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Contemporary Trends in Chemical, Pharmaceutical and Life Sciences Volume II

Editors:
Mr. Mukul M. Barwant
Dr. Bassa Satyannarayana

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CONTEMPORARY TRENDS IN CHEMICAL,

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PREFACE

The field of chemical, pharmaceutical, and life sciences has experienced unprecedented growth and transformation over recent decades. This volume, *Contemporary Trends in Chemical, Pharmaceutical and Life Sciences* seeks to capture and present the current advancements, research, and trends that are shaping these dynamic fields today.

The compilation of research and review articles in this volume highlights the interdisciplinary nature of modern science, where boundaries between chemistry, pharmacology, and biology are increasingly blurred. This synergy is driving innovation, leading to new therapeutic strategies, cutting-edge technologies, and a deeper understanding of the fundamental processes of life.

This book aims to provide readers, whether they are seasoned researchers, educators, or students, with a comprehensive overview of the latest developments. It also serves as a platform for scientists and scholars to share their findings and contribute to the collective knowledge in these fields.

We are at a pivotal moment in history where the convergence of disciplines is opening new avenues for exploration and discovery. The contributions in this volume reflect the dedication, creativity, and intellectual rigor of the scientific community, and we hope that it will inspire further research and innovation.

I would like to extend my gratitude to all the authors who have contributed to this volume, as well as the reviewers whose insights have ensured the quality and relevance of the content. It is our sincere hope that this book will serve as a valuable resource for all those engaged in the chemical, pharmaceutical, and life sciences.

Editors:
Mr. Mukul Machhindra Barawnt and Dr. Bassa Satyannarayana

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Chapter 1

CEPHALOSPORIN: AN OVERVIEW OF COMMON ANTIBACTERIAL AGENTS

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ABSTRACT

Cephalosporins are beta-lactam antibiotics that are used to treat a variety of bacterial infections, both gram-positive and gram negative. Cefalotin is the first clinically authorized cephalo-sporin antibacterial agent. It is a class of dihydrothiazine fused/Mactam antibacterial agents that have been around for five generations. This chapter focuses on cefotaxime, ceftriaxone and cefepime, a broad-spectrum antibiotic with the ability to enter the cerebral spinal fluid, such as Neisseria spp., H influenzae, and Enterobacteriaceae.

KEYWORDS: Antibiotics, Cephalosporins, Mycophenolic Acid, Protein Binding, Structural Analysis, Antibiotic Generations, Drug Development**.**

INTRODUCTION

The term "antibiotic" has its origins in the word "antibiose," which was originally used by Paul Vuillemin1 in his 1890 article to characterize the antagonistic action between different microorganisms (e.g., bacteria vs. protozoa; fungi vs. bacteria). The term "antibiotic" was used to refer to naturally occurring secondary compounds that were created by fungi and bacteria that had the ability to either kill (bactericidal) or limit growth (bacteriostatic) in these microorganisms. These days, the word has two different meanings: it can refer to engineered molecules in one sense, and it can also refer to specific measures that are taken against bacteria or fungi, but not viruses, in another meaning (Nicolaou *et al.,* 2018).

Mycophenolic acid was the first antibiotic to be identified from nature. This antibiotic was obtained as a crystalline solid from *Penicillium glaucum* (*P. brevicompactum*) by the Italian physician and microbiologist BartolomeoGosio in 1893 when he was researching pellagra. At that time, it was demonstrated that mycophenolic acid inhibits *Bacillus anthracis* development (Gosio *et al.,* 1893).

Later research revealed other benefits, including antiviral, antifungal, anticancer, and anti-psoriasis effects. This ground-breaking finding was overlooked until mycophenolic acid was rediscovered in the United States in 1913 (perhaps because it was published in Italian). Its complete synthesis was attained in 1969, although its structure was not recognized until 1952 (Kitchin *et al.,* 1997).

Whereas in 1969 its complete synthesis was accomplished. The US Food and Drug Administration did not approve the 2-(morpholin-4-yl)ethyl ester of mycophenolic acid (a prodrug of 1) until 1995. However, this approval was granted as an immunosuppressant to prevent transplant rejection, rather than as an antibacterial medication (by inhibiting DNA biosynthesis).

THE CEPHALOSPORINS

Cephalosporin C, the first member of the β-lactam subclass known as cephalosporins, was first identified in 1945 by Giuseppe Brotsu from *Cephalosporium acremonium* (now *Acremonium chrysogenum*). It possesses bactericidal properties similar to those of penicillin. Cephalosporin C was identified in 1955 and its structure was clarified in 1961 through X-ray crystallographic research and chemical degradation studies. Robert B. Woodward completed its first complete synthesis in 1965, which he presented in his Nobel talk prior to its 1966 publication. Cefalotin is the first clinically authorized cephalosporin antibacterial agent. Despite cephalosporin C's failure to become a clinical agent, its structure sparked a number of synthetic attempts that resulted in the synthesis of analogs that eventually gave rise to potent antibacterial medications (Brotzu *et al.,* 1948)

Giuseppi Brotzu set out to search for novel organisms that produced antibiotics in Sardinia in 1945, which was the beginning of the research that would eventually lead to the discovery of the first cephalosporin. Brotzu was a local politician and bacteriology professor who had recently given up his position as the University of Cagliari's rector. He went on to become the president of the Sardinian Regional Council and a missionary for public health, hygiene, and education. By the time World War II ended, he was aware of the extraordinary medical benefits and restrictions associated with benzylpenicillin, also known as penicillin G. He investigated the microbial flora of seawater near a sewage outfall, speculating that antibiosis might play a part in the "self-purification" of sewage.

He swiftly isolated a strain of *Cephalosporium acremonium*, today also known as *Acremonium chrysogenum* (Abraham *et al.,* 1987) This strain released substances that were active against both Gram-positive and Gram-negative bacteria. Brotzu aggressively administered crude concentrates intravenously and intramuscularly to patients suffering from brucellosis, paratyphoid infections, and typhoid fever. He also injected live culture filtrates of the Cephalosporium species directly into staphylococcal and streptococcal boils and abscesses. He concluded that, particularly in typhoid cases, the treatment frequently resulted in an improvement (Abraham *et al.,* 1987).

It was no accident that cephalosporins were discovered. The need for antibiotics during World War II prompted researchers to look for drugs made by microbes. Even with our comparatively greater understanding of these medications, there are still a lot of issues with their qualitative and quantitative analysis. The common beta-lactam nucleus's chemical instability and the little

structural variations between the analogues are the causes of these problems (El-Shabouryet *et al.*, 2007).

