up to five hours. A combination of carrageenan and polyvinyl alcohol has been studied to reduce the burst release in carrageenan hydrogel 15. Other modifications using polyacrylamide and carboxymethyl of carrageenan have been prepared to improve the ability for drug delivery. Using doxazosin melysate as a drug model, carrageenan (§, κ, and λ) extended the drug release up to 24 hours; κ-carrageenan demonstrated a burst release effect.

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Pectin is a polysaccharide and oligosaccharide made up of α-(1,4)-linked D-galacturonate units with a methyl ester group on the C-6.Pectin's degree of methylation affects its solubility and capacity to form networks. and the features and mechanism of gelation. Low methoxy pectin is more hydrophilic and soluble than high methoxy pectin in pH 7.4 buffer, while high methoxy pectin is poorly soluble and forms gel at pH around 3. The degree of esterification and molecular size of the pectin determine its gelling property. According to reports, pectin forms gel at pH 1-3, and its gelation properties decrease as pH rises. When natural polymers come into contact with a medium, they instantly hydrate, expand, and form a viscous gelatinous surface barrier that controls drug release and permits medium penetration into the matrix system's core. Drug and polymer solubility, polymer hydration/erosion rate, and other factors determine the drug release kinetics and mechanism from these matrices.particle size and shape, drug-to-polymer ratio, and the capacity for swelling and gelling. Different drug release patterns, kinetics, and mechanisms result from variations in drug release kinetics. Therefore, it is necessary to clarify and study the drug release properties, kinetics, and mechanism from natural polymers like carrageenan, pectin, and glucomannan as a single system using difference dispersion drug to polymer ratio. To the best of our knowledge, no assessment of drug release kinetics, models, and properties utilizing natural polymers like carrageenan, pectin, and glucomannan has been carried out thus far. Therefore, the purpose of this study was to examine and assess the drug release properties, models, and kinetics of sustained release tablet formulations based on natural polymers, such as carrageenan, pectin, and glucomannan[1,2]

**SUSTAINED RELEASE TABLET**

Extended release By preserving a steady-state concentration of the medication in the systemic circulation, dosage forms are especially made to extend the duration of therapeutic activity, decrease the frequency of administration, lessen adverse effects, and ultimately increase patient compliance. In order to ensure therapeutic efficacy with less variations in plasma drug concentration, these dosage forms seek to administer the medication at a regulated pace over a longer period of time.Diffusion, erosion, osmotic pressure, and swelling-controlled release are the mechanisms involved in sustained release; each one contributes in a unique way to regulate the drug's release from the dosage form. Because of its ease of use, versatility in dosage form formulation, and improved patient acceptability, the oral route of medication administration is the most popular. However, it is crucial.should take into

account elements that can affect the behavior of the medication and the effectiveness of the dosage form throughout its transit, such as the enzyme system, gastrointestinal motility, and the fluctuating pH levels throughout the gastrointestinal tract. To provide a steady and gradual release of the medication into the gastrointestinal environment, the majority of oral sustained release devices rely on dissolution, diffusion, or a combination of these processes. A zero-order release mechanism, in which the drug is supplied at a constant rate and produces a stable blood concentration–time profile akin to that of continuous intravenous infusion, is the ideal sustained release delivery method, both theoretically and desirably. By reducing the possibility of dose-related adverse effects and increasing overall treat efficacy, such a system offers the best possible therapeutic benefits[3].

**CONTROLLED RELEASE**:-

A variety of prolonged action formulations that offer continuous release of their active components at a predetermined rate and for a predetermined amount of time are included in controlled release dosage forms. Although these devices have lately been created for parenteral administration, ocular insertion, and transdermal application, the bulk of these formulations are intended for oral delivery. The primary goal of this system's creation is to provide a longer duration of effect, which will increase patient compliance[4].

**ADVANTAGES OF SUSTAINED RELEASE TABLETS:-**

1) Increased Effectiveness of Treatment Prolonged Drug Release: Sustained-release tablets improve the pharmacological response by keeping therapeutic drug levels in the bloodstream for a longer amount of time.

2.) Enhanced Patient Compliance Decreased Dosing Frequency: Patients take these tablets once a day or less, which improves adherence to the treatment plan, particularly for long-term diseases.

3) Mitigate the toxicity by decelerating the absorption of the drug.

4) It keeps a therapeutic concentration for an extended duration.

5) Less frequent intakes.

4) Mitigate adverse effects.

6) Consistent drug release throughout the duration[5,6].

**DISADVANTAGES OF SUSTAINED RELEASE TABLETS**:-

(1) Very costly

(2) Bioavailability is often inadequate

(3) Requirement for additional patient counseling and education.

(4) Überdosierung bei der Applikation

(5) Häufig mangelhafte Korrelation zwischen in vivo und in vitro. Mitigate the toxicity by decelerating the absorption of the drug.

6) It keeps a therapeutic concentration for an extended duration.

7) Less frequent intakes.

8) Mitigate adverse effects.

9) Consistent drug release throughout the duration[7,8].

**POLYMERS:-**

Es gibt deep historical ties between the domain of polymer science and nature. It is worth mentioning that polymers are, in fact, essential for all living organisms. As an illustration, cellulose, recognized as the most prevalent organic substance on Earth, serves as a primary structural component for plants. Foods such as potatoes and cereal grains contain a high amount of starch. Various bacteria, including Cupriavidus necator and Alcaligenes latus, naturally produce polyhydroxyalkanoates (PHAs). Natural rubber is obtained from Hevea brasiliensis trees. Chitin makes up the exoskeletons of insects and shellfish. The mulberry silkworms produce silk. Proteins, crucial for all life forms including humans, are involved in essentiallyall processes in every living cell, as well as nucleic acids that hold the genetic information for all Earth's life forms, are located in the cell nuclei. Studying the structures, properties, and biological functions of natural polymers is of significant scientific interest, as it can help reveal nature's secrets and discover new applications, including in the biomedical and pharmaceutical

fields.From the outset of polymer research, attention has been directed toward designing, synthesizing, and utilizing new polymers, as well as natural polymers, for nature[9].

**NATURAL POLYMERS:-**

Proteins, which are composed of various amino acids and exhibit monodispersity, can have different physical and biochemical properties due to the attachment of various moieties to their amino acid side chains. Proteins can have limitations, including immunogenicity and variations from one batch to another due to the purification process. Moreover, protein materials are typically obtained from animals, which adds complexity to their translation into a clinical context [.Research has been conducted on proteins like collagen, elastin, silk fibroin, and gelatin to evaluate their potential as scaffolds for tissue applications. Protein-based materials like these are beneficial for sutures, drug delivery vehicles, and more. Materials based on proteins, as well as biomaterials overall, must offer adjustable degradability to regulate the sequestration and delivery of particular bioactives. elements that enhance and direct healing and regeneration for an extended duration. Below, we will discuss collagen, gelatin, and silk fibroin along with the incorporation of bioactive glasses[10].

**SOURCE OF NATURAL POLYMERS:-**

Due to its physicochemical properties, natural polymer has undoubtedly garnered interest in the drug delivery system. The polymers sourced from plants (such as pectin, guar gum, and mannan), microbes (like dextran and xanthan gum), and animals (including chitosan or chondroitin) are found abundantly in the atmosphere and can be easily reproduced using recombinant DNA technology. The polymers of monosaccharides possess numerous advantageous characteristics, including high stability, non-toxicity, hydrophilicity, biodegradability, gel-forming capability, and ease of chemical modification. The structural compositions of plant polysaccharides vary widely, linked not only to different plant species but also to the specific parts of plants from which they are derived, including leaves, seeds, roots, and tubers.Two specific structural characteristics can elucidate the complexity and diversity of polysaccharides: First, monosaccharides can be linked in α or β configuration; second, because of the branched side chains. Amino acid-based natural polymers are relatively uniform in size, with no variation present. Polymers of this kind are described as homogeneous or monodisperse. Generally, the natural polymers are produced through condensation polymerization techniques. Natural polymers

are usually easily biodegradable and do not have adverse effects on the environment or humans. According to the sources, natural polymers are classified into three main categories, as shown in table[11].

**TABLE:-**

| **Natural Polymer** | **Source** | **Key Properties** | **Mechanism of Release Control** |
|---|---|---|---|
| **Guar Gum** | *Cyamopsis tetragonolobus* | Hydrophilic, forms viscous gels | Swelling and diffusion control |
| **Xanthan Gum** | *Xanthomonas campestris* (bacterial origin) | High viscosity, stable at various pH | Matrix formation and diffusion |
| **Okra Gum** | *Abelmoschus esculentus* | Good binding and swelling properties | Swelling and gel barrier formation |
| **Pectin** | Citrus peels, apple pomace | Gel-forming in acidic pH | Ion-exchange and diffusion |
| **Sodium Alginate** | Brown algae | Forms hydrogels with $Ca^{2+}$ ions | Diffusion and erosion control |
| **Chitosan** | Chitin (crustacean shells) | Mucoadhesive, biocompatible | pH-dependent release |

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**.CLASSIFICATION OF POLYMERS**:-

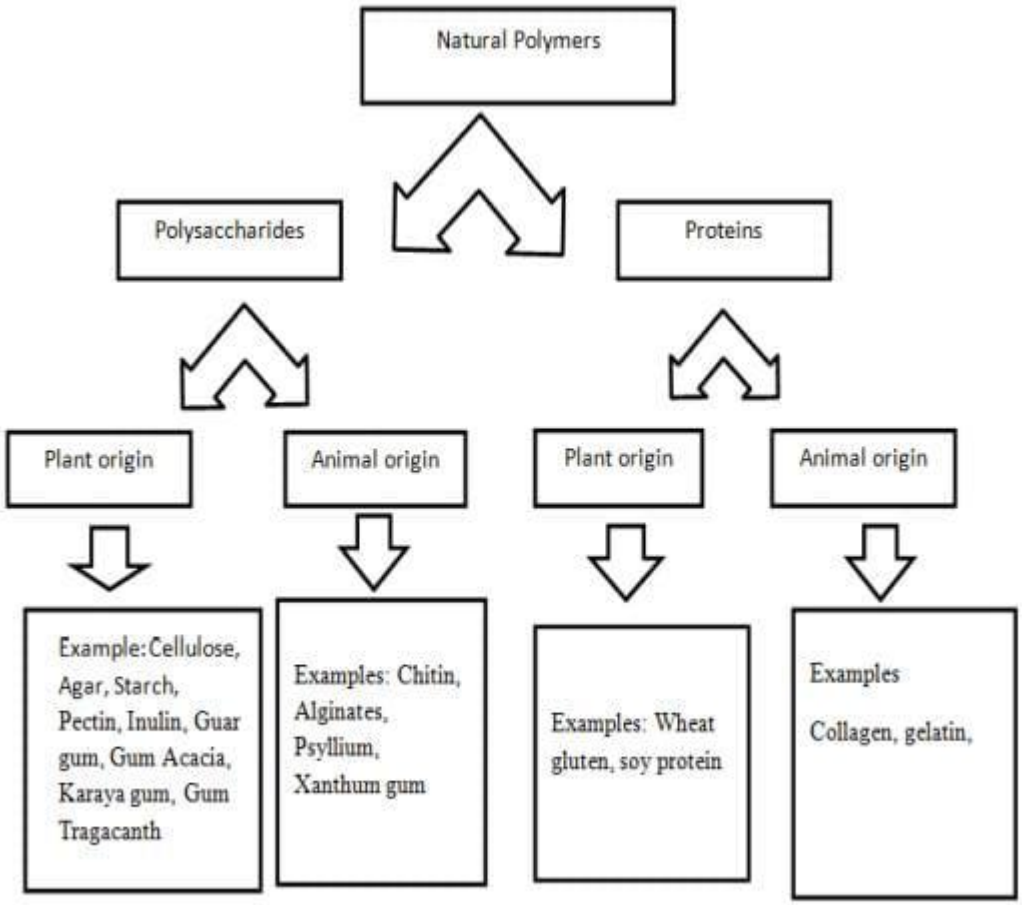


Fig 2 :- classification of polysaccride

**CLASS 1 :-POLYSACCHARIDE**

**POLYSACCHARIDES FROM PLANT ORIGIN**

**a) CELLULOSE:-**

*Composition:- It is an organic polysaccharide made up of a linear sequence of several hundred to more than ten thousand D-glucose units linked by β (1→4) bonds, with the formula $(C_6H_{10}O_5)_n$. The primary components of the plant cell wall are cellulose, hemicelluloses, and pectin.

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*Appications :- In the pharmaceutical sector, microcrystalline cellulose serves primarily as a diluent and binder in tablets, applicable to both granulation and direct compression methods.

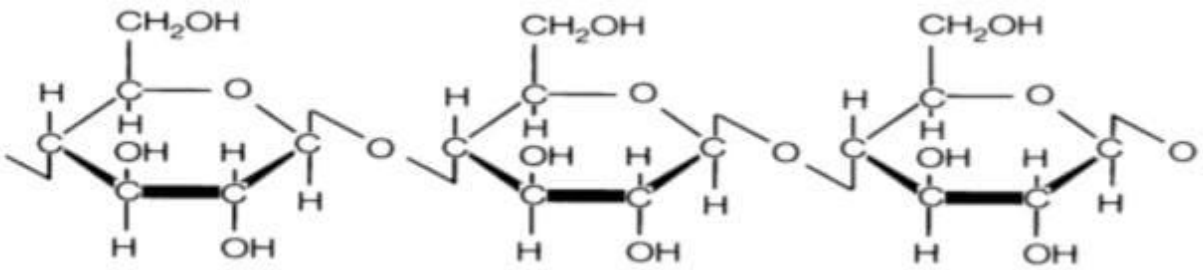

**Fig 3:- Cellulose**

**b) AGAR**

*Composition: Agar setzt sich aus einer Kombination von Agarose und Agaropektin zusammen. Agarose, a linear polymer, consists of repeating units of the monomer agarobiose. Agarobiose, on the other hand, is a disaccharide composed of D-galactose and 3,6-anhydro-L-galactopyranose. Agaropectin consists of a variety of smaller acidic molecules

*Application : Agar serves various roles, including as a suspending agent, emulsifying agent, and gelling agent in products such as suppositories, surgical lubricants, tablet disintegrants, bacterial culture media, and laxatives. Additionally, it serves in the making of jellies and sweets, as well as in tissue culture research and microbiological studies.

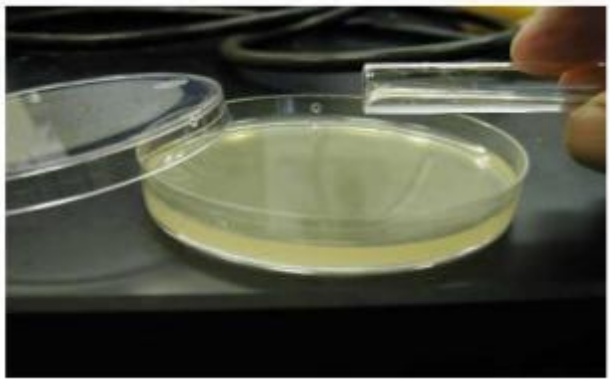

**Fig 4:- Agar**

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**C) STARCH**

*Composition

Starch, also known as amylum, is a carbohydrate made up of numerous glucose units linked together through glycosidic bonds. It is composed of two polymers: amylose, which is a non-branching helical polymer made up of α-1,4 linked D-glucose monomers, and amylopectin, a highly branched polymer containing both α-1,4 and α-1,6 linked D-glucose monomers.