STRUCTURE OF CEPHALOSPORINS

A class of dihydrothiazine fused/Mactam antibiotics known as traditional cephalosporins is generated by the fungus families Cephalosporium (cephalosporin C) and *Streptomyces* (cephamycins), as well as derivatives derived from the peripheral modification of these fermentation products. The word "ceph" has been expanded throughout time to encompass a number of nuclear counterparts of the general structure, several of which show better chemical stability and biological activity. This chapter uses the generally recognized conventional nomenclature, which is based on the Cepham ring system. CIO or C3' is the name given to the carbon atom that is joined to C3. Regarding the double bond, the corresponding isomers are denoted as 2/3-cephem or, alternatively, as A2/A3-cephem.

The stereochemistry at C7 is expressed as either a//? Or as an absolute value of R/S, depending on whether the substituent (such as amino) is attached above or below the plane. It is important to distinguish between this traditional system—particularly the numbering scheme—and the IUPAC-approved nomenclature that Chemical Abstracts uses. Cephalosporanic acid is identified by Chemical Abstracts as (Z?)-3-[(acetyloxy) methyl]. Oct-2-ene-2-carboxylic acid -8-oxo-5-thia-1 -azabicyclo[4.2.0] (Zhang *et al.*, 1996).

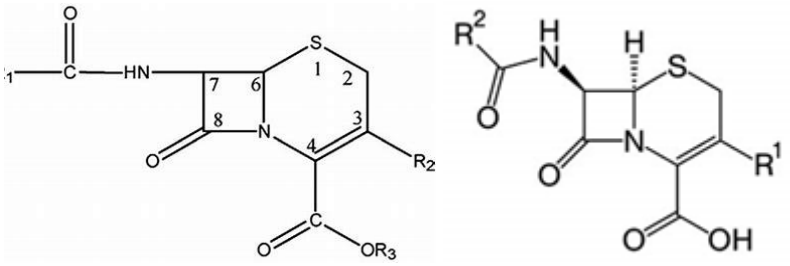

Fig. 1: General structure of cephalosporins

STRUCTURAL ANALYSIS AND PROTEIN BINDING OF CEPHALOSPORINS

Protein binding is a crucial pharmacokinetics factor that affects therapeutic outcomes as it determines drug distribution. The most prevalent blood protein, human serum albumin, is a key factor in drug-protein binding. Serum albumin is a basic protein that many acidic and neutral medications connect to through intermolecular interactions. Although binding is reversible, the amount of medicine that is free to diffuse to the site of action depends on the degree of binding. Many physiological situations, including pregnancy, liver illness, and malnutrition, cause variations in serum albumin concentrations, which affect the free fraction of medication for strongly bound drugs. Consequently, in these circumstances, drug-protein binding interactions are important for drug therapy in terms of agent selection and patient response evaluation (Buxton *et al.*, 2017).

Cephalosporins are an antibacterial drug subclass belonging to the β-lactam class, for which protein binding data is easily accessible. On the other hand, the precise functional group

connections connected to protein binding patterns are poorly understood. Two there is no relationship between cephalosporin generation and degree of protein binding, despite the fact that they are categorized into generations according to the range of antibacterial activity they cover (Tawara *et al.,* 1992).

Two highly protein-bound cephalosporins, cefazolin and ceftriaxone, which differ in bacterial coverage and production, serve as examples of this (Nerli *et al.,* 1996). Cephalosporins and other medications known to bind to albumin have had their structural characteristics examined in earlier research. Ceftriaxone, for instance, has been shown to attach to albumin at the same location as endogenous bilirubin, which may be related to the medication being displaced (Ghuman *et al.,* 2005).

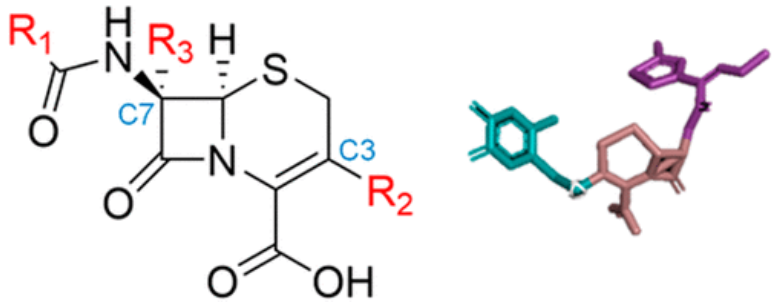

Fig. 2: Cephempharmacophore and ceftriaxone (R1 purple, R2 blue) (Kanis*et al.,* 2022).

GENERATION OF CEPHALOSPORINS

Cephalosporins are β-lactam antibiotics that are used to treat a variety of bacterial infections, both gram-positive and gram-negative. Based on the range of germs they may kill (both gram-positive and gram-negative) and when they were discovered, cephalosporins are divided into five generations. Infections such as meningitis, pneumonia, and skin and soft tissue infections can be effectively treated with cephalosporins, which have been around for five generations.

FIRST GENERATION CEPHALOSPORINS

The cephalosporins belonging to the first generation comprise cefazolin, cephalothin, cephapirin, cephradine, cefadroxiland cephalexin. While providing only limited protection against gram-negative bacteria, first-generation cephalosporins exhibit active coverage against the majority of gram-positive cocci, including *staphylococci* and *streptococci, E.coli*, *Kpneumoniae* and *Pmirabilis* are among the gram-negative bacteria that are more vulnerable to first-generation cephalosporins (Hsieh *et al.,* 1975).

When treating simple skin and soft tissue infections like cellulitis and abscesses caused by *staphylococci* or *streptococci*, oral first-generation cephalosporins are frequently given. They are also useful for bloodstream infections, otitis media, bone, respiratory tract, genitourinary tract, biliary tract, and surgical prophylaxis. For surgical prophylaxis, cefazolin is the preferred cephalosporin. First-generation cephalosporins are used off-label for the prophylaxis of endocarditis in patients who are vulnerable and undergoing dental or respiratory procedures (Griffith, 1983, Bergeron *et al.,* 1973).

SECOND GENERATION CEPHALOSPORINS

The second-generation and the cephamycin subgroups are the two subgroups of second-generation cephalosporins. Cefuroxime and cefprozil are a couple of the second-generation subgroups. The members of the cephamycin subgroup are cefoxitin, cefmetazole, and cefotetan. Cefuroxime provides better protection against *Hinfluenzae* in the first subgroup. Lyme illness in children and pregnant women is another indication for cefuroxime. The cephamycin subgroup exhibits heightened efficacy against species of Bacteroides. While second-generation cephalosporins exhibit better action against gram-negative bacilli, they are less effective against gram-positive cocci than first-generation cephalosporins. They are frequently used to treat lung infections such pneumonia and bronchiolitis.

Other indications (bone, respiratory tract, genitourinary tract, biliary tract, bloodstream infection, otitis media, and surgical prophylaxis) for second-generation cephalosporins are comparable to those for first-generation indications. Second-generation cephalosporins are resistant to *H influenzae*, *Enterobacter aerogenes*, *Neisseria* spp., and *Serratia marcescens* in addition to the gram-negative bacteria that first-generation cephalosporins are effective against (Tartaglione *et al.,* 1985).

THIRD GENERATION CEPHALOSPORINS

The cephalosporins belonging to the third generation comprise Cefotaxime, Ceftazidime, Cefdinir, Ceftriaxone, Cefpodoxime, Cefoperazone, and Cefixime. With a wider range of gram-negative bacteria covered by this generation, it is frequently used to treat gram-negative infections that are resistant to other β-lactam antibiotics or to the first and second generation of antibiotics. Intravenous (IV) use of third-generation antibiotics, particularly ceftriaxone and cefotaxime, can cross the blood-brain barrier and treat bacteria present in the cerebral spinal fluid. Meningitis brought on by *H influenzae*, *Neisseria meningitidis*, or *Streptococcus pneumoniae* can be treated with ceftriaxone. Disseminated Lyme disease and gonorrhea are two more conditions that ceftriaxone treats. Crucially, ceftazidime contains coverage for *Pseudomonas aeruginosa* (Klein *et al.,* 1995, Arumugham*et al.,* 2019)

FOURTH GENERATION CEPHALOSPORINS

Cefepime belongs to the fourth generation of cephalosporins. A broad-spectrum antibiotic with the ability to enter the cerebral spinal fluid is cefepime. Because cefepime contains an extra quaternary ammonium group, it can more easily pass through gram-negative bacteria's outer membrane. Cefepime can treat *S pneumoniae* and methicillin-sensitive *Staphylococcus aureus* (MSSA), acting similarly to cefotaxime and ceftriaxone. Crucially, cefepime can substitute for *P aeruginosa*, just like ceftazidime does. Cefepime can offer coverage against β-lactamase-producing gram-negative bacilli in addition to the gram-negative bacteria that third-generation covers, such as *Neisseria* spp., *H influenzae*, and Enterobacteriaceae. Cefepime is only used in

individuals with severe systemic infection who have multi-resistance organisms, while being effective against both gram-positive and gram-negative bacteria (Okamoto *et al.,* 1994).

FIFTH GENERATION CEPHALOSPORINS

The ceftaroline and ceftobiprole belong to the fifth generation of cephalosporins. Due to its broad-spectrum antibacterial properties, ceftaroline can treat both gram-positive and gram-negative organisms that are vulnerable. Its ability to combat methicillin-resistant *S aureus* (MRSA) sets it apart from the other cephalosporins (Zhanel *et al.,* 2009). *Listeria monocytogenes* and *Enterococcus faecalis* are also susceptible to ceftaroline. Ceftaroline, however, is not effective against *P aeruginosa*. Ceftobiprole has efficacious activity against MRSA, *E faecalis*, and penicillin-resistant *S pneumoniae* (pending approval by the US Food and Drug Administration, FDA) (Mahmoud *et al.,* 2020, Lupia *et al.,* 2021).

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Chapter 2

PHARMACEUTICAL ALCHEMY: TRANSFORMATION OF MOLECULES INTO MEDICINES

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ABSTRACT

Pharmaceutical chemistry is a multidisciplinary field encompassing the design, development, synthesis, and analysis of drugs and medications. Drug design and development form the foundation stages of pharmaceutical chemistry. Pharmacokinetics and pharmacodynamics govern the way drugs interact within the body. Pharmacokinetics focuses on drug absorption, distribution, metabolism, and excretion (ADME), while pharmacokinetics studies their mechanisms of action and therapeutic effects. The chemical properties of drugs influence their stability, solubility, and formulation. Utilisation of organic synthesis, physical chemistry, and molecular modelling to modify drug structures and enhance the properties of drugs. Analytical techniques such as spectroscopy, chromatography, and mass spectrometry play vital roles in characterizing drug compounds and ensuring their quality and purity. Synthesis and manufacturing processes involves techniques like synthetic chemistry, process engineering, and formulation science which are employed to develop scalable manufacturing processes that meet regulatory standards for safety, efficacy, and quality. Regulatory affairs and quality control ensures drug safety and efficacy. Quality control involves rigorous testing and compliance with good manufacturing practices (GMP) to maintain consistent product quality. In conclusion, pharmaceutical chemistry is integral to advancing healthcare by developing safe, effective, and personalized therapies. Continued research and innovation in drug design, biotechnology, and regulatory science will shape the future landscape of pharmaceuticals addressing unmet medical needs and improvising patient outcomes globally.

KEYWORDS: ADME, GMP, SAR, Pharmacokinetics, Pharmacodynamics, Liquidambar Formosana, Spectrometry, Fragment Library, Cefixime.

INTRODUCTION

A drug is a chemical which interacts with proteins in the body to affect and show various physiological functions. When these chemicals start absorbing in the systemic circulation they bind with certain proteins and lead to changes resulting in the functioning of the cell slightly.

For example, anticancer drugs bind to proteins on the surface of cancer cells that stimulate the cells to die. Here the cell death is the physiological action of the drug.

Therefore, most of the drugs that we take also consist of inactive ingredients that work to fill out the drug. Inactive ingredients are those that have no effect on the functioning of cells such as lactose, dyes and gluten. If the drug has to be taken orally, the inactive ingredients work to bind the drug together and lubricate the drug. (easy to swallow)

Fig. 1: Physiological action of Drug

The key stages are as follows:

1.The absorption of the drug into the bloodstream and across the cell membranes to enter into the cells

2.The distribution of the drug is carried throughout the body

3.The metabolism or breakdown of the drug is taken place and

4.The excretion of the drug out of the body.

Each drug has its own unique nature. The amount of drug available has an effect on the biological system. A certain drug's bioavailability is determined by its Pharmacokinetics. For example, some drugs are not well absorbed as they do not cross cell membranes as effectively as others and so less of the drug will pass into the systemic circulation where it needs to be in order to have an effect on the site of target.