* Appications Thermoplastic starch serves various purposes, including in packaging, containers, mulch films, textile sizing agents, and adhesives.


**Fig 5:-starch**

**D) GUAR GUM**

* Composition:- Guar gum is a natural polysaccharide made up of the sugars galactose and mannose from a chemical perspective. It is a galactomannan, a linear polysaccharide made up of β-D-mannose monomers linked by (1→4)-diequatorial connections, with some connected to single α-D-galactose sidechains. The backbone of guar gum consists of β-1,4-linked D-mannopyranoses, with an α-D-galactose linked 1→6 to every alternate mannose on average.

*Application :-Various modified forms of guar gum are utilized in drug delivery systems.The formulation of the transdermal therapeutic system utilizes carboxymethyl guar film. Guar gum is especially effective

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for colon delivery as it can be broken down by certain enzymes found in this area of the gastrointestinal tract[12].

**Fig 6:- gaur gum**

**II. POLYSACCHARIDES FRON ANIMAL ORIGIN**

**a) Xanthan gum**

*Composition:- Xanthan consists of long-chain polysaccharides that have numerous trisaccharide side chains. The side chains consist of two mannose units and one glucuronic acid unit.

*Application :-Xanthan gum serves as a suspending and stabilizing agent in a variety of products, including oral and topical pharmaceuticals, cosmetics, and food items. Additionally, it serves as a thickening and emulsifying agent. Xanthan gum has been utilized in the formulation of sustained-release matrix tablets. An ophthalmic liquid dosage form has been developed that includes xanthan gum. This ingredient interacts with mucin, aiding in the dosage form's extended retention in the precorneal area. Recent studies have shown that xanthan gum can serve as an excipient in spray-drying and freeze-drying processes, leading to improved results.

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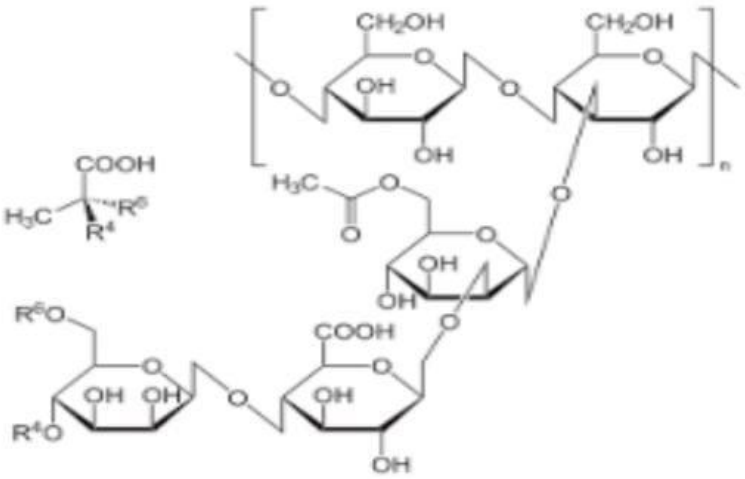

**Fig 7:- xanthan gum**

**b) ALGINATE**

*Composition:- These polymers consist of two different monomers in varying proportions, namely D-mannuronic acid and L-glucuronic acid, linked by 1,4-glucosidic bonds. They can exist as blocks of only D-mannuronic acid and L-glucuronic acids in homopolymers or as alternating sequences of the two in heteropolymeric blocks.

*Application:- A variety of oral and topical pharmaceutical formulations utilize sodium alginate. Sodium alginate serves as a binder and disintegrant in tablet formulations, while in capsule formulations, it has been utilized as a diluent. Sodium alginate has also been employed in creating sustained-release oral formulations In topical preparations, sodium alginate serves as a common thickening and suspending agent in various types of pastes[13].

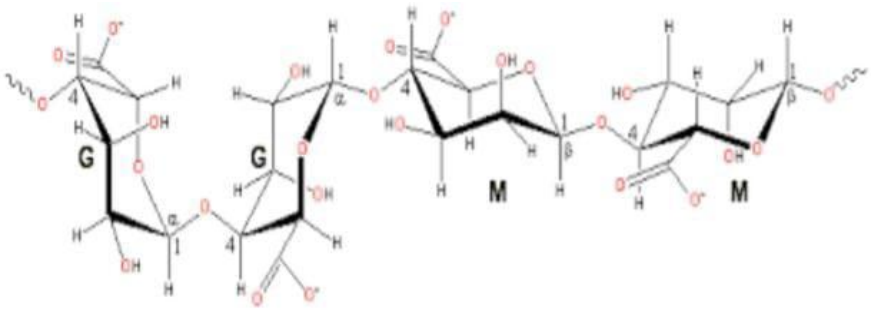


**Fig 7:-alginate**

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**CLASS 2:- PROTIEN**

**a) Wheat gluten.**

*Composition :-Wheat gluten is composed of two primary types of proteins: gliadin and glutenin. Gliadins are protein molecules characterized by low molecular weight, a low proportion of amino acids with charged side groups, and the presence of disulfide bonds. Glutenins are more complex proteins, possessing a three-dimensional structure. Their molecular weight is at least tenfold greater than that of gliadins.

* Application:- Wheat gluten has shown to be a superb film forming agent.

**Fig 9:-wheat gluten**

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**B) soy protein**

*Composition :- The most purified type of soy protein is soy protein isolate, which consists of around 90% protein. Essentially, soy protein concentrate is soybean that lacks the water-soluble carbohydrates. It consists of roughly 70 percent protein.

*Application :- Since 1959, it has been utilized in various food products due to its functional properties, such as emulsification and texturizing. The popularity of soy protein has been rising recently, primarily due to its health benefits. It has been demonstrated that soy protein can aid in the prevention of heart issues.

**Fig 10:-soy protein**

**ii.PROTEIN FROM ANIMAL ORIGIN**.

**a)collagen**.

*Composing :-There are 27 types of collagen, each made up of different polypeptides that primarily consist of glycine, proline, hydroxyproline, and lysine. Only the glycine content determines how flexible the collagen chain

*Appications :- In ophthalmology, collagen films serve as drug delivery systems that facilitate the slow release of their embedded medications.It was also utilized in tissue engineering for skin replacement, bone substitutes, and artificial blood vessels and valves.

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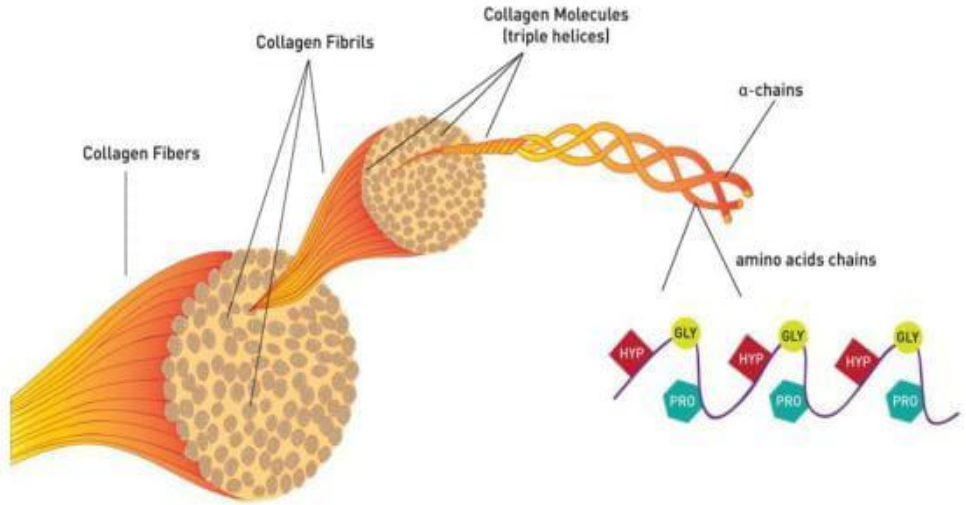


**Fig 11:-collagen**

**C) Gelatine**

*Composition:-Collagen can be denatured and/or undergo physical–chemical degradation to produce a high molecular weight polypeptide known as gelatin40. Gelatin, which is also a protein, is made up of 19 amino acids41. It can dissolve in water. Weitere tierische Proteine sind Elastin, Albumin und Fibrin.

*Applications:-Emulsifiers, foaming agents, colloid stabilizers, biodegradable film-forming materials, and microencapsulating agents are among these widely used[14].

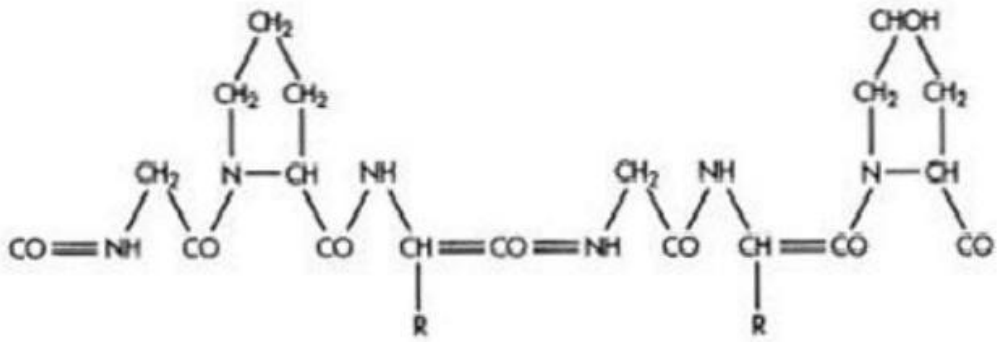

**Fig 12:- gelatine**

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**FORMULATION OF SUSTAINED RELEASE TABLETS**

*__Direct Compression__: This method, which is both uncomplicated and inexpensive, can be used to create sustained-release matrix tablets. The active pharmaceutical ingredient (API) is combined with excipients, mainly polymers that create the matrix, during this process. A tablet press is then used to compress the mixture directly into tablets. This approach is appropriate for drugs that have good flow and compressibility characteristics. Agents that are typically utilized for forming matrices include polymers like hydroxypropyl methylcellulose (HPMC), ethyl cellulose, and polyvinyl alcohol.

*__Wet Granulation__: This process entails mixing the drug and excipients with a liquid binder to create granules, which are subsequently dried and compressed into tablets. This approach improves the flowability and compressibility of the drug-polymer mixture, which helps to achieve a consistent drug content in the matrix tablets. A binder, like povidone, starch paste, or hydroxypropyl cellulose, is essential for binding the particles together. Depending on the desired release profile, the polymers utilized in wet granulation may consist of hydrophilic or hydrophobic materials. Although tablets produced via wet granulation exhibit enhanced mechanical strength, this method necessitates extra steps and equipment, rendering it more time-consuming and costly than direct compression

* __Melt Granulation__: This is a solvent-free method where a polymeric binder is heated until it melts and then combined with the drug and excipients to create granules. As a granulating agent, the molten binder removes the necessity for water or organic solvents. Commonly used are hydrophobic polymers like glyceryl monostearate, carnauba wax, or polyethylene glycol (PEG). Afterward, the granules are cooled down, sieved, and formed into tablets through compression. Melt granulation is especially advantageous for creating sustained release formulations that utilize hydrophobic matrix systems. Moreover, it circumvents problems concerning the extraction of solvent, which renders it a method that is comparatively gentle on the environment. Nevertheless, the application of heat can restrict its use for drugs that are sensitive to heat.

* __Coating Technique__:-Coating techniques are used to manage the release of medication by putting a polymer layer on top of an immediate-release core tablet. Depending on the desired release profile, the coating material can be hydrophilic, hydrophobic, or pH-sensitive. Methods like fluidized bed coating, dip coating, or pan coating are frequently employed. It is common to use polymers such as ethyl

cellulose, Eudragit, or HPMC. Coated matrix tablets are particularly effective for attaining delayed or pulsatile drug release. Nonetheless, specialized equipment and precise control of parameters are necessary for the coating process to ensure uniformity and reproducibility, which can lead to higher manufacturing costs.

***Ion Exchange Resins** :- This method involves creating a drug-resin complex by binding the drug to ion-exchange resins. While the drug passes through the gastrointestinal tract, it is released in response to alterations in the ionic environment, including changes to pH or electrolyte concentration. The resins function as a matrix system, guaranteeing a sustained release of the drug. This method is especially beneficial for medications that are prone to enzymatic degradation or have narrow absorption windows. Although ion-exchange systems provide exact release control, they necessitate comprehensive formulation optimization to guarantee stability and reproducibility[15,16].

**EVALUATION OF SUSTAIN RELEASE TABLET**

1. FT-IR Spectroscopy

2. Tablet Thickness

3. Tablet Hardness

4. Friability

**1.FTIR spectroscopy**

The Fourier transform infra-red spectroscopy of the drug, polymers, and their physical mixtures was conducted using a Shimadzu FTIR spectrophotometer with the KBr pellet technique. The instrument was used with a dry air purge, and the scan was taken at a scanning speed of 2 mm/sec and a resolution of 4 $cm^{-1}$ over the range of 4500–400 $cm^{-1}$. The identified peaks were matched with the main peaks of the reported FT-IR spectrum to authenticate the sample[17].

**2. Tablet Thickness**

The thickness of the tablet is assessed using a micrometer screw gauge. Twenty tablets are tested randomly, and average values are computed[18].

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**3. Hardness**

For tablets from every batch, a hardness test was performed using a Monsanto hardness tester, after which average values were determined[19].

**4. Friability.**

Using a Roche friabilator [Campbell Electronics, Mumbai, India] [n = 20], the friability of the prepared formulations was assessed. The samples of tablets corresponding to 6.5 g were precisely weighed, located in the drum. After the drum made 100 revolutions, the tablets were taken out. Any loose dust from the tablets was eliminated, an accurate weight was recorded, and the % friability was computed based on the weights of the tablets before and after the test[20].

**5. In vitro drug release from tablet**

Drug release studies were performed using a USP-22 dissolution apparatus-2 with a paddle type (Electrolab, Mumbai, India), rotating at 50 rpm and maintaining a temperature of 37±0.5º. The dissolution media consisted of 900 ml of 0.1 mol/l HCl for the initial 2 hours, after which a pH 6.8 phosphate buffer solution was used for 12 hours. The sink condition was upheld throughout the entire experiment. At regular intervals, samples (10 ml) were taken out and the same volume of pre-warmed (37±0.5º) fresh dissolution medium was added to keep the volume constant. Samples that were withdrawn were passed through a 0.45 µm membrane filter (Nunc, New Delhi, India). The drug content of each sample was analyzed using a UV spectrophotometer (Shimadzu UV-1700) at 233 nm after suitable dilution[21].