The side effects associated with some of the medications are more detrimental than the disease state they are troubling with. In these situations, you and your doctor must work together to determine the risk and benefit profile of taking the medication. To completely determine the risks, you MUST tell your doctor which medications you are taking concomitantly, including the herbal supplements, any allergies that you have and any previous adverse effects which you have experienced from medication.

Make sure enough you are aware of all the medications you are taking in, what they are for and the risks associated with each. If the side effects are adverse, you may not want to continue with the treatment. Ask your doctor if there are any alternatives and if not discuss the consequences of not taking the medication. However, do not stop taking medication without consultation of your doctor.

DRUG DESIGN AND DEVELOPMENT

Drug design and its development is a complex process that involves several key steps:

The drug discovery process initiates with identifying a biological target, such as a protein or enzyme, which is involved in a disease. It is sent for screening large libraries of compounds to find the potential "lead" compounds that can bind to and modulate the target.

Once a lead compound is identified and verified, researchers use structure-activity relationship (SAR) studies to systematically modify the compound's structure to estimate its binding affinity, selectivity, potency, and some other properties. This also involves analysing how changes to the compound's chemical structure affect its biological activity.

Computational methods such as molecular docking and quantitative structure-activity relationship (QSAR) modelling are increasingly used to guide the SAR process and accelerate the identification of promising lead compounds.

These techniques allow researchers to virtually screen and evaluate large numbers of compounds.

Ultimately, the goal is to identify a drug candidate that meets key criteria for safety, efficacy, and other drug-like properties.

This optimized compound then progresses to preclinical and clinical testing before potentially being approved as a new medication.

We will see some of the important drugs necessary which are as follows:

TETRACYCLINE: Tetracycline is a broad-spectrum antibiotic that has been a significant player in medicinal chemistry since its discovery in the 1940s.

- It is a polypeptide-derived compound with a complex structure consisting of four fused rings, giving it its name ("tetra-" for four, "-cycline" for rings)
- They inhibit bacterial protein synthesis by binding to the 30S ribosomal subunit, preventing the attachment of four aminoacyl-tRNA to the ribosomal acceptor site.
- Tetracyclines exhibit activity against a wide range of gram-positive and gram-negative bacteria, as well as atypical organisms like chlamydiae, mycoplasmas, and rickettsiae.
- They are used extensively in the therapy of human and animal infections, and some countries add them to animal feeds as growth promoters.

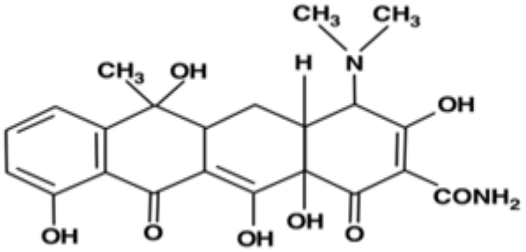

Fig. 2: Tetracycline structure

The above figure 2 shows the Core Structure: having a linear fused tetracyclic nucleus, consisting of four hydrocarbon rings (designated as A, B, C, and D) in a linear arrangement.

Functional Groups:

The A ring has a dimethylamino group at position 4.

The B ring is a phenol-type ring with a hydroxyl group at position 6.

The C ring has an amide group at position 2 and a hydroxyl group at position 12.

The D ring is similar to a benzene ring but contains an enol functionality with hydroxyl groups at positions 10 and 11.

The chemical formula: $C_{22}H_{24}N_2O_8$.

The molecular weight is approx 444.44 grams per mole (g/mol).

CEPHALOSPORIN: Cephalosporin compounds were first isolated from the cultures of Cephalosporium acremonium from a sewer in Sardinia in 1948 by an Italian scientist Giuseppe Brotzu.

- Cephalosporins are obtained naturally from cephalosporin C that is obtained from a fungus Cephalosporium acremonium.
- Chemically they are derived from aminocephalosporanic acid and they are structurally and functionally related to penicillins because they share a common β- lactam ring.
- BCephalosporins are composed of a six membered ring having sulphur atoms attached to a β-lactam ring.
- Cefixime comes under the third generation semisynthetic β-lactam antibiotic of cephalosporin group. It has molecular weight 453.4 and molecular formula $C_{16}H_{15}N_5O_7S_2$.
- Cefixime is marketed in the form of tablets and suspensions only for oral use.

Structure activity relationship Chemically it is composed of a cephem nucleus that is attached to a six membered ring of dihydrothiazine. At position 3, cephem nucleus consists of a vinyl group for absorbing intact molecules through the intestine and at 7-position the acetic acid oxy-imine group and aminothiazole ring are attached for the antibacterial activity. Its structure is shown in figure as below:

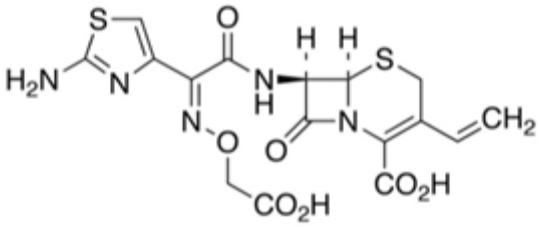

Fig. 3: Cephalosporin structure

STREPTOMYCIN: Streptomycin is an antibiotic which plays a critical role in medical treatments due to its antibacterial properties.

Streptomycin was the first effective antibiotic used to treat tuberculosis (TB). Its introduction marked a significant breakthrough in the fight against this deadly disease.

It is often used in combination with other antibiotics to prevent the development of resistance, especially in treating TB and other bacterial infections.

It is also used in veterinary medicine to treat bacterial infections in animals, contributing to animal health and the prevention of zoonotic diseases.

As one of the earliest antibiotics discovered, streptomycin paved the way for the development of other aminoglycoside antibiotics and has a historical importance in the field of antimicrobial therapy.

However, the use of streptomycin must be carefully managed to avoid issues like antibiotic resistance and potential side effects, such as ototoxicity and nephrotoxicity.

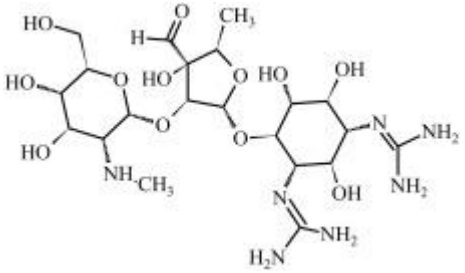

Fig. 4: Streptomycin structure

Streptomycin is an aminoglycoside antibiotic composed of three main components:

1. Streptose - a monosaccharide
2. Streptobiosamine - a disaccharide
3. Streptidine - a cyclitol

The structure of streptomycin can be described as follows:

Streptose is linked glycosidically to strepto bioamine, which is a disaccharide consisting of N-methyl-D-glucosamine and D-streptose.

- This disaccharide moiety is then linked glycosidically to streptidine, a cyclitol containing two guanidino groups.[1][5]

The complete chemical structure of streptomycin is $C_{21}H_{39}N_7O_{12}$, with a molecular weight of 581.58 g/mol.[1][4] This complex structure gives streptomycin its unique antibacterial properties, particularly its ability to inhibit protein synthesis in bacteria by binding to the 30S

GENTAMICIN: Gentamicin is an aminoglycoside antibiotic used to treat several types of bacterial infections and aerobic infections in the body

- It was discovered and isolated from Micromonospora purpurea in the late 1963s.
- This includes bone infections, pelvic inflammatory disease, pneumonia, urinary tract infections, and sepsis.
- Some of the bacterial infections can be opportunistic infections (OIs) of HIV.
- Gentamicin C1, a natural product found inLIQUIDAMBAR FORMOSANA.
- Newborn infants apparently absorb tiny amounts ofgentamicin, but their serum levels with three times daily dosages are below those attained when treating the newborn infections and systemic effects ofgentamicin.

- There are also benefits of synergy when gentamicin is co-administered with other antibacterials such as beta-lactams. This synergistic activity plays a key role in the treatment of complex infections and also contributes to dose optimization.

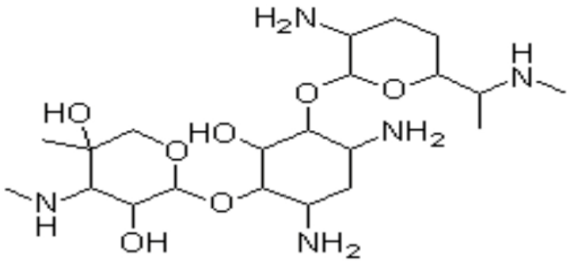

Fig. 5: Gentamicin structure

It is a complex structure having a central aminocyclitol ring system with various sugar moieties attached. The central aminocyclitol ring is 2-deoxystreptamine, and the sugar moieties are 2,6-diamino-2,6-dideoxy-D-glucose and 6'-N-methyl-D-glucosamine. It is a mixture of several closely related compounds, with gentamicin C1 being the major component. The chemical formula is $C_{21}H_{43}N_5O_7$ and the molecular weight is 477.596 g/mol.

PHARMACOKINETICS AND PHARMACODYNAMICS

The main difference between pharmacokinetics (PK) and pharmacodynamic (PD) is pharmacokinetics is the study of what the body does to a drug which mainly focuses on the absorption, distribution, metabolism, and excretion (ADME) of the drug and pharmacodynamics is the study of what the drug does to the body, focusing on the biochemical and physiological components and effects of the drug with its relationship to drug concentration. Altogether PK and PD explains the dose-exposure-response relationship of a drug. PK provides information on drug safety by measuring the systemic exposure, while PD contributes on drug efficacy by measuring the relation between drug concentration and the pharmacological effects.

The four crucial steps of pharmacokinetics are:

Absorption - The pathway of a drug entering the body and crossing membranes to reach the bloodstream depends on factors like route of administration of drugs.

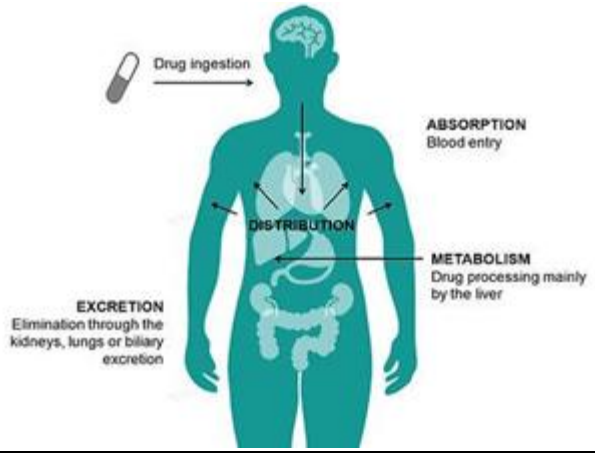

Fig 6: The ADME mechanism

Distribution - The transportation of drugs and dispersing throughout the body via the bloodstream and tissues. Factors like blood flow, lipophilicity, and protein binding influence the process of distribution.

Metabolism - The way drug is chemically transformed, primarily in the liver, to initiate excretion. Mapping metabolic pathways is crucial for understanding the potential toxicity.

Excretion - The drug and its metabolites are eliminated or excreted from the body, usually via urine or faeces. Molecular properties also influence the excretion route.

In the fig.6 the ADME mechanism is shown and understanding this ADME properties of a drug candidate is critical in the drug design and development process to optimise efficacy and safety.

Pharmacodynamics encompasses the mechanisms of action of drugs, their interactions with molecular targets like receptors or enzymes. It also explores factors such as the dose-response relationship (how the drug's effect changes with varying doses), the time course of drug action, and the variability in response among individuals.

The main aspects of pharmacodynamics include:

1. **Mechanism of Action:** It describes how a drug interacts with certain molecules (e.g., receptors, enzymes, ion channels) in a body to produce its effects.
2. **Receptor Theory:** Focuses on the relation between the drug binding to receptors and their biological effects. This involves agonist (activating) and antagonist (blocking) effects.
3. **Dose-Response Relationship:** Examines how the intensity of a drug's effect changes with dosage. This relationship helps determine the optimal dose for therapeutic effect and minimizes side effects.
4. **Drug Potency and Efficacy:** Potency deals with the concentration of a drug required to produce a specific effect, whereas efficacy refers to the maximum effect that a drug can produce regardless of dose.
5. **Onset and Duration of Action:** It explains how quickly a drug's effects begin (onset) and how long they last (duration), which can be varied based on factors such as drug formulation and route of administration.
6. **Variability in Response:** It understands that individuals may respond differently to the same drug because of the factors such as genetic variations, age, underlying health conditions, and concomitant use of some other medications.