**CHARECTERESTICS AND EVALUATION OF GRANULES**

1 Angle of repose

2 Bulk density

3 Compressibility index

**1 Angle of repose** :-The funnel method was used to determine the granules' angle of repose. Granules with the correct weight were placed in the funnel. The funnel was adjusted to a height where its tip just

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made contact with the apex of the powder blend. The granules were permitted to move through the funnel freely onto the surface13. The granules' cone diameter was measured, and the angle of repose was determined using the equation below.

Tan θ = h/r,

where h represents the height of the powder cone.

r = radius of the conical powder[22].

**2 Bulk density**: The bulk density of a powder is determined by dividing its mass by the bulk volume, with the result expressed in gm/cm$^3$. The formula used for the calculation of bulk density was:

Bulk Density = M / Vo

Where M represents the weight of the sample

Vo = apparent powder volume[23].

**3 Compressibility index** :- Carr created an indirect method for assessing powder flow based on bulk densities. A low Carr's index indicates that the primary packing arrangement is effective and there are fewer voids in the volume. The flow of powder diminishes as the values of these indices increase[24].

**ADVANTAGES OF NATURAL POLYMER**

The following are only a few of the many benefits of natural plant-based materials.

(1) Biodegradable: Because they are created by all living organisms and are naturally occurring, they are biodegradable.

(2) Non-toxic and biocompatible: These plant components are essentially repeating sugar polysaccharides.

(3) Low cost: Using them as natural sources is less expensive. The cost of manufacture is lower than that of synthetic materials. Agriculture is the main source of income for India and many other developing nations, and it receives significant financial investment.

(4) Eco-friendly processing: Because of the straightforward production methods, a wide variety of natural chemicals derived from various plant sources are used extensively in the pharmaceutical sector and gathered in incredibly enormous numbers.

(5) Local availability (particularly in developing countries): The government of India and other homogeneous developing nations promotes the production of plants as pharmaceutical excipients and also provides the facilities for bulk production, such as gum and mucilages, due to their numerous industrial uses.

(6) Public acceptance and patient tolerance: Natural materials are less likely to have negative side effects than synthetic ones.

**DISADVANTAGES OF NATURAL POLYMER**

While there are certain better benefits to natural polymers, there are also some drawbacks that should be taken into account. The most typical drawbacks are:

1. There may have been microbial contamination.

2. There is fluctuation from batch to batch.

3. There is no control over the rate of hydration.

4. The formulation's viscosity decreased as it was being stored.

5. Seasonality characterizes most natural polymers[25].

**NATURAL POLYMER APPROACH IN SUSTAINED RELEASE DRUG DELIVERY SYSTEM**

Research on the delivery of drugs using natural polymers and their semi-synthetic derivatives is still ongoing. In matrix systems, drug-release retarding polymers are crucial. Numerous polymers, each with a unique approach to the matrix system, have been studied as drug-retarding agents. Matrix systems are often divided into three primary categories based on the characteristics of the retarding polymer: hydrophilic, hydrophobic, and plastic. The best polymers for delaying drug release are hydrophilic ones, and their use in sustained drug administration is becoming more and more

popular.Numerous natural polymers, including hibiscus mucilage, have been studied as sustained release agents. The fresh leaves of Hibiscus rosa-sinensis are used to remove the mucilage. Known by many as the "China rose," Hibiscus rosa-sinensis, a member of the Malvaceae family, is a popular landscaping shrub that may reach heights of 7 to 12 feet. Its medium-textured, glossy, dark green leaves give a striking look, as do its spectacular flowers, which are 4 to 6 inches broad and up to 8 inches long. Diclofenac sodium matrix tablets were designed and their release retardant activity in manufactured sustained release formulations was investigated utilizing mucilage from Hibiscus rosa-sinensis leaves. The physicochemical characteristics of Hibiscus rosa-sinensis leaves were assessed.Diclofenac sodium tablets made from the mucilage of Hibiscus rosa-sinensis leaves were prepared. The weight, hardness, friability, and drug content of the matrix tablets were found to be more uniform with low deviating values. The mucilage from dried Hibiscus rosa-sinensis leaves can be utilized as a matrix-forming material to create sustained release matrix tablets, as demonstrated by the swelling behavior, release rate characteristics, and in vitro dissolution studies. The chosen formulation's kinetics were zero order. The mucilage from Hibiscus rosa-sinensis leaves was found to be a useful matrix-forming polymer for maintaining the release of Diclofenac sodium from the formulation.

1 Aloe mucilage

2 Fenugreek Mucilage

3 mimosa pudica mucilage

4 Hibiscus mucilage

5 orka gum

**1.Aloe mucilage** :-

Numerous chemicals with a variety of structures have been isolated from the central parenchyma tissue of Aloe vera leaves as well as the exudates produced by the cells next to the vascular bundles in the inner portion of Aloe vera (L.) Burm.f. (Aloe barbadensis Miller) leaves. 1,8dihydroxyanthraquinone derivatives and their glycosides7 are present in the bitter yellow exudates. In addition to the various carbohydrates, it has been demonstrated that the aloe parenchyma tissue or pulp contains proteins, lipids, amino acids, vitamins, enzymes, inorganic chemicals, and tiny organic molecules. Several

researchers have determined that the main polysaccharide of the gel is partially acetylated mannan (also known as acemannan), while others have discovered that pectic material is the main polysaccharide.

**2.Fenugreek Mucilage :-**

Fenugreek, or Trigonella Foenum-graceum, is a herbaceous plant of to the leguminous family. Mucilage, a naturally occurring sticky material found in many seed coverings, makes up a large portion of fenugreek seeds. Mucilage does not dissolve in water, but when it comes into contact with liquids, it turns into a sticky, viscous substance. Fenugreek seeds swell and turn slippery when they come into contact with liquids, just like other materials that contain mucilage. In order to separate the husk from the seeds, the size-reduced seeds are first suspended in chloroform for a while before being decanted. The oily part is extracted using chloroform and subsequently air dried.There are also reports of an alternative extraction method for separating the mucilage from the husk. Hexane is used to extract the powdered seeds, which are then cooked in ethanol. After being soaked in water, the treated powder is mechanically agitated and filtered. After centrifugation, the filtrate is concentrated under vacuum and combined with 96% ethanol. After that, it is refrigerated for four hours in order to precipitate the mucilage13. The use of fenugreek seed mucilage in matrix compositions containing propranolol hydrochloride was examined in one study. For comparison, Methocel® K4M was utilized as a typical controlled release polymer.

**3.Mimosa pudica mucilage:-**

The sensitive plant, Mimosa pudica (family Mimosaceae), is a spreading undershrub that is widely distributed throughout India's tropical and subtropical regions. Mucilage from M. pudica seeds is made up of d-xylose and d-glucuronic acid. When mimosa seed mucilage comes into contact with water, it quickly hydrates and expands. The dissolving and binding characteristics of Mimosa seed mucilage were assessed in a previous work conducted in our lab. Using diclofenac sodium (DS) as a model medication, we have isolated, characterized, and assessed the sustained-release characteristics of Mimosa seed mucilage. The wet granulation method was used to formulate the DS matrix tablet, which was then assessed for appearance, weight variation, hardness, friability, in vitro drug release, swelling, and erosion behavior.

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**4.Hibiscus Mucilage:-**

Mucilage, which provides long-lasting activity, is extracted from fresh Hibiscus rosa-sinensis leaves. (Malvaceae family). L-rhamnose, D-galactose, D-galacturonic acid, and D-glucuronic acid are among the chemical components found in Hibiscus rosa-sinensis mucilage. There have been reports of using its mucilage to create sustained-release pills.

**5.Okra gum:-**

Abelmoschusculentus (Fam. Malvaceae) is the botanical name for this tall, upright annual plant. In the majority of Nigeria's tropical regions, it is extensively grown. throughout addition to being used as food and soup throughout Asia and Africa, okra has been the focus of agricultural and culinary research. When okra is crushed and extracted in water, a viscous mucilaginous solution is produced. Okra gum's potential as a pharmaceutical excipient has been discussed in literature as a binder, control release, film coating, bio-adhesive, and suspending agent. Using paracetamol as a model medication, okra gum has been assessed as a controlled-release agent in modified release matrices in contrast to sodium carboxymethylcellulose (NaCMC) and hydroxyl-propyl-methylcellulose (HPMC).Direct compression was used to create tablets, and the in-vitro drug release was evaluated for six hours under settings that resembled the gastrointestinal tract. For over six hours, okra gum matrices offered a regulated release of paracetamol, with release rates that followed time-independent kinetics. The drug's concentration within the matrix determined the release rates. The release kinetics and dissolution process were changed by the inclusion of tablet excipients, lactose and Avicel[26,27,28].

**FUTURE PERSPECTIVE**

The development of drug-delivery vehicles utilizing synthetic and natural polymers is a field of study that is progressing quickly. The most notable advancements in polymeric drug delivery are being made in the field of responsive delivery systems, which enable the tailored administration of medications based on certain sites or blood level monitoring. The researchers anticipate a number of uses for these copolymers, including lining prosthetic organs, performing immunological tests, acting as drug-targeting agents, operating in chemical reactors, and offering substrates for cell development. Implanted devices that accurately or locally distribute medications to target areas can be created using a particular polymeric system to achieve the right blood levels.Because biomimetic and bioinspired

systems can overcome a number of obstacles associated with polymeric drug delivery, they hold considerable potential for the future. It will have effectively enabled the incorporation of biocompatible and bio-related copolymers and dendrimers in cancer treatments, particularly in their role as carriers of powerful anti-cancer drugs like cisplatin and doxorubicin. Dendrimers' unique characteristics, such as their well-defined molecular weight, globular topology, high degree of branching, and multivalence, make them a promising novel scaffold for polymeric drug delivery systems. The creation and synthesis of new polymers may enable us to use a greater variety of polymer combinations in future drug delivery systems[29].

## CONCLUSION

Natural polymers play a vital role in the development of modern drug delivery systems due to their biocompatibility, biodegradability, and ability to control the rate and duration of drug release. Materials such as carrageenan, pectin, glucomannan, cellulose, agar, and xanthan gum have demonstrated excellent potential in sustained and controlled release formulations. Their capacity to swell, form gels, and interact with drugs allows for precise modulation of release kinetics, thereby maintaining therapeutic drug levels for extended periods. Sustained release tablets formulated with these polymers not only enhance treatment effectiveness but also improve patient compliance by reducing dosing frequency and minimizing side effects. The physicochemical properties of each polymer—such as solubility, viscosity, and molecular structure—significantly influence the release behavior and stability of the dosage form. Ongoing research continues to focus on optimizing natural polymer-based systems and combining them with synthetic polymers to achieve more efficient, site-specific, and responsive drug delivery. In the future, biomimetic and bioinspired polymer systems are expected to revolutionize targeted therapy, particularly in chronic and cancer treatments, by offering safe, reliable, and controlled drug release mechanisms. Thus, natural polymers represent a sustainable and promising foundation for the advancement of next-generation pharmaceutical technology.

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# ANTAGONISTIC EFFECT OF TRICHODERMA SPP.AGAINST C.COCCOIDES

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## ABSTRACT

The infected Samples of Tomato anthracnose collected from different fields of Marathwada region like Beed, Gangapur, Paithan, and Jalna during academic year 2024-2025 crop seasons. Isolation of pathogen was done by inoculating the samples on Rose Bengal agar medium and the cultures were further Purified and maintained on potato dextrose agar medium at 26+10C.The isolate of *C.coccoides* was selected for the purpose of integrated management under antagonism by different fungal antagonistic isolates. *Trichoderma atroviride,T.harzianum, T.viride.*Among them *Trichoderma atroviridi* and *T.harzianum* were found to be effective.

## KEYWORDS

*Anthracnose, C. coccoides, Trichoderma*

## INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is an important vegetable as well as nutritive crop, cultivated worldwide It is not only used in many cuisines but also found to have many medicinal properties Tomato (*Solanum lycopersicum* L.) is valued for its diverse commercial uses throughout world. India is major producer, consumer and exporter of Tomato *Colletotrichum coccoides*, India had been the largest producer and exporter of tomato, but since a few years the production has declined significantly and presently, India stands at the third number in terms of tomato production (FAOSTAT, 2012) as the most predominant species in the major Tomato growing states namely Karnataka State and Andra Pradesh (Rama chandranet al. 2008). Anthracnose is a major problem on mature leaves and fruits, causing severe losses due to both pre-harvest and post-harvest fruit decay (Hadden JF, Black LL., 1989) *Trichoderma spp*. have been known as biocontrol agents (BCA) for the control of plant diseases for decades (Weindling, 1932; Harman et al., 2004).

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**METHODOLOGY**

1) The infected samples of Tomato anthracnose collected from different fields of Marathwada region like Beed, Gangapur, Paithan, and Jalna during 2024-25 crop season.

2) Isolation of pathogen was done by inoculating the samples on Rose Bengal agar medium and the cultures were further purified and maintained on potato dextrose agar medium at 26+1°C

3) The isolate of infected fruits of tomato was selected for the purpose of integrated management under antagonism by different fungal antagonistic isolates. *Trichoderma atroviride*. *T.harzianum-1, T.harzianum-2, T viride*

4) To study the antagonistic effect, an experiment was laid out in Petri plates poured with sterilized Czapek Dox Agar Solidified medium in the plates was inoculated by placing the discs (4 mm diameter) of bio-agents culture and exacting opposite to this disc of test fungus (7 days old culture) were placed in such a manner that both organisms would get equal opportunity for their growth.

5) The experiment was conducted with three replications and one control plate containing only test fungus.

6) The antagonistic effect of *Trichoderma* was assessed on the basis of pathogen mycelial on seventh day (Vincent 1947, Dennis and Webster 1971. Arora, D K and inhibition Upadhyay, R. K. 1978).