CHEMICAL PROPERTIES OF DRUGS

Some important points regarding the chemical properties of drugs, focusing on the solubility, stability, and stereochemistry, are as follows:

Solubility: A critical property that affects a drug's absorption, distribution, metabolism, and excretion (ADME) profile. Over 40% of new drug candidates have poor water solubility. Factors affecting solubility include pH, polarity, particle size, and temperature. Techniques to

Techniques t enhance solubility include reducing particle size, forming solid dispersions, and using surfactants.

Stability: Drug stability refers to the ability of a drug to maintain its chemical integrity and potency under the specified storage and some conditions. Factors affecting stability are temperature, humidity, light exposure, and interactions with excipients. Degradation can be seen through hydrolysis, oxidation, photolysis, and other additional chemical reactions.

Stereochemistry: The stereochemistry of a drug refers to the spatial arrangement of atoms in a molecule which can significantly impact on its pharmacological activity, toxicity, and ADME properties. Enantiomers (mirror-image molecules) often have various biological effects thus, the stereochemical purity of a drug is important. It can influence a drug's solubility, stability, and interactions with biological targets and transporters.

In summary, understanding the solubility, stability, and stereochemical properties of drug candidates is crucial in the drug design and development process to optimise their efficacy and safety.

ANALYTICAL TECHNOLOGY OF PHARMACEUTICAL CHEMISTRY

Analytical technique is a method used to determine a chemical or physical property of a chemical substance, chemical element, or mixture. There are varieties of techniques used for analysing, from simple weighing to advanced techniques using highly and efficient specializedinstrumentation. This technique plays a major role in the pharmaceutical industry, enabling the identification, quantification and purification of chemical substances along with components in drug formulations.

Some of the main analytical techniques include:

Chromatographic Methods: Techniques like HPLC, GC, TLS, HPTLC and UPLC are mostly used for separation, identification and quantification of drug compounds and their impurities.

Spectroscopic Methods: UV-Vis, IR, NMR, and MASS spectrometry give structural information and the quantitative analysis of drugs.

Hyphenated Methods: Techniques like LC-MS, GC-MS and ICP-MS are widely used for the standards of drug improvement.

Electrochemical Methods: Potentiometry, voltammetry, and electrochemical sensors are widely used for quantitative analysis of drugs.

Radiochemical Methods: Radioactive labelling and detection techniques are a model for studying drug metabolism and pharmacokinetics.

Other Techniques include titrimetry, polarimetry, and refractometry which are also employed for the pharmaceutical analysis. These analytical techniques are very complex throughout the drug developing process - from compound identification and characterization to the quality control and stability testing. The below fig. 7 shows a chart executing the most important techniques involved.

Fig. 7: The major analytical techniques used in pharmaceutical chemistry

SYNTHESIS AND MANUFACTURING OF DRUGS

Steps involved in drug discovery includes synthesis, screening, and reprofiling

Drug synthesis: It is an expensive and time taking process Current efforts have been proving efficient for the production and modification of drug-delivery systems in the pharmaceutical industry. Contemporary drug-delivery systems portrayed effective nanoparticle delivery of drugs (ex., anticancer drugs, etc.) or some other therapeutic molecules to the target site for various clinical applications.

Drug screening: Drug screening is concerned with estimation of physiological specificity or need of a drug candidate. Many techniques are in today's usage for identifying hit molecules in the drug discovery process. These drug screening methods include ligand and target based virtual screening fragment-based hit identification, high-throughput cellular microarray system, and forced floating and hanging drop methods for 3D spheroid culture which are distinctly applicable in pharmaceutical profiling for hit identification.

Drug profiling: It deals with an emerging strategy for drug discovery and development which involves medicines with confirmed efficacy, safety, and pharmacokinetic profiles already in clinical use, and are comprehensively reassessed at molecular level to aim of developing new drugs. Assessment and identification of these mechanisms of the side effects of these drugs can be used to develop many safer therapies for other related or unrelated diseases. Including drugs already withdrawn from the market or those that failed clinical trials due to various reasons other than safety issues. This is also referred to as drug reprofiling or drug repurposing. The fig.8 explains a much more detailed steps in manufacturing of a drug.

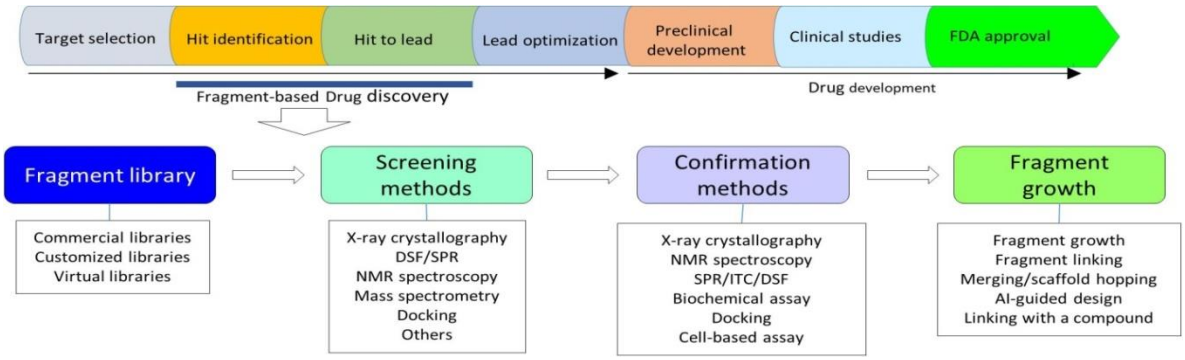

Fig. 8: A detailed process of synthesis of drugs and its manufacturing

PHARMACEUTICAL MANUFACTURING

Pharmaceutical manufacturing is a niche and a very complicated business in today's world. Nevertheless, like any other business, it has its own mechanism and time-tested business models which allowed various companies to be successful in this field. With each model many economic decisions are made that may not always be in sync or convenient with engineering decisions. This manufacturing involves primary pharmaceutical manufacturing which deals with the production of chemical compounds of therapeutic value (active pharmaceutical ingredients (APIs)), and secondary pharmaceutical manufacturing produces medicines by suitable formulation of API(s) along with excipients in a final product (e.g., tablets).

REGULATION AFFAIRS AND QUALITY CONTROLS

The pharmaceutical industries around the world are moving ahead and are competitive. Regulatory agencies are being established across the globe. Regulatory agencies along with organizations play a key role to meet the requirements of legal procedures related to drug development processes in a country.

In the current scenarios, pharmaceuticals are considered the most highly regulated industries worldwide. It ensures compliance in different legal and regulatory aspects of a drug. Every nation has their own regulatory authority, which ensures the responsibility to enforce the rules and regulations by issuing the guidelines to regulate drug development process, licensing, registration, manufacturing, marketing and labelling of pharmaceutical products. USFDA(USA), MHRA(UK), TGA(Australia), CDSCO(India) (MCC(South Africa), SFDA (China),NAFDAC(Nigeria), MEDSAFE(Newzeland), MHLW(Japan), MCAZ(Zimbabwe), SWISSMEDIC(Switzerland), KFDA(Korea), MoH (Sri Lanka) are some of the regulatory agencies and organizations established in respective nations.

SOME OF THE VERY KNOWN AGENCIES LIKE FDA AND EMA

FDA ensures the medications that are available to hospitals, health systems and patients are safe and of high quality. For typically prescription drugs, FDA's approval is the first step. The drug application approval includes assessing and examining the manufacturing process along with facilities including information about the agency gaining through inspections or alternative tools.

Fig. 9.1 and 9.2: The agencies responsible for evaluation and examination of drugs

To make sure the proposed manufacturing process is performed with applicable standards and produce high-quality External Link Disclaimer drugs.

In addition, FDA oversees the safety and quality of medications which are not marketed under an appropriate approved application.

The European Medicines Agency (EMA) belongs to the European Union (EU) whose goal is to protect human and animal health. The EMA is the European Union's equivalent to the U.S. Food and Drug Administration FDA. EMA or sometimes is called the European Medicines Evaluation Agency or EMEA.

The EMA practices pharmacovigilance to maintain and promote safety and efficacy of medicines.

EMA is not involved in any clinical trials or R&D.

Individual countries can approve drugs that the EMA has not approved. (the above shown fig 9.1 and 9.2 are well known agencies around the world)

FUTURE TRENDS IN PHARMACEUTICAL CHEMISTRY

Nanotechnology: Utilisation of nanoparticles for targeted drug delivery to improve drug bioavailability and reduce their side effects.

Personalised Medicine: Developing drug delivery systems to improve in their individual genetic profiles for more effective treatments.

Smart Drug Delivery Systems: Using stimuli-responsive systems (e.g., pH, temperature) for control which enhances site-specific drug release.

Biodegradable Polymers: Employing the biodegradable materials to reduce any kind of long-term side effects and improve patient safety.

3D Printing: Creating custom drug delivery devices and personalised dosages is the aim.

Microneedle Patches: Providing a painless alternative to injections with patches that can easily deliver drugs through the skin.

Wearable Drug Delivery Devices: Using devices that provide continuous drug administration and monitoring and keeps a check on your health status.

These are some of the emerging trends that you will see in the near future and will be the most prominent among the pharmaceutical industries.

CONCLUSION

In this chapter, the key concepts of drug designs and its development has been discussed which focuses on the mechanisms of model of drug and SAR. Some of the important drugs include tetracycline, cephalosporin, streptomycin and gentamicin which explain their value these days. Dealing with pharmacokinetics and pharmacodynamics evaluates the key concept of the pharmaceutical industries. Companies like FDA and EMA ensures the regulation and standards of all these mechanisms and procedures required for the drug development. There is a lot of future development in this field because of its emerging needs in today's life.

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Chapter 3

AN INSIGHT INTO THE DRUG DESIGN

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ABSTRACT

Medicinal chemistry integrates chemistry, biology, and pharmacology principles to design and develop therapeutic drugs. This chapter explores key concepts, including structure-activity relationships (SAR), drug design strategies, and the role of computational methods in optimizing drug efficacy and safety.

KEYWORDS: Medicinal Chemistry, Drug Discovery, Structure-Activity Relationships (SAR), Drug Design, Pharmacokinetics, Computational Chemistry, Target Identification.

INTRODUCTION

Medicinal chemistry plays a pivotal role in modern healthcare by translating chemical insights into effective therapies. This introduction provides an overview of the field's objectives, emphasizing its interdisciplinary nature and contributions to drug development. This chapter includes various concepts or methods that help us understand various methods of drug design.

SAR (STRUCTURE-ACTIVITY RELATIONSHIPS)

Chemistry and pharmacology use the Structure-Activity Relationships (SAR) technique to investigate how a molecule's chemical structure impacts its biological activity. Scientists can modify a chemical to increase its efficacy or lessen its adverse effects by analyzing surface atomic resonance (SAR) data. A molecule's constituent elements are first altered, and the activity of the molecule is then tracked as a result. To change a molecule's activity or its interactions with biological targets such as enzymes or receptors, one way to modify it would be to add a functional group or alter a side chain (Illustrated in Fig. 1). SAR analysis helps in the development of new medications by identifying the chemical changes that enhance the intended function, such as binding to a target protein or inhibiting an enzyme that causes illness.

Quick ways to calculate SAR are now part of the drug design process because the three-dimensional space of a target the site and its ligand are involved in both geometric and electrostatic interactions.

SAR is useful in situations where a lot of information is needed to understand how a ligand interacts with a target active site. SAR can be utilized to generate targeted and powerful

bioactive medications by optimizing ligands and explaining how ligands interact with receptors.

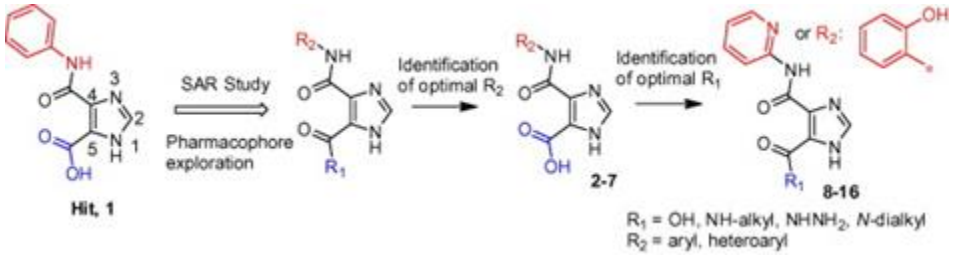


Fig 1: Parts of drug design process

For example, the progression from Penicillin and its numerous derivatives is with the help of SAR.

Increasing drug absorption, lowering toxicity, and enhancing potency are the main goals of optimization efforts. Under such circumstances, capturing and encoding particular SAR can be facilitated by quickly characterizing SAR using in silico techniques (computational modeling). Considering other methods, computational techniques serve as a guide for integrating and summarizing vast amounts of data. Although computational methods aid in identifying, explaining, and predicting structure-activity correlations, their misuse might result in incorrect data interpretations since they are essentially models. This parameter helps identify the specific conditions under which the forecasts are reliable. As a result, a variety of methods for determining a model's domain of applicability have been developed.