Per cent inhibition over control was calculated as per the formulae Eq. (1) by Vincent, (1947).

$$I = \frac{C-T}{C} \times 100$$

Where, I = Per cent inhibition over control

C=Growth of test pathogen with absence of antagonist (mm)

T= Growth of test pathogen with antagonist (mm)

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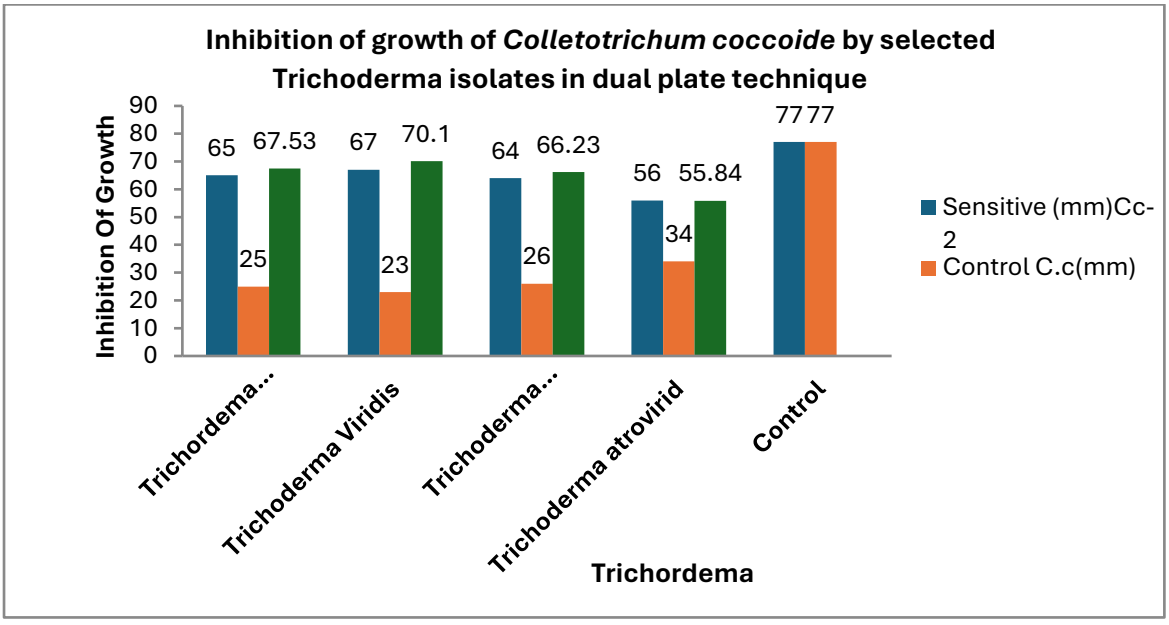
## RESULTS AND DISCUSSION

| Sr. No. | *Trichoderma*spp. | *C.coccoides* | Cc-5 Resistant(mm) | PCE* |
|---|---|---|---|---|
| 1 | *Trichoderma harizianum*-1 | 21.8 | 68.22 | 71.68 |
| 2 | ***T. viride*** | **20.0** | **70.00** | **74.02** |
| 3 | ***T.harizianum*-2** | **20.0** | **70.00** | **74.02** |
| 4 | *T. atroviride* | 30.4 | 59.66 | 60.50 |
| 5 | Control<br>C.D. (P= 0.05) | 77.0<br>16.89 | --<br>6.20 | --<br>3.34 |




The effect of seed and soil treatment with *Trichoderma harzianum* and *Trichoderma viride* were significantly effective against seed borne fungal pathogens including *Colletotrichum spp.* (RaoVCh. Narayana YD., 2010) The highly isolate of *C. coccoides* was selected for the purpose of integrated management under antagonism by different fungal antagonistic isolates. *Trichoderma atroviride,T harzianum-1, T harzianum-2, T viride Among them Trichoderma harzianum-2, T viride* were found to be effective *T viride* gave PCE 60. 10 to 74.02

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# BIOLOGY AND MANAGEMENT OF TOMATO LEAF MINER (TUTA ABSOLUTA MEYRICK, 1917): A COMPREHENSIVE REVIEW.

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## ABSTRACT

The tomato leaf miner, *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae), is one of the most destructive insect pests of tomato worldwide. Native to South America, this invasive pest has rapidly spread across Europe, Africa, the Middle East, and Asia, including India, causing severe yield losses ranging from 80–100% under uncontrolled conditions. Its endophytic feeding habit, high reproductive potential, multivoltine nature, and ability to develop resistance to insecticides make its management extremely challenging. This review synthesizes published research from reputed journals on the biology, distribution, damage symptoms, and management strategies of *T. absoluta*. Emphasis is placed on integrated pest management (IPM) approaches, including cultural, mechanical, biological, botanical, biotechnical, host plant resistance, and chemical control methods. The review highlights recent advances, challenges, and future research needs for sustainable management of *T. absoluta*, particularly under diverse agro-climatic conditions of developing countries.

## KEYWORDS

*Tuta absoluta*, tomato leaf miner, Solanaceous crops, biology, integrated pest management, biological control, botanicals, pheromones

## INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the most important vegetable crops grown worldwide for fresh consumption and processing. It ranks among the top vegetable crops in terms of area and production, contributing significantly to food security, nutrition, and farm income. Tomatoes are rich sources of vitamins A, C, and E, minerals, and antioxidants such as lycopene, which is associated with reduced risks of cardiovascular diseases and certain cancers.

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Despite its economic and nutritional importance, tomato production is severely constrained by insect pests and diseases. Among the insect pests, the tomato leaf miner, *Tuta absoluta* (Meyrick, 1917), has emerged as a major threat to tomato cultivation globally. Since its first detection outside South America in Spain in 2006, *T. absoluta* has spread rapidly across Europe, Africa, the Mediterranean basin, and Asia, including India, Bangladesh, and Nepal. In India, the pest was first reported in 2014 and has since established itself in almost all major tomato-growing states.

Biological invasions such as *T. absoluta* are increasingly facilitated by globalization, international trade, and climate change. Invasive arthropod pests pose serious challenges to sustainable agriculture due to their rapid spread, lack of effective natural enemies in new areas, and heavy reliance on chemical insecticides. Therefore, an integrated pest management (IPM) approach is essential for effective and environmentally sound management of *T. absoluta*.

## 2. Global Distribution and Invasion History

*Tuta absoluta* is native to South America and was first described from Peru in 1917. It later spread to several South American countries, including Brazil, Argentina, Chile, Colombia, and Venezuela. The pest was first detected in Europe in Spain in 2006 and subsequently spread throughout Southern Europe, North Africa, and the Mediterranean region.

In Africa, *T. absoluta* has been reported from countries such as Egypt, Ethiopia, Kenya, Sudan, and Nigeria, where it poses a serious threat to smallholder and commercial tomato production. In Asia, the pest has been recorded in Iran, Iraq, Israel, Turkey, India, Bangladesh, and Nepal. In India, its rapid spread across diverse agro-climatic regions has resulted in severe yield and quality losses, making it one of the most destructive tomato pests in recent decades.

## 3. Biology and Life Cycle

**Table 1. Summary of biology and life cycle of *Tuta absoluta***

| Life stage | Description | Duration (days)* | Key characteristics |
|---|---|---|---|
| **Egg** | Elliptical, creamy white to yellowish; laid singly or in clusters on underside of leaves, stems, buds and fruits | 4–7 | Female lays up to 250–260 eggs; incubation influenced by temperature |

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| | | | |
|---|---|---|---|
| **Larva** | Four instars; whitish initially, later greenish or pinkish | 10–15 | Most destructive stage; mines leaves, stems and fruits |
| **Pupa** | Formed in soil, leaf mines or plant debris; green turning dark brown | 5–10 | Protected stage; survives adverse conditions |
| **Adult** | Small moth (~10 mm); silvery-grey scales; nocturnal | 10–15 (adult longevity) | Active at night; responsible for mating and oviposition |

*Duration varies with temperature and environmental conditions.

The life cycle of *T. absoluta* consists of four stages: egg, larva, pupa, and adult. The duration of the life cycle varies with temperature and host plant, typically completing in 24–38 days.

**3.1 Egg**

Eggs are small, elliptical, creamy white to yellowish, and laid singly or in small groups on the underside of leaves, stems, buds, or calyx of fruits. A single female can lay up to 250–260 eggs during her lifetime. Egg incubation period ranges from 4–7 days, depending on temperature.

**3.2 Larva**

Larvae pass through four instars and are the most destructive stage. Newly hatched larvae are whitish, later turning greenish or pinkish. Larvae mine leaves, stems, and fruits, forming galleries that reduce photosynthetic area and marketability of fruits. Larval development lasts 10–15 days.

**3.3 Pupa**

Pupation occurs either in the soil, within leaf mines, or on plant debris. Pupae are initially green and later turn dark brown. The pupal stage lasts about 5–10 days.

**3.4 Adult**

Adults are small moths, about 10 mm long, with silvery-grey scales and filiform antennae. They are nocturnal and remain hidden during the day. Adults live for 10–15 days, during which mating and oviposition occur.

## 4. Nature of Damage and Economic Importance

*Tuta absoluta* attacks tomato plants at all growth stages, from seedlings to fruiting plants. Larvae mine leaves, bore into stems, and penetrate fruits, making them unmarketable. Severe infestations can lead to 80–100% yield loss under favorable conditions. Apart from tomato, the pest can also infest other Solanaceous crops such as potato, brinjal, and capsicum, as well as several wild host plants.

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**5. Management Strategies**

**Table 2. Comparison of management strategies used against *Tuta absoluta***

| Management approach | Tools/agents used | Mode of action | Advantages | Limitations |
|---|---|---|---|---|
| **Cultural control** | Crop rotation, removal of infested plant parts, deep ploughing, sanitation | Reduces pest carryover and breeding sites | Low cost, eco-friendly | Requires strict field hygiene |
| **Mechanical/Physical control** | Handpicking, light traps, insect-proof nets | Physical removal or exclusion | Safe, non-toxic | Labour intensive, limited efficacy alone |
| **Biological control** | *Trichogramma* spp., *Nesidiocoris tenuis*, *Dolichogenidea gelechiidivoris* | Parasitism and predation | Sustainable, long-term control | Slow establishment, climate dependent |
| **Entomopathogenic fungi** | *Beauveria bassiana*, *Metarhizium anisopliae* | Infection leading to larval mortality | Eco-friendly, compatible with IPM | Slower action, affected by humidity |
| **Botanical pesticides** | Neem, garlic, lemongrass extracts | Antifeedant, repellent, growth inhibition | Safe to non-targets, biodegradable | Variable efficacy |
| **Biotechnical control** | Sex pheromone traps | Monitoring, mass trapping, mating disruption | Species-specific, safe | Needs proper installation and maintenance |

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| | | | | |
|---|---|---|---|---|
| **Chemical control** | Chlorantraniliprole, indoxacarb, spinosad, emamectin benzoate | Nervous system disruption | Quick knockdown | Resistance development, harmful to natural enemies |

**5.1 Cultural Control**

Cultural practices play an important role in reducing pest populations. These include removal and destruction of infested plant parts, crop rotation with non-host crops, deep ploughing to destroy pupae, use of pest-free seedlings, and avoidance of continuous tomato cultivation.

**5.2 Mechanical and Physical Control**

Mechanical methods such as handpicking of infested leaves and fruits, use of light traps, and installation of insect-proof nets in nurseries and greenhouses can help reduce infestation levels.

**5.3 Biological Control**

Biological control is a key component of IPM for *T. absoluta*. Several natural enemies, including parasitoids (*Trichogramma* spp., *Dolichogenidea gelechiidivoris*), predators (*Nesidiocoris tenuis*), and entomopathogenic fungi (*Beauveria bassiana*, *Metarhizium anisopliae*), have shown promising results. Conservation and augmentation of these natural enemies can significantly suppress pest populations.

**5.4 Botanical and Biopesticides**

Botanical pesticides such as neem (*Azadirachta indica*), garlic (*Allium sativum*), and lemongrass (*Cymbopogon citratus*) extracts have shown insecticidal, antifeedant, and repellent effects against *T. absoluta*. Entomopathogenic fungi have also demonstrated substantial larval mortality under field conditions, offering eco-friendly alternatives to chemical insecticides.

**5.5 Biotechnical Control**

Pheromone-based tools, including sex pheromone traps, are widely used for monitoring, mass trapping, and mating disruption. These methods are effective, species-specific, and environmentally safe.

**5.6 Chemical Control**

Chemical insecticides such as chlorantraniliprole, indoxacarb, spinosad, emamectin benzoate, and Bt formulations have been used against *T. absoluta*. However, indiscriminate use has led to the

development of resistance and negative impacts on natural enemies. Therefore, chemical control should be used judiciously and in rotation with other management strategies.

**6. Integrated Pest Management (IPM)**

An effective IPM strategy for *T. absoluta* involves the integration of cultural, mechanical, biological, botanical, biotechnical, and chemical methods. Regular monitoring, use of economic threshold levels, conservation of natural enemies, and farmer awareness are essential components of successful IPM programs.

## CHALLENGES AND FUTURE PROSPECTS

Major challenges in managing T. absoluta include rapid resistance development, lack of awareness among farmers, limited availability of biological control agents, and variability in climatic conditions. Future research should focus on developing resistant tomato varieties, improving biological control efficiency, and strengthening IPM adoption at the farmer level.

## CONCLUSION

Tuta absoluta continues to pose a serious threat to global tomato production. Sustainable management of this pest requires a holistic IPM approach that minimizes reliance on chemical insecticides and promotes eco-friendly alternatives. Continued research, extension efforts, and policy support are crucial for mitigating the impact of this invasive pest and ensuring sustainable tomato production.

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# GREEN-SYNTHESIZED METAL NANOPARTICLES IN POULTRY PRODUCTION: ANTIMICROBIAL PROPERTIES, STRESS MANAGEMENT, AND GROWTH ENHANCEMENT

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## ABSTRACT

Nanotechnology presents groundbreaking approaches to tackle antimicrobial resistance, improve stress management, and boost productivity in agriculture. This review consolidates findings on environmentally-friendly synthesized silver (Ag), copper (Cu), and iron (Fe) nanoparticles, exploring synthesis techniques, characterization, antimicrobial characteristics, and their applications in poultry. The use of mint (Mentha spp.), basil (Ocimum basilicum), and pomegranate peel in green synthesis offers eco-friendly alternatives to traditional chemical methods. Silver nanoparticles exhibit significant antimicrobial properties, with a minimum inhibitory concentration of 2.49 µg/mL against Escherichia coli, along with protective effects against aflatoxin. Copper nanoparticles improve stress adaptation, intestinal structure, and antioxidant levels in response to cold stress. Iron oxide nanoparticles enhance growth performance by 15.8% in body weight and effectively decrease ammonia emissions during heat stress, utilizing doses that are 60-80% lower than traditional sources. Nonetheless, it is essential to conduct a thorough assessment of tissue accumulation and oxidative stress. This review highlights the potential of green-synthesized nanoparticles as sustainable alternatives to antibiotic growth promoters, while also pinpointing existing knowledge gaps in mechanistic understanding, standardization, and regulatory frameworks.

## KEYWORDS

green synthesis; nanoparticles; mint extract; poultry production; antimicrobial activity; stress management

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## INTRODUCTION

The global agriculture and poultry sectors encounter significant challenges such as antimicrobial resistance, environmental stressors, mycotoxin contamination, and the necessity to meet food demands in a sustainable manner. Traditional methods such as antibiotic growth promoters have sparked worries regarding the emergence of resistance and environmental contamination (Gunal et al., 2006; Havenstein et al., 2003). The 2006 ban by the European Union on antibiotic growth promoters, as outlined in Regulation (EC) No. 1831/2003, required the development of alternative strategies.

Nanotechnology presents a transformative approach characterized by improved bioavailability, precise delivery, regulated release, and minimized environmental effects (Ahmadi & Rahimi, 2011; Remya et al., 2017). Metal nanoparticles (1-100 nm) display unique physicochemical characteristics such as elevated surface area-to-volume ratios, heightened reactivity, enhanced cellular uptake, and innovative optical properties (Tsekhmistrenko, 2024), allowing for supplementation at reduced doses while achieving superior biological effects.

Silver, copper, and iron nanoparticles exhibit significant antimicrobial effects and play crucial nutritional roles. The use of plant extracts, microorganisms, or agricultural by-products in "green synthesis" as reducing and stabilizing agents presents advantages such as environmental sustainability, cost-effectiveness, biocompatibility, and improved biological properties (Khan et al., 2013; Remya et al., 2017). Plant extracts abundant in polyphenols, flavonoids, and terpenoids play a dual role in the reduction of metal ions and the stabilization of nanoparticles.

## 2. Green Synthesis Methods and Characterization

### 2.1 Fundamental Concepts and Botanical Resources

Green synthesis utilizes biological materials as reducing and stabilizing agents, thereby removing toxic chemicals and reducing the high energy consumption associated with traditional methods (Tsekhmistrenko, 2024). Plant-derived compounds such as polyphenols, flavonoids, and terpenoids play a crucial role in the reduction of metal ions and contribute to the stabilization of colloids through surface capping (Remya et al., 2017).

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Mint extracts (Mentha piperita, M. arvensis) that are abundant in polyphenols (9.81 mg/mL) facilitate the production of silver and copper nanoparticles. FTIR analysis indicates the presence of hydroxyl (3349-3404 $cm^{-1}$), carbonyl (1597-1646 $cm^{-1}$), and C-O stretching (1048-1108 $cm^{-1}$) groups involved in reduction and stabilization. The process of synthesizing silver nanoparticles entails the combination of mint extract with 1 mM $AgNO_3$ at a temperature of 30°C for a duration of 24 hours, as verified by UV-Vis spectroscopy, which shows peaks in the range of 400-470 nm. Basil (Ocimum basilicum) extract yields iron oxide nanoparticles with an average size of 40 nm, whereas pomegranate peel, containing 9.33% tannin, synthesizes silver nanoparticles also measuring 40 nm, exhibiting a zeta potential of -29 mV and demonstrating excellent stability (Al-Othman et al., 2017).

### 2.2 Characterization

The synthesis is confirmed by UV-Visible spectroscopy, which shows surface plasmon resonance at 400-470 nm for AgNPs and 275-285 nm for CuO. XRD analysis indicates the presence of crystalline structures: silver exhibits a face-centered cubic (FCC, JCPDS 04-0783, 4.1-25 nm crystallites), while copper oxide displays a monoclinic structure (JCPDS 00-000-0661, 2.8-19.08 nm). TEM and SEM demonstrate a variety of morphologies, including spherical, triangular, and hexagonal shapes, ranging from 10 to 50 nm. The dynamic light scattering technique provides measurements of hydrodynamic diameter ranging from 49 to 53 nm, alongside zeta potential values between -20 and -23 mV, indicating stability. EDX verifies the elemental composition, indicating silver content ranging from 41.40% to 67.98%. The green synthesis method yields larger particles, measuring 12.2 nm compared to 3.5 nm from thermochemical processes, and does so at significantly lower temperatures of 60°C versus over 300°C, while also demonstrating enhanced environmental compatibility (Tsekhmistrenko, 2024).

## 3. Silver Nanoparticles: Antimicrobial Properties and Applications

### 3.1 Antimicrobial Efficacy

Silver nanoparticles exhibit significant antimicrobial properties via multiple synergistic mechanisms, offering broad-spectrum effectiveness against a variety of pathogens. The minimum inhibitory concentration (MIC) values against Gram-negative bacteria, including Escherichia coli, can be as low as 2.49 µg/mL, indicating a competitive edge over traditional antibiotics such as kanamycin. The MIC

for Gram-positive Staphylococcus aureus varies between 11.1 and 51.5 µg/mL, which highlights the significant protective benefit provided by their considerably thicker peptidoglycan layers (20-80 nm, in contrast to the 7-8 nm thickness found in Gram-negative bacteria) (Al-Saeedi et al., 2021; Faizan et al., 2024). The antimicrobial action of silver nanoparticles functions through various interconnected mechanisms. These include membrane disruption due to the electrostatic attraction between positively charged nanoparticles and negatively charged bacterial cell walls, DNA damage that interferes with replication processes, enzyme inhibition impacting essential ATP production pathways, the generation of reactive oxygen species (ROS) that cause lethal oxidative damage to cellular components, and the continuous release of silver ions that enhance these antimicrobial effects. In addition to their effects on bacterial targets, AgNPs exhibit notable antifungal properties by suppressing the growth of Aspergillus flavus and significantly reducing aflatoxin production (Zhao et al., 2017). Copper oxide nanoparticles demonstrate significant antifungal activity, showing inhibition zones of 1.5 cm against Candida albicans, which is the highest efficacy recorded among all microorganisms tested.

### 3.2 Poultry Production Effects

The administration of AgNPs enhances growth performance in a dose-dependent manner. In broilers receiving 20-50 ppm via drinking water, there was a significant increase in beneficial Lactobacilli populations in the jejunum and ileum at 40-50 ppm (14 and 42 days), while E. coli populations decreased dramatically, with 50 ppm resulting in the lowest counts (Al-Saeedi et al., 2021). In rabbits subjected to heat stress at 33°C, the administration of subcutaneous AgNPs at a dosage of 0.5 mg/kg resulted in a notable enhancement of final body weight.

The effects on the immune system are intricate and vary with dosage. Administration of AgNPs (5 mg/kg orally) resulted in an increase in phagocytic activity, leukocyte metabolic activity, and lysozyme activity after 24 days (Ognik et al., 2016). Intermediate concentrations could potentially hinder bursa development by disrupting the microbial balance, whereas elevated concentrations (50 ppm) might lead to toxicity.

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### 3.3 Safeguarding Against Aflatoxin and Ensuring Safety

In broilers exposed to aflatoxin (70 ppm), the addition of AgNPs (150 ppm) resulted in a reduction of aflatoxin levels from 1.91 to 1.86 ppm and led to a significant decrease in liver damage, including congestion, thrombus formation, sinusoid dilatation, bile duct hyperplasia, necrosis, edema, and hemorrhage (Jasim & Al-Taee, 2023). Protection mechanisms encompass direct adsorption, interference with absorption, antioxidant properties, and improved hepatic detoxification.

Concerns regarding safety encompass oxidative stress and the accumulation of tissue. AgNPs (22 nm) resulted in a reduction of SOD and CAT activities, an increase in lipid peroxidation markers (LOOH, MDA), and a rise in cholesterol/LDL levels (Ognik et al., 2016). Silver residues accumulated in rabbit plasma and meat in a dose-dependent manner, showing variations among different breeds (Abdelsalam et al., 2019). Given that silver is not a necessary nutrient, the presence of tissue residues poses significant food safety issues.

## 4. Copper Nanoparticles: Analyzing Stress Management and Metabolic Support

### 4.1 Effects of Cold Stress

Copper plays a crucial role in metabolism, immunity, and antioxidant defense via Cu-Zn SOD. Conventional sources exhibit restricted bioavailability as a result of phytate binding. Nanoparticles improve absorption by increasing surface area and facilitating interactions with transporters such as DMT1 and CTR1 (Abdullah et al., 2022).

In Hubbard broilers subjected to cyclic cold stress (13°C±2°C, 8 hours daily, days 22-35), the addition of CuNP (5, 10, 15 mg/kg, 25 nm size) enhanced body weight and feed conversion relative to cold-stressed controls, with the most significant effects observed at 15 mg/kg (Abdullah et al., 2022). CuNPs influenced thyroid metabolism by linearly decreasing T3 levels while increasing T4, indicating enhanced metabolic efficiency that reduces the necessity for excessive T3 elevation.

### 4.2 Gastrointestinal Well-being and Oxidative Defense

Cold stress led to a decrease in villus height, villus surface area, and the VH:CD ratio throughout the intestinal segments. CuNP supplementation led to a notable enhancement in intestinal morphometry

in a dose-dependent manner, exhibiting linear increases ($p<0.05$) in villus height, width, crypt depth, and surface area across all segments. The group receiving 15 mg/kg exhibited the highest values. There was an observed increase in goblet cell populations within the jejunum and ileum, especially those producing acidic mucins that contribute to microbial defense (Abdullah et al., 2022).

CuNPs enhanced antioxidant status, showing a linear increase in SOD activity while MDA levels decreased linearly with dosage. Improved copper bioavailability facilitated the synthesis of Cu-Zn SOD, thereby bolstering antioxidant defenses. Serum corticosterone exhibited a linear decrease with supplementation, suggesting a diminished stress response (Abdullah et al., 2022).

**5. Iron Oxide Nanoparticles: Growth Enhancement and Environmental Benefits**

**5.1 Growth Performance Under Heat Stress**

Iron plays a crucial role in oxygen transport, as hemoglobin comprises 60-70% of the body's iron. It is also vital for enzyme activation, energy metabolism, and antioxidant defense mechanisms. Heat stress negatively affects feed intake, growth, immunity, and meat quality, while also leading to decreased iron concentrations (Almeldin et al., 2024). Traditional iron supplementation encounters difficulties due to phytate binding. Nanoparticles address these challenges by improving absorption capabilities.

In Ross 308 broilers subjected to heat stress (34.5°C/45% RH from days 1-21; 28.5°C/40% RH from days 22-42), the administration of green iron oxide nanoparticles (20, 40 mg/kg) resulted in a linear enhancement of body weight ($R^2$=0.574) and weight gain ($R^2$=0.367) by day 42. The 40 mg/kg dose resulted in 2,245.3 g compared to 1,939.5 g in the controls, indicating a 15.8% improvement. Body weight gain increased by 16.15% with a dosage of 40 mg/kg. The feed conversion ratio showed consistent improvement across all periods ($R^2$=0.424), with the 20 mg/kg treatment yielding the most efficient FCR at 1.455, representing a 14.56% enhancement compared to the control group at 1.703. The feed intake remained consistent, suggesting improved nutrient utilization (Almeldin et al., 2024).

**5.2 Environmental Benefits and Meat Quality**

The application of Nano-Fe led to a notable decrease in excreta ammonia content ($R^2$=0.454) at both 21 and 42 days, with the lowest levels observed at a dosage of 40 mg/kg. This reduction enhances

animal welfare and promotes environmental sustainability by mitigating respiratory diseases, atmospheric pollution, acid rain, and eutrophication. The mechanism encompasses the effects of Nano-Fe on the nitrogen metabolism of intestinal microbes (Almeldin et al., 2024).

The incorporation of Nano-Fe has led to enhancements in meat quality, evidenced by a higher dressing percentage, reduced abdominal fat, improved water-holding capacity in both breast and leg muscles, and a decrease in cooking loss. The iron content exhibited a dose-dependent increase across various tissues (breast, leg, liver, serum) while remaining within safe limits (EU maximum residue limit: 150 mg/kg poultry meat), which could enhance nutritional value for consumers (Almeldin et al., 2024).

## 6. Comparative Analysis and Safety Considerations

### 6.1 Bioavailability Enhancement

The enhanced efficacy of nanoparticles arises from their small size (1-100 nm) and a large surface area-to-volume ratio, which contribute to improved bioavailability. They efficiently infiltrate the intestinal epithelium through mechanisms such as endocytosis, pinocytosis, and transporter-mediated uptake, where an increased surface area facilitates enhanced interaction with transporters (DMT1, CTR1) (Abdullah et al., 2022; Singh, 2016). This allows for efficient supplementation at significantly reduced doses: iron oxide at 20-40 mg/kg compared to the NRC-recommended 85 mg/kg; copper at 5-15 mg/kg versus the typical 8-16 mg/kg.

Nanoparticles exhibit significantly reduced susceptibility to interactions with phytate compared to traditional sources, thereby preserving bioavailability. The use of green synthesis capping agents, such as polyphenols and proteins, enhances colloidal stability and enables controlled release. This approach effectively prevents aggregation and oxidation, while also modulating the release of mineral ions. As a result, it contributes to sustained bioavailability and minimizes toxicity (Remya et al., 2017).

### 6.2 Safety Profiles

Concerns have been raised about the accumulation of silver nanoparticles in tissues and their potential toxicity. Data indicates the presence of oxidative stress, a reduction in antioxidant enzymes, changes in immune function, and a dose-dependent buildup (Abdelsalam et al., 2019; Ognik et al.,

2016). Given that silver is not a necessary nutrient, the presence of residues prompts concerns regarding food safety.

Copper and iron nanoparticles exhibit more advantageous safety profiles as vital nutrients when administered in suitable dosages. Iron nanoparticles combined with algae demonstrated no negative impacts on organs and enhanced production parameters (Almeldin et al., 2024). Copper nanoparticles (5-15 mg/kg) enhanced growth, intestinal health, and antioxidant status while showing no signs of toxicity. Nonetheless, an overabundance of supplementation may lead to toxicity mediated by reactive oxygen species. Enhancing tissue may provide advantages to consumers by increasing nutritional value, provided that the levels stay within safe limits.

### 6.3 Size-Dependent Toxicity and Environmental Impact

Nanoparticle toxicity shows strong size dependence, with smaller particles exhibiting greater toxicity due to increased surface area (Faizan et al., 2024). In broilers, 5 nm lipid-coated AgNPs produced more severe oxidative stress than 22 nm AgNPs (Ognik et al., 2016). Green synthesis producing larger particles (12.2 nm vs. 3.5 nm) may offer favorable safety margins while maintaining efficacy.

Green synthesis offers substantial environmental advantages: lower temperatures (60-100°C vs. >300°C), elimination of toxic chemicals, aqueous media operation, and good stability/biocompatibility (Tsekhmistrenko, 2024). Enhanced bioavailability enables 60-80% lower doses, substantially reducing mineral excretion and environmental accumulation. Significant ammonia reduction ($R^2$=0.454) and improved feed efficiency (14.56%) contribute to resource conservation, reducing land use, water consumption, and greenhouse gas emissions per production unit.

## FUTURE PERSPECTIVES AND RESEARCH PRIORITIES

Future studies should focus on the systematic optimization of nanoparticle characteristics, emphasizing precise size control across specified ranges (5-10 nm, 10-25 nm, 25-50 nm, 50-100 nm), surface modifications with biocompatible materials (lipids, polysaccharides, proteins), the influence of shape (spherical, rod-shaped, triangular, hexagonal) on cellular uptake, and the optimization of extract concentration. A comprehensive mechanistic understanding is still lacking, necessitating

exploration of cellular uptake pathways (such as receptor-mediated, clathrin-mediated, and caveolae-mediated endocytosis), intracellular trafficking, interactions with microbiota, modulation of signaling pathways, and ADME kinetics via transcriptomic, proteomic, metabolomic, and advanced microscopy techniques.

The establishment of uniform synthesis protocols, rigorous quality control measures, and defined characterization requirements would enhance reproducibility and support the path to commercialization. Essential parameters encompass particle size distribution (polydispersity index <0.3), surface charge (zeta potential), crystallinity (XRD patterns), purity, morphology, and stability. Well-defined regulatory frameworks are crucial, focusing on maximum tissue residue levels, good manufacturing practices, labeling requirements, environmental impact assessments, post-market surveillance, and risk assessment frameworks tailored to nanomaterials. Global harmonization would enhance trade across borders and guarantee uniform safety standards.

Extended applications encompass in ovo administration for early-life advantages, environmental disinfection of litter and housing, intelligent delivery systems with controlled release that respond to specific triggers such as pH changes, temperature increases, and enzyme presence, as well as combination strategies with other feed additives like probiotics, prebiotics, enzymes, and organic acids to achieve synergistic effects. Investigations ought to encompass laying hens, breeders, turkeys, ducks, and additional poultry species, as diverse species may exhibit differing responses attributable to variations in digestive physiology, growth rates, metabolic requirements, and susceptibility to stress.

## CONCLUSION

Metal nanoparticles synthesized through green methods present potential advancements for agriculture and poultry production. The production of silver, copper, and iron nanoparticles through plant extracts demonstrates enhanced antimicrobial properties, improved stress management, and greater growth promotion when compared to conventional techniques.

Silver nanoparticles exhibit significant antimicrobial properties (MIC 2.49 µg/mL against E. coli), enhance the balance of intestinal bacteria, and offer protection against aflatoxin toxicity. However, they may also induce oxidative stress and tissue accumulation, necessitating a thorough safety

assessment. Copper nanoparticles (5-15 mg/kg) assist birds in managing cold stress, enhance growth and feed efficiency, and bolster intestinal health at doses 60-80% lower than traditional sources. Iron oxide nanoparticles enhance growth by 15.8% and feed efficiency by 14.56% during heat stress at considerably lower doses (20-40 mg/kg) compared to standard recommendations (85 mg/kg), while also significantly decreasing ammonia emissions and enhancing meat quality within safe limits.

The process of green synthesis utilizing extracts from mint, basil, and pomegranate is advantageous for the environment, as it avoids the use of toxic chemicals and functions at significantly lower temperatures (60-100°C compared to over 300°C). Improved bioavailability achieved by increasing surface area, enhancing absorption, minimizing phytate binding, and regulating release allows for effective application at doses 60-80% lower, leading to cost savings and a reduced environmental footprint.

Significant obstacles persist: the need for long-term safety evaluations, the establishment of production standards, a deeper understanding of cellular mechanisms, assessments of environmental impact, and thorough economic evaluations. It is essential to establish precise regulations regarding residue levels, manufacturing practices, and safety monitoring. Through ongoing investigation and appropriate supervision, green-synthesized nanoparticles hold significant promise for enhancing agricultural productivity and sustainability, providing alternatives to antibiotics and traditional minerals for a safer and more efficient approach to animal agriculture.

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# TYPES OF ENTREPRENEURSHIPS

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## ABSTRACT

Entrepreneur is a word borrowed from the French words entreprendre, “one who undertakes”—that is, a “manager.” In fact, the word entrepreneur was shaped probably from celui qui entrapment, which is loosely translated as “those who get things done.” In the early eighteenth century, a group of thinkers called the Physiocrats surfaced in France around a school of new economic theory. They were the first proponents of laissez-faire and opposed all government intervention in industry, especially taxation. Their doctrine was that the economic affairs of society are best guided by the decisions of individuals.

One of the most famous among them was Richard Cantillon. In a paper he worked on between 1730 and 1734 and that was later published in 1775 as Essai sur la Nature du Commerce en General, he introduced the concept of entrepreneur. He developed these early theories of the entrepreneur after observing the merchants, farmers, and craftsmen of his time. Jean-Baptiste Say, a French businessman turned economist, followed Cantillon with his Trait d’economie politique in 1803. His work commented on the theory of markets and how the entrepreneur is involved in this transaction of goods for money.

## KEYWORDS

Technology, Business Entrepreneur**,** Entrepreneurship

## OBJECTIVE OF THE RESEARCH STUDY

1. To study and understood the concept of entrepreneurship**.**
2. To study types of entrepreneurships.

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## RESEARCH METHODOLOGY

The primary source of data collection in this research paper is the secondary data. The available information on **Entrepreneurship** has been extensively used to complete the research paper. All the available Journals, Related books, Web, Articles, Publish and unpublished information and Papers provided necessary information to the finalize the research paper.

## TYPES OF ENTREPRENEURSHIPS

People have different visions, goals, dreams and aspirations for the type of business they want to create. For some, hard work is the success factor and for some having enough capital results in a successful venture. Some entrepreneurs give social good priority over other aspects.

Learning about the type of entrepreneurship a company follows can help you decide whether you can survive their work culture. The type of entrepreneurship affects the working environment and the qualities of the entrepreneur. For example, if you are looking to work in a company that fosters creativity and innovation, applying for a job in imitative or social entrepreneurship will not serve the purpose. For you, the ideal workplace would be companies following technology or innovative entrepreneurship.

### 1. Small business entrepreneurship

Small businesses represent an overwhelming majority of Indian entrepreneurial ventures. People who establish small business entrepreneurship make profits to support their families and live a modest lifestyle. As small businesses are small and lack the innovative factor, they fail to attract venture capital for smooth running. These people usually fund their ventures themselves or take up loans from friends and family members. The employees are usually local people or family members.

Local hairdressers, grocery shops, milk booths, plumbers, carpenters and small boutiques are part of the small business entrepreneurship.

### 2. Large company entrepreneurship

Companies with a finite life cycle display large company entrepreneurship. These companies sustain because of innovation and it is the best choice for advanced professionals who know how to sustain

innovation. When you work in a large company, you are likely to be a part of a large C-level executive team. The products these companies offer are different variants around their core product. Small business entrepreneurship witnessing accelerated growth can become large company entrepreneurship in no time. This is also possible when a large company acquires them.

**3. Scalable startup entrepreneurship**

This type of entrepreneurship starts with a unique idea that can bring a change. From creating a business plan to launching it, scalable startup entrepreneurship recognizes what is missing in the market and creates a solution. Such business usually receives funding from venture capitalists that provide funding based on the uniqueness of the idea. They hire specialized employees because they seek rapid expansion and high returns.

**4. International entrepreneurship**

In international entrepreneurship, entrepreneurs conduct business activities across the Indian national boundaries. This could either be opening a sales office in another country or exporting goods from India to a foreign country. International entrepreneurship is beneficial when the demand for goods and services is declining in the domestic market and the demand arises from the international market. Usually, international entrepreneurs sell products in the Indian market until they reach the maturity stage and then sell them in the foreign market to earn profits.

**5. Social entrepreneurship**

Social entrepreneurship is a type of entrepreneurship in which entrepreneurs recognise a social problem and tailor their activities to create social value. Such entrepreneurs develop services, solutions or products to solve critical social issues and bring about social change. This social change could be related to environment conservation, animal rights protection or philanthropic activities for the underserved community. The motivating factor of social entrepreneurship is achieving social benefits. Working in a social enterprise means prioritising transformative social change while ensuring financial sustainability.

These organizations use ethical practices such as conscious consumerism and corporate social responsibility to facilitate success. Instead of making profits and earning wealth for the owners, social entrepreneurship aims to make the world a better place to live.

Non-profit organizations are the best social enterprise examples.

**6. Environmental entrepreneurship**

It is also known as ecopreneurship and green entrepreneurship. Profit generation and a concern for the environment drive the primary goal of such businesses. An ecopreneur adopts highly environmentally responsible business values and practices. They also try to replace the existing product or services with products that are environmentally safe to use. In short, environmental entrepreneurship prioritizes the business impact on people and the environment besides profits.

Impact blogging, publishing an audiobook and creating SaaS software are a few examples of environmental entrepreneurship as they protect the environment by not cutting trees.

**7. Technopreneurship**

Technopreneurship is what you get on uniting technology with entrepreneurship. It is also known as technology entrepreneurship. A technopreneur merges entrepreneurial talent and skills with the technical prowess to develop a business that thrives on the intensive use of technology. Technopreneurs undertake calculated risks that have chances of earning profits. In short, these are entrepreneurs who have the ability to revolutionize the prevailing economic conditions and introduce breakthrough products for the customers. The foundation of the products and services of such a business is technology. Such a business prefers to employ creative and technology-savvy people who are passionate about bringing technological change.

**8. Hustler entrepreneurship**

A hustler entrepreneur is a self-starter motivated by their goals and aspirations to succeed in entrepreneurship. Such people start small and work hard to grow their business. Instead of using money or capital to achieve their business goals, they put in their best efforts. They never wait for

opportunities to come because they create opportunities. Hustlers do not have a give-up attitude, have a big risk-taking appetite and are always ready to face challenges.

**9. Innovative entrepreneurship**

The foundation of innovative entrepreneurship is inventions and new ideas. These entrepreneurs can think about novel ways of doing business and have the potential to turn a new idea into a successful venture. They are business leaders and contribute significantly to the economy. Moreover, such companies strive to make life better by providing products, solutions and services which other companies have not. Innovative entrepreneurship is ambitious and requires significant investment to turn a new idea into a breakthrough service or product.

**10. Imitative entrepreneurship**

This entrepreneurship mimics or imitates existing business ideas and works hard to improve them. Such companies imitate already functioning products and services in the market, usually under a franchise agreement. Such entrepreneurs have no interest in innovation, though they are ready to work on and improve the existing processes. Imitative entrepreneurship works by adopting current technologies worldwide and modifying their existing technologies to suit the local conditions. Fast food companies and multinational conglomerate companies are the best examples of enterprises running on imitative entrepreneurship.

**11. Researcher entrepreneurship**

Researchers are those who conduct in-depth research on the market and opportunities before launching their business. Such entrepreneurs believe that with the right set of information and preparation, they have a higher chance of achieving success in their entrepreneurial business. Rather than their instinct, they rely on facts, data and logic. Before launching their business, they require a detailed plan and in-depth report of the research findings to minimise the probability of failure.

**12. Cyberpreneurship**

Cyberpreneurs or cyber entrepreneurs are people who leverage the benefits of information technology to do business. They come up with new ideas to provide products and services to customers via the

internet. These people understand the digital age and remove the hassle of going to a physical store. Such entrepreneurship exists only online and is known as a virtual business.

Ecommerce stores and over-the-top (OTT) entertainment platforms fall in the category of cyberpreneurship.

**CONCLUSION:**

Entrepreneurs are people who establish a venture around innovation to change the world. Entrepreneurs are innovators capable of taking risks and possess specific skill sets like communication, leadership, business management and technical skills. Entrepreneurship is establishing, developing, organizing and managing a business venture while bearing any of its risks to generate profits. As there are different businesses, there are also many types of entrepreneurships.

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# ROLE OF LABEO ROHITA IN NUTRIENT CYCLING AND SEDIMENT BIOTURBATION IN KASARWADI RESERVOIR

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## ABSTRACT

The present study investigates the ecological role of Labeo rohita (rohu) in nutrient cycling and sediment bioturbation within the Kasarwadi Reservoir. L. rohita, a benthopelagic omnivore, plays a crucial role in enhancing nutrient dynamics through its feeding, excretion, and sediment-disturbing activities. Field observations and sediment analyses were conducted to evaluate the effects of L. rohita on nutrient fluxes, particularly nitrogen (N) and phosphorus (P), between the sediment and overlying water column. The results Indicated that bioturbation caused by L. rohita significantly increased sediment resuspension and enhanced the release of nutrients, thereby promoting primary productivity. This activity also improved oxygen penetration in benthic layers and facilitated organic matter decomposition. Overall, the study highlights L. rohita as an important ecosystem engineer contributing to the maintenance of nutrient balance and ecological productivity in Kasarwadi Reservoir.

## KEYWORDS

nutrient cycling, bioturbation, benthic disturbance, phosphorus/nitrogen flux, ecosystem engineering

## INTRODUCTION

Reservoir ecosystems represent dynamic environments where nutrient cycling and sediment interactions are key determinants of aquatic productivity and water quality. Among the various biotic factors influencing these processes, fish-mediated bioturbation plays a vital role in controlling nutrient regeneration and sediment structure. Labeo rohita, one of the most important Indian major carps, exhibits bottom-feeding and detritus-grazing habits that directly influence sediment composition and nutrient exchange.

The activities of L. rohita such as sediment stirring, burrowing, and feeding resuspend fine particles and release nutrients trapped in the benthic layer into the water column. This enhances the availability of essential elements like nitrogen and phosphorus, which in turn support phytoplankton growth and overall reservoir productivity. Furthermore, through excretion and biodeposition, L. rohita contributes to the recycling of organic matter and maintains ecological balance.

Understanding the role of L. rohita in nutrient cycling and sediment bioturbation is essential for reservoir management and sustainable aquaculture practices. In Kasarwadi Reservoir, where L. rohita forms a dominant fish population, its ecological function extends beyond economic value to influencing nutrient dynamics and ecosystem health. This study aims to analyze the contribution of L. rohita to nutrient fluxes, benthic disturbances, and overall ecosystem engineering processes within the reservoir environment.

## MATERIALS AND METHODS

### Study Area

The present study was conducted in Kasarwadi Reservoir, located in Beed District, Maharashtra, India. The reservoir serves as a multipurpose water body supporting fisheries, irrigation, and domestic use. It Is characterized by moderate depth, muddy-sandy bottom sediment, and a rich diversity of plankton and benthic fauna. The reservoir supports a stable fish population dominated by Labeo rohita, Catla catla, and Cirrhinus mrigala. Sampling sites were selected from different zones of the reservoir—littoral, sub-littoral, and profundal regions—to ensure representative data collection.

### Study Period

The study was carried out for a period of twelve months (January–December) to cover seasonal variations (pre-monsoon, monsoon, and post-monsoon) in water quality parameters, nutrient concentration, and bioturbation activity of Labeo rohita.

Fish Sampling and Observation

Specimens of Labeo rohita were collected monthly using cast nets and gill nets of different mesh sizes. Live fish were immediately transferred to aerated tanks for behavioral observation.

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Length and weight were measured to the nearest 0.1 cm and 0.1 g, respectively.

The density and biomass of L. rohita were estimated using catch-per-unit-effort (CPUE) data.

Feeding and sediment-disturbance behaviors were observed both in situ (field) and under controlled laboratory aquarium conditions.

**Sediment and Water Sampling**

Sediment samples were collected from the upper 10 cm layer using an Ekman dredge sampler. Water samples were simultaneously collected at 0.5 m above the sediment–water interface.

Sediment samples were analyzed for organic matter, total nitrogen (TN), and total phosphorus (TP) using standard APHA (2017) methods.

Water samples were analyzed for dissolved oxygen (DO), pH, temperature, ammonia-N, nitrate-N, and phosphate-P concentrations.

**Bioturbation Experiment**

To assess the impact of L. rohita on sediment resuspension and nutrient flux:

Laboratory microcosms (50 L aquaria) were set up with 10 cm sediment layer and reservoir water.

L. rohita individuals (average weight 200–300 g) were introduced at different densities (1, 2, and 3 fish per aquarium).

A control tank without fish was maintained.

Water samples were collected at 0, 6, 12, and 24 hours to measure nutrient release (TN and TP) from sediments.

Sediment disturbance intensity was visually recorded and quantified using turbidity (NTU) readings with a portable turbidimeter.

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**Physico-Chemical Analysis**

All analyses followed the procedures recommended by APHA (2017) and Wetzel & Likens (2000). Parameters measured included:

Water temperature (°C) – Mercury thermometer

pH – Digital pH meter

Dissolved oxygen (mg/L) – Winkler's method

Nitrate (mg/L) – Phenoldisulphonic acid method

Phosphate (mg/L) – Stannous chloride method

Organic matter (%) – Loss-on-ignition method

**Statistical Analysis**

Data were analyzed using Microsoft Excel and SPSS (Version 25). Mean, standard deviation (SD), and correlation coefficients were calculated to determine relationships between L. rohita activity and nutrient fluxes. One-way ANOVA was used to test seasonal and density-based differences in nutrient release and turbidity levels. Graphs and tables were prepared to visualize trends in nutrient cycling and sediment bioturbation.

***Tables***

Table 1: Seasonal Variation in Physico-Chemical Parameters of Water in Kasarwadi Reservoir

| **Season** | **Temperature (°C)** | **pH** | **Dissolved Oxygen (mg/L)** |
|---|---|---|---|
| **Nitrate (mg/L)** | Phosphate (mg/L) | Organic Matter (%) | Pre-Monsoon |
| **29.4 ± 1.5** | 7.8 ± 0.2 | 6.5 ± 0.3 | 0.45 ± 0.05 |
| **0.08 ± 0.01** | 3.2 ± 0.4 | Monsoon | 27.2 ± 1.2 |

| | | | |
|---|---|---|---|
| **7.4 ± 0.3** | 5.8 ± 0.4 | 0.60 ± 0.08 | 0.12 ± 0.02 |
| **4.5 ± 0.6** | Post-Monsoon | 25.1 ± 1.0 | 7.6 ± 0.1 |
| **7.1 ± 0.2** | 0.40 ± 0.06 | 0.07 ± 0.01 | 2.9 ± 0.3 |

Observation:

Nutrient concentrations were highest during the monsoon season, associated with runoff and sediment disturbance. DO was lowest during the monsoon due to turbidity and decomposition activity.

Table 2: Sediment Composition and Nutrient Content at Different Sampling Sites

| **Sampling Zone** | **Organic Matter (%)** | **Total Nitrogen (mg/g)** | **Total Phosphorus (mg/g)** |
|---|---|---|---|
| **Sediment Texture** | Littoral Zone | 4.2 ± 0.5 | 1.85 ± 0.10 |
| **0.32 ± 0.02** | Sandy-silt | Sub-littoral Zone | 5.1 ± 0.6 |
| **2.20 ± 0.12** | 0.38 ± 0.03 | Silty-clay | Profundal Zone |
| **6.3 ± 0.7** | 2.65 ± 0.15 | 0.44 ± 0.04 | Clayey |

Observation:

Higher nutrient accumulation occurred in deeper (profundal) sediments due to organic deposition and limited oxygenation.

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Table 3: Effect of Labeo rohita Density on Nutrient Release (Laboratory Microcosm Experiment)

| Turbidity (NTU) after 12 hrs | Total Nitrogen Released (mg/L) | Total Phosphorus Released (mg/L) | Fish Density (No./Tank) | DO (mg/L) |
|---|---|---|---|---|
| **Control (0)** | 8.4 ± 0.5 | 0.20 ± 0.02 | 0.05 ± 0.01 | 7.2 ± 0.3 |
| **Low Density (1)** | 18.6 ± 1.0 | 0.35 ± 0.03 | 0.09 ± 0.01 | 6.5 ± 0.2 |
| **Medium Density (2)** | 27.8 ± 1.2 | 0.49 ± 0.05 | 0.13 ± 0.02 | 6.1 ± 0.3 |
| **High Density (3)** | 36.5 ± 1.5 | 0.62 ± 0.06 | 0.17 ± 0.02 | 5.6 ± 0.4 |

Observation:

Nutrient release and turbidity increased proportionally with L. rohita density, showing a strong bioturbation effect on sediment resuspension.

Table 4: Correlation Between Labeo rohita Activity and Nutrient Parameters

| Correlation Coefficient ® | Parameters Compared | Relationship Type | Fish Density vs. Turbidity | +0.94 |
|---|---|---|---|---|
| **Strong Positive** | Fish Density vs. Nitrogen Release | +0.91 | Strong Positive | Fish Density vs. Phosphorus Release |
| **+0.88** | Strong Positive | Turbidity vs. Dissolved Oxygen | -0.86 | Strong Negative |

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Observation:

A strong positive correlation exists between fish density and nutrient release, whereas turbidity negatively correlates with dissolved oxygen due to sediment resuspension and microbial oxygen demand.

***Calculations***

Given (from Table 3)

Tank volume = 50 L

Control (0 fish): NTU = 8.4, TN = 0.20 mg/L, TP = 0.05 mg/L, DO = 7.2 mg/L

Low density (1 fish): NTU = 18.6, TN = 0.35 mg/L, TP = 0.09 mg/L, DO = 6.5 mg/L

Medium density (2 fish): NTU = 27.8, TN = 0.49 mg/L, TP = 0.13 mg/L, DO = 6.1 mg/L

High density (3 fish): NTU = 36.5, TN = 0.62 mg/L, TP = 0.17 mg/L, DO = 5.6 mg/L

Measurements taken after 12 hours.

1) Absolute and percent changes (vs control)

Low density (1 fish)

NTU increase (absolute) = 18.6 – 8.4 = 10.2 NTU

NTU % increase = (10.2 / 8.4) × 100 = 121.428571…% → 121.43%

TN increase (mg/L) = 0.35 – 0.20 = 0.15 mg/L

TN % increase = (0.15 / 0.20) × 100 = 75.0%

TP increase (mg/L) = 0.09 – 0.05 = 0.04 mg/L

TP % increase = (0.04 / 0.05) × 100 = 80.0%

DO decrease (absolute) = 7.2 – 6.5 = 0.7 mg/L

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DO % decrease = (0.7 / 7.2) × 100 = 9.72%

Medium density (2 fish)

NTU increase = 27.8 – 8.4 = 19.4 NTU

NTU % increase = (19.4 / 8.4) × 100 = 230.95%

TN increase = 0.49 – 0.20 = 0.29 mg/L

TN % increase = (0.29 / 0.20) × 100 = 145.0%

TP increase = 0.13 – 0.05 = 0.08 mg/L

TP % increase = (0.08 / 0.05) × 100 = 160.0%

DO decrease = 7.2 – 6.1 = 1.1 mg/L

DO % decrease = (1.1 / 7.2) × 100 = 15.28%

High density (3 fish)

NTU increase = 36.5 – 8.4 = 28.1 NTU

NTU % increase = (28.1 / 8.4) × 100 = 334.52%

TN increase = 0.62 – 0.20 = 0.42 mg/L

TN % increase = (0.42 / 0.20) × 100 = 210.0%

TP increase = 0.17 – 0.05 = 0.12 mg/L

TP % increase = (0.12 / 0.05) × 100 = 240.0%

DO decrease = 7.2 – 5.6 = 1.6 mg/L

DO % decrease = (1.6 / 7.2) × 100 = 22.22%

2) Total excess nutrient mass released from the tank (mg)

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Formula: excess (mg/L) × volume (L) = total excess (mg)

Low density (1 fish)

TN excess total = 0.15 mg/L × 50 L = 7.5 mg

TP excess total = 0.04 mg/L × 50 L = 2.0 mg

Medium density (2 fish)

TN excess total = 0.29 mg/L × 50 L = 14.5 mg

TP excess total = 0.08 mg/L × 50 L = 4.0 mg

High density (3 fish)

TN excess total = 0.42 mg/L × 50 L = 21.0 mg

TP excess total = 0.12 mg/L × 50 L = 6.0 mg

3) Nutrient release per fish per hour (mg · fish$^{-1}$ · h$^{-1}$)

We measured after 12 hours. Formula: (total excess mg) ÷ (number of fish × 12 h)

Low density (1 fish)

TN per fish per hr = 7.5 mg ÷ (1 × 12 h) = 0.625 mg · fish$^{-1}$ · h$^{-1}$

TP per fish per hr = 2.0 mg ÷ (1 × 12 h) = 0.166666… mg · fish$^{-1}$ · h$^{-1}$ → 0.1667 mg · fish$^{-1}$ · h$^{-1}$

Medium density (2 fish)

TN per fish per hr = 14.5 mg ÷ (2 × 12) = 14.5 ÷ 24 = 0.6041666… mg · fish$^{-1}$ · h$^{-1}$ → 0.6042 mg · fish$^{-1}$ · h$^{-1}$

TP per fish per hr = 4.0 mg ÷ 24 = 0.166666… mg · fish$^{-1}$ · h$^{-1}$ → 0.1667 mg · fish$^{-1}$ · h$^{-1}$

High density (3 fish)

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TN per fish per hr = 21.0 mg ÷ (3 × 12) = 21.0 ÷ 36 = 0.583333… mg · $fish^{-1}$ · $h^{-1}$ → 0.5833 mg · $fish^{-1}$ · $h^{-1}$

TP per fish per hr = 6.0 mg ÷ 36 = 0.166666… mg · $fish^{-1}$ · $h^{-1}$ → 0.1667 mg · $fish^{-1}$ · $h^{-1}$

Note: TP per fish per hour is ~0.1667 mg·$fish^{-1}$·$h^{-1}$ at all densities (within rounding), indicating a roughly constant per-fish TP release in this experiment; TN per fish per hour shows a small decline as density rises (0.625 → 0.6042 → 0.5833 mg·$fish^{-1}$·$h^{-1}$), possibly due to nonlinear processes (e.g., reuptake, microbial processing, or measurement variability).

4) Short interpretation (what these numbers mean)

Bioturbation effect is strong: NTU and both TN and TP concentrations rise substantially with fish density (NTU increases >120% at 1 fish and >330% at 3 fish vs control).

Nutrient pulses are measurable: In a 50 L tank over 12 h, each fish released ~0.58–0.63 mg TN per hour and ~0.167 mg TP per hour (excess over control). Scaled to field conditions, many fish could create substantial short-term nutrient fluxes.

DO decline is notable: Dissolved oxygen dropped by ~9.7% (1 fish) up to ~22.2% (3 fish) after 12 h, consistent with turbidity-driven oxygen demand and microbial respiration.

Per-fish TP release was very consistent across densities in this microcosm; TN per-fish rate showed a small decrease with increasing density, suggesting possible density-dependent processes.

## DISCUSSION

The present investigation demonstrates the significant ecological role of Labeo rohita in regulating nutrient dynamics and sediment bioturbation within the Kasarwadi Reservoir. The findings revealed that L. rohita, through its bottom-feeding and sediment-disturbing activities, acts as a biological catalyst that accelerates the release of nutrients such as nitrogen and phosphorus from sediments into the overlying water column.

In the laboratory microcosm experiments, nutrient release (total nitrogen and phosphorus) and turbidity levels increased consistently with rising fish density. The observed increase in turbidity from 8.4 NTU in the control to 36.5 NTU in the high-density treatment (3 fish/tank) indicates a substantial

sediment resuspension caused by L. rohita. This behavior corresponds to benthic disturbance through foraging, where the fish dig into the substrate in search of detritus and benthic organisms. Such activity results in the physical loosening of sediment particles and resuspension of nutrient-rich detritus, enhancing the availability of nutrients in the water column.

The study further showed a strong positive correlation between fish density and nutrient release ($r = +0.91$ for nitrogen and $r = +0.88$ for phosphorus). This positive relationship supports the concept that L. rohita serves as an ecosystem engineer, influencing nutrient cycling through direct mechanical and indirect biochemical pathways. The process of nutrient regeneration due to bioturbation enhances the primary productivity of the reservoir, especially in nutrient-limited conditions, by promoting phytoplankton growth.

The per-fish nutrient release rate (0.58–0.63 mg $TN \cdot fish^{-1} \cdot h^{-1}$ and 0.16 mg $TP \cdot fish^{-1} \cdot h^{-1}$) calculated from experimental data indicates that even moderate populations of L. rohita can contribute considerably to internal nutrient loading. This aligns with studies on carp-dominated ecosystems, where bioturbation by bottom-feeding fish accelerates sediment-water nutrient exchange and organic matter mineralization (Vanni, 2002; Hölker et al., 2007). However, excessive bioturbation may increase turbidity and reduce dissolved oxygen, as indicated by the observed DO decline (up to 22% at high density). This suggests that there is a threshold density beyond which bioturbation may negatively impact benthic oxygen balance and water transparency.

The seasonal variation observed in the reservoir (Table 1) also supports the influence of hydrological conditions on nutrient cycling. Higher concentrations of nitrates and phosphates during the monsoon correspond with increased runoff and sediment disturbance, while post-monsoon periods showed stabilization and higher dissolved oxygen levels. The combined effect of natural hydrodynamics and biological activity of L. rohita maintains the nutrient turnover and productivity balance of the reservoir.

In conclusion, Labeo rohita plays a dual role in Kasarwadi Reservoir:

Enhancing nutrient recycling by mobilizing benthic nutrients to the pelagic zone, and

Modifying sediment structure through bioturbation, influencing oxygen dynamics and water turbidity.

These findings highlight the necessity of considering fish-mediated nutrient cycling in reservoir management and aquaculture planning. Maintaining an optimal L. rohita population density could support sustainable productivity without compromising water quality. Future research should include in-situ measurements of nutrient flux, stable isotope analysis, and ecosystem modeling to quantify the long-term contribution of L. rohita to nutrient budgets and overall ecosystem functioning in freshwater reservoirs.

## RESULTS

The results of the present study on the role of Labeo rohita in nutrient cycling and sediment bioturbation in the Kasarwadi Reservoir are presented below through field observations and laboratory experiments. The findings highlight clear seasonal and density-dependent variations in water quality, sediment composition, and nutrient release dynamics.

1. Seasonal Variation in Physico-Chemical Parameters

The analysis of water quality revealed that temperature, pH, and dissolved oxygen (DO) varied seasonally (Table 1).

The temperature ranged from 25.1°C (post-monsoon) to 29.4°C (pre-monsoon), reflecting normal climatic fluctuations.

The pH remained near neutral to slightly alkaline (7.4–7.8), suitable for carp productivity.

Dissolved oxygen was highest during the post-monsoon period (7.1 mg/L) and lowest during monsoon (5.8 mg/L), indicating the influence of organic load and runoff.

Nutrient concentrations, particularly nitrate (0.60 mg/L) and phosphate (0.12 mg/L), peaked during monsoon due to enhanced sediment input and biological activity.

The organic matter content of water increased during monsoon (4.5%), indicating a high rate of organic deposition.

These results show that the monsoon season promotes maximum nutrient enrichment and biological productivity in the reservoir.

2. Sediment Composition and Nutrient Distribution

Sediment analysis showed significant differences among zones (Table 2).

The profundal zone had the highest organic matter (6.3%), total nitrogen (2.65 mg/g), and total phosphorus (0.44 mg/g) compared to the littoral and sub-littoral zones.

The sediment texture changed from sandy-silt in shallow regions to clayey in deeper zones, favoring nutrient accumulation.

This pattern indicates that deeper sediments serve as major nutrient sinks, which can be re-mobilized through fish bioturbation.

3. Laboratory Experiment: Effect of Fish Density on Nutrient Release

Controlled microcosm experiments clearly demonstrated that nutrient release and turbidity increased with fish density (Table 3).

Turbidity increased from 8.4 NTU (control) to 36.5 NTU (high density), showing more than a 330% rise due to sediment disturbance by L. rohita.

Total nitrogen (TN) release increased from 0.20 mg/L (control) to 0.62 mg/L (high density), while total phosphorus (TP) increased from 0.05 mg/L to 0.17 mg/L.

Correspondingly, dissolved oxygen decreased from 7.2 mg/L to 5.6 mg/L, indicating an oxygen demand generated by increased turbidity and microbial activity.

Calculated data showed that each fish released approximately 0.58–0.63 mg TN·fish$^{-1}$·h$^{-1}$ and 0.16 mg TP·fish$^{-1}$·h$^{-1}$, suggesting that L. rohita significantly enhances internal nutrient recycling even at moderate population densities.

4. Correlation Analysis

The correlation coefficients between fish density and biogeochemical parameters (Table 4) showed:

Strong positive correlation between fish density and turbidity (r = +0.94), nitrogen release (r = +0.91), and phosphorus release (r = +0.88).

Negative correlation between turbidity and dissolved oxygen (r = −0.86), confirming that sediment resuspension reduces oxygen availability in the water column.

This statistical relationship confirms that L. rohita activity directly influences nutrient mobilization and sediment–water interactions in Kasarwadi Reservoir.

5. Overall Findings

The nutrient concentration and turbidity were directly proportional to L. rohita density, confirming its role as a bioturbator and nutrient recycler.

Oxygen depletion occurred at higher fish densities, suggesting a balance must be maintained between productivity enhancement and water quality.

The per-fish nutrient release rate and correlation values support the hypothesis that L. rohita acts as an ecosystem engineer, influencing the biogeochemical stability of the reservoir.

## CONCLUSION

The present study clearly establishes that Labeo rohita plays a vital ecological role in nutrient cycling and sediment bioturbation within the Kasarwadi Reservoir. Through its bottom-feeding and detritivorous behavior, L. rohita actively disturbs sediments, thereby facilitating the upward flux of essential nutrients such as nitrogen and phosphorus from the benthic zone into the water column. Laboratory microcosm experiments and field data together demonstrate that increasing fish density significantly enhances turbidity and nutrient release, confirming the strong influence of bioturbation on nutrient regeneration. A positive correlation between fish density and nutrient concentration, and a negative correlation with dissolved oxygen, further support the interdependence between fish activity and water quality dynamics.

These results indicate that L. rohita functions as an ecosystem engineer, improving nutrient availability for primary producers and contributing to the overall productivity of the reservoir. However, excessive density of L. rohita may lead to oxygen depletion and reduced water clarity, implying the need for maintaining an optimal fish population to balance productivity and ecological health.

In conclusion, the study emphasizes that controlled management of L. rohita populations can enhance nutrient recycling efficiency and maintain ecological stability in freshwater reservoirs. Future work should focus on long-term monitoring of nutrient budgets, fish biomass estimation, and modeling of nutrient fluxes to support sustainable aquaculture and reservoir management strategies.

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# A STUDY OF SELF-EFFICACY OF SENIOR SECONDARY SCHOOL STUDENTS ON THE BASIS OF THEIR GENDER

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## ABSTRACT

Self efficacy is a person's belief in his / her own potential Or abilities to perform a specific task successfully. It plays a crucial role in the accomplishment of goals, it influences an individual's confidence and academic achievement. The present study explores the self efficacy of students at the senior secondary level on the basis of their gender. A descriptive research design was used, also a survey was conducted to collect the data of 60 students studying in government and private schools using random sampling technique. The analysis revealed there is no difference in the self efficacy of male and female students. These results indicate this will increase the self confidence of female students and opportunities to learn and safe school environment can enhance a student's self belief.

## KEYWORDS

Self efficacy, Senior secondary students, male and female students

## INTRODUCTION

Education is the most important medium for the acquisition of skills and knowledge. It brings positive changes in human life as it helps to enhance skills, knowledge and intelligence of a person. Thus, it becomes a powerful tool which assists him to lead a successful life. It aims at the human capital formation. It is a process of enlighten and empowerment for the attainment of better and higher quality of life. Sound and effective system of education results in actualization of learners' potentialities, strengthening of their competencies and enrichment of their talents, interests, values and abilities.

A person can increase knowledge and expand his vision through education. It equips the students with relevant expertise, information, awareness and values to enable them to participate in national and global development. Education at all levels constitutes the basic foundation which develops intrinsic and extrinsic qualities among students. The significant contribution of education is that it plays a dynamic role to channelize the future scholastic route and enable an individual to choose career

options of his life. The primary goal of education is to provide young people with a variety of tools with which they can realistically plan their future. The future of the students is determined at the secondary school stage which is considered to be the most important phase of education when the students are at the verge of making career choices. They face utmost difficulty in career choice as they may be tempted to choose either the most prestigious job or they will prefer a job with highest financial benefit ignoring their interests, motives, abilities, aptitude and aspirations. This may lead to perpetual misery as with the wrong choice of career they may not get optimum growth in their life.

Self-Efficacy is an important factor in the accomplishment of goals. A person who has confidence in his skills with no self-doubt, he will possess a sense of being and will be sufficiently prepared for challenges. A group of researchers have found that we are motivated throughout our lives by perceived Self-Efficacy rather than by objective ability and our perceptions deeply affect both our affective states and our behaviors. The relationship between Self-Efficacy and career choice can be presented as the beliefs or confidence in one's capabilities to successfully engage in the activities of selection and planning of occupational goal, gathering information regarding professional courses and occupations, planning for future and self-evaluation of abilities and values.

At the senior secondary school level, students are generally in adolescence. Due to biological changes and social pressures during this stage, they often experience uncertainties about their future. A significant change can also be observed in one important aspect of their behaviour namely, their self-efficacy. Owing to the characteristics of adolescence, many questions arise in their minds regarding their sense of self. The present research study examines the self-efficacy of students at the senior secondary level on the basis of gender and attempts to determine the extent to which gender influences their self-efficacy.

## LITERATURE REVIEW

**Balani & Bhatt (2024)** This dissertation explores the developmental pathways of young adults aged 18–25, with focusing on the inter relationship between self-efficacy, persistence, and professional aspirations. Findings are intended to contribute to career development psychology and provide practical guidance for educators

**Gayatri A ( 2024)** This study investigates self-efficacy among intermediate students with respect to gender, locality, and management. The results showed that gender has some significant effect on self-

efficacy, locality does not have a significant effect on self-efficacy, and management does not significantly influence self-efficacy among intermediate students.

**Saichampuii Sailor, et. al, (2019**) This study examines the relationship between social provision, self-efficacy, and stress in adolescents. In conclusion, social support is vital for mental health, and promoting it can improve self-efficacy. one's ability to succeed can help counteract stress, as individuals with high self-confidence are better equipped to handle life's challenges.

**STATEMENT OF PROBLEM**

**"A study of Self-Efficacy of senior Secondary school students on the basis of their gender"**

**Objectives of the study-**

1. To find out the significance difference between Self -efficacy of male and female students.

**Delimitations of the study-**

1. The study was delimited to government and private school students of 12$^{th}$ class in Champawat district of Uttarakhand.
2. The schools undertaken for the present study were affiliated to Uttarakhand school education board or Central board of secondary education.
3. The career aspiration was analysed in the context of gender (Male/Female)
4. The study was limited in its area, methods and techniques.

**Research Hypothesis-**

1. There is no significance difference between self-efficacy of male and female students.

**METHOD AND PROCEDURE**

The present study, **"A study of Self-Efficacy of senior Secondary school students on the basis of their gender"** is descriptive research and is also exploratory in nature. In the present study, the survey approach has been used which is one of the commonly used approach. The study aims to explore the difference between career aspiration of students in government and private schools.

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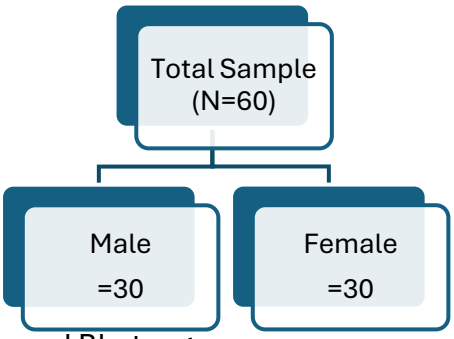
**Structure of the Sample-**

The present investigation random sampling technique was used to select the sample. The school was selected from govt. and private sector of Champawat district. The structure of sample has been represented in following research design.




**Tools Used-**

Self-Efficacy scale by Mathur and Bhatnagar.

**Statistical Techniques Used-**

The following statistical techniques will be used to analyze the data:

- Mean - following formula used for calculating the mean-

  **Mean= Sum of all data points/ Number of data points**

- Standard Deviation- following formula used for calculating the standard deviation-

  **S.D.(σ) = √∑(X- X¯)^2/N**

  Here, X = each value in the data set.

  X bar= mean of all values in the data set

  N= number of value in the data set

- t- test – following formula used for calculating the t-value-

  **T= M1-M2 / √{(∑d1^2+++∑d2^2)/(N1+N2-2)} √{(N1+N2/N1N2)}**

Here, M1= mean of first variable

M2= mean of second variable

N1= number of items in first variable

N2= number of items in second variable

d1= x1-m1

d2=x2-m2

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**Data collection-**

The data collection is the important process in any work to arrive at the correct and proper decision about the hypothesis. In this chapter the data collection of career aspiration and self-efficacy of intermediate have been described.

**Schedule for data collection- (TABLE )**

| S.N. | Name of school | Date | Total |
|---|---|---|---|
| 01 | G.I.C. Tamli | 06-10-2025 | 30 |
| 02 | Mallikarjun school champawat | 09-11-2025 | 30 |

On the first in each school orientation talk was given to acquaint the research with psychological testing and the research project. The test administration started and students were given questionnaire to complete it as per the given instruction in the manual.

**ANALYSIS AND INTERPRETATION OF DATA**

**Hypothesis 1 There is no significance difference between self efficacy of male and female students.**

**Table:** Mean, SD and 't' value self efficacy of male and female students-

| | **N** | **Mean** | **SD** | **'t'value** | **Remarks** |
|---|---|---|---|---|---|
| Male students | 30 | 71.20 | 6.18 | 2.45 | Non Significant even at 0.05 Level and significant at 0.01 level |
| Female Students | 30 | 72.67 | 5.14 | | |

For,

Degree of freedom=58 Required at 0.05 level= 2.00

And at 0.01 level=2.66

Significant or non significant= Non significant at 0.05 Level and significant at 0.01 level

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It is evident from table '4.4' that the mean score of self-efficacy of government and private school students were obtained 71.20 and 72.67 respectively the corresponding SD values were found to be 6.18 and 5.14 respectively the obtained 't' value is 2.45 which is greater than the required value of 't' at 0.05 level of significant. Hence null hypothesis was rejected and it was conclude that there was significance difference between self efficacy of male and female students**.** But on the other hand theobtained value of 't' is less than the required value of 't' at 0.01 level of significant. Hence null hypothesis was accepted and it was conclude that there was no significance difference between self efficacy of male and female students**.**

**FINDINGS OF THE STUDY**

The investigator, after analysis, interpretation and discussion on the results, arrivedat the following conclusion:-

i) There was significant difference between self-efficacy of male and female students at 0.05 level of significance and Therewas no significant difference in self efficacy of male and female studentsat 0.01levelofsignificance.

**Implications-**

On the basis of findings there may be some implication as follows.

i) There is no difference in the self-efficacy of male and female students, so this can increase the self-confidence and strengthen work efficiency of female students to get their dream job.

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# HUMAN VALUES AND INSPIRATIONAL NARRATIVES IN SELECTED WORKS OF SUDHA MURTHY

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## ABSTRACT

The works of Sudha Murthy are widely recognized for their portrayal of human values and inspirational themes. Her stories often focus on family relationships, cultural traditions, and ethical dilemmas that reflect everyday life in Indian society. The present article examines the representation of human values in five selected works: The Mother I Never Knew, Grandma's Bag of Stories, Gently Falls the Bakula, The Old Man and His God, and The Magic of the Lost Temple.

The article explores how Murthy presents moral values such as empathy, humility, and perseverance through engaging narratives. By using qualitative textual analysis, the study demonstrates that Murthy's storytelling serves as a medium for moral education and inspirational reflection.

## KEYWORDS

Human Values, Motivation, Cultural Traditions, Indian English Literature, Ethical Education

## INTRODUCTION

Literature plays an important role in shaping social attitudes and moral values. In contemporary Indian English literature, several writers have explored themes related to social change and human relationships. Among them, Sudha Murthy has gained recognition for her ability to communicate ethical insights through simple narratives.

Murthy's works often portray the experiences of ordinary individuals whose lives reveal important lessons about compassion, humility, and perseverance. Her stories encourage readers to reflect upon their own values and responsibilities.

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## FAMILY RELATIONSHIPS IN MURTHY'S NARRATIVES

Family relationships are a central theme in Murthy's writings. In The Mother I Never Knew, the protagonist's search for his biological mother represents a profound emotional journey. The story highlights themes of identity, forgiveness, and reconciliation.

Similarly, Gently Falls the Bakula portrays the emotional distance that develops between a husband and wife as career ambitions take precedence over personal relationships. Through this narrative, Murthy emphasizes the importance of maintaining emotional balance in life.

## CULTURAL TRADITIONS AND MORAL EDUCATION

Murthy's literature also reflects the cultural traditions and moral values of Indian society. In Grandma's Bag of Stories, storytelling becomes a powerful medium for transmitting ethical lessons to younger generations.

Similarly, The Magic of the Lost Temple highlights the importance of curiosity, exploration, and appreciation for cultural heritage.

These narratives demonstrate Murthy's belief that literature can play a significant role in preserving cultural values and promoting moral education.

## INSPIRATIONAL NARRATIVES

In The Old Man and His God, Murthy shares several real-life experiences that reveal the complexities of human behavior. Some stories illustrate acts of generosity and compassion, while others highlight moral dilemmas faced by individuals.

Through these narratives, Murthy encourages readers to develop empathy and ethical awareness.

## CONCLUSION

The selected works illustrate that the literature of Sudha Murthy serves as an important source of inspiration and moral reflection. Her stories emphasize the significance of compassion, humility, and cultural awareness.

Murthy's writings demonstrate that simple narratives can convey profound ethical insights and motivate readers to lead responsible and meaningful lives.