Researchers use SAR- To optimize drug design, to predict biological activity, to explore chemical space

HIGH-THROUGHPUT SCREENING (HTS)

Using automated technology, high throughput screening (HTS) quickly examines thousands to millions of samples for biological activity at the model organism, cellular, route, or molecular levels. The most popular kind of HTS involves parallel screening of 103–106 small molecule compounds with known structures. A researcher can quickly perform millions of chemical, genetic, or pharmacological tests with HTS with data processing/control software, liquid handling equipment, and sensitive detectors. The outcomes of these studies serve as a basis for developing new drugs. Differential assay plates are prepared on demand; the stock plates themselves are not used in research. To prepare assay plates, a tiny amount of liquid—typically measured in nanoliters—is pipetted into the relevant wells of an empty plate using a stock plate. The stock plate is duplicated exactly using this procedure. Once enough time has passed for the biological material to bind, absorb, or otherwise react (or not react) with the substances in the wells, the several wells on the plate are measured, either manually or mechanically.

COMPUTATIONAL MODELING

Drug research and discovery is a costly and time-consuming process that uses every field known to science, including computer-aided drug design (CADD), to produce the intended

effects. CADD offers novel recommendations for molecular structures to synthesize, insightful information on mechanisms of action and experimental discoveries. Ligands can be detected using standard identifying procedures like HTS tests or utilizing different CADD approaches. Ligands can be inhibitors, activators, agonists, antagonists, or substrate analogs. HTS and CADD approaches are frequently viewed as complementary to one another due to their unique advantages and disadvantages for drug discovery. CADD approaches are typically quicker, more cost-effective, and simpler to set up than HTS. Lipid-based and structure-based CADD are the two general kinds of CADD. Ligand-based CADD uses chemical similarities searches or the creation of predictive, quantitative structure-activity relation (QSAR) models to determine the interactions for each compound tested. Structure-based CADD is widely applied to soluble proteins that crystallize easily when high-resolution structural data on the target protein is accessible.

LEAD OPTIMIZATION

Lead optimization is the process of developing and refining a previously recognized lead compound. It relies on chemical alterations to the compound and manipulates several of its properties. To maximize the compound's activity, potency, and selectivity as well as its ADMET qualities (absorption, distribution, metabolism, excretion, and toxicity), synthetic modifications are done during this process. This compound's ability to enter the bloodstream (absorption), travel to the intended location throughout the body (distribution), break down efficiently once inside the body (metabolism), exit the body with the compound and any metabolites (excretion), and cause any adverse effects on the body (toxicity) are all related to these ADMET properties. A compound must meet at least five requirements to be classified as drug-like: potency, bioavailability, duration, safety, and reasonable pharmaceutical properties. Selectivity, effectiveness, and dose proportionality are a few other crucial attributes that must be taken into account.

DRUG METABOLISM AND PHARMACOKINETICS (DMPK)

This area of research looks at how a medicine enters the body and gets absorbed, distributed, metabolized, and eliminated. It aids in comprehending how the medication behaves in the body and its general effects. Here are some important points:

1. **Drug Metabolism:** The process by which the body breaks down and transforms drugs into active chemical compounds. Mostly takes place in the liver. Contains enzymes that change medications into more easily excreted molecules via water.

2. **Pharmacokinetics:** Explains the drug's gradual passage through the body. It comprises four primary procedures: Absorption, Distribution, Metabolism, and Excretion (Illustrated in Fig.2).

TARGETED THERAPIES

Specifically targeting cancer cells while limiting harm to healthy cells is known as targeted therapy.

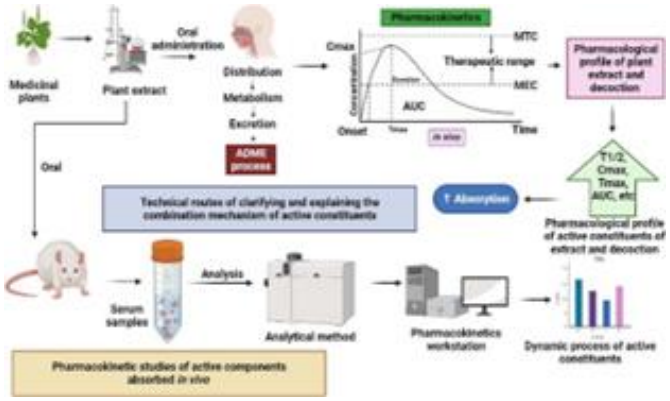


Fig. 2: Pharmacokinetic studies of active components

Here are the main ideas:

- They target particular chemicals and routes that are essential to the growth and survival of cancer cells called specificity
- Mechanism: They can prevent the growth and metastasis of cancer cells by obstructing these targets.

Targeted drug delivery aims to optimize treatment efficacy by focusing on two main criteria: utilizing drugs designed to specifically target diseased cells (targeted drug therapy) and employing delivery systems that deliver drugs directly to the diseased area (targeted drug delivery systems). Effective drug delivery hinges on four key requirements: retaining the drug throughout the administration, avoiding destruction by the body's defenses, ensuring drug accumulation at the target site, and releasing the drug from the delivery system at the intended location. There are now passive, active, and physical targeting techniques thanks to developments in targeted drug-delivery systems. In the fields of oncology, neurology, cardiovascular illness, respiratory disease, and diagnostics, among others, these methods provide benefits. Targeted drug-delivery systems have yet to be widely used commercially, despite encouraging results. Obstacles include increasing production devising from preclinical research to clinical success, and getting regulatory approval.

ARTIFICIAL INTELLIGENCE (AI) AND MACHINE LEARNING

Machine learning (ML) techniques have become increasingly popular in the pharmaceutical industry because of their ability to speed up and automate the processing of massive volumes of currently available data. Machine learning (ML) is a branch of artificial intelligence that aims to develop and apply computer algorithms that can learn from raw, unprocessed data to perform certain tasks in the future. The main tasks of AI algorithms inside a massive data collection include classification, regression, grouping, and pattern recognition. Many machine-learning approaches have been used by the pharmaceutical industry to predict new chemical characteristics, biological activity, interactions, and side effects of pharmaceuticals. These include Support Vector Machines, Random Forest, Naive Bayes, and, Deep Neural Networks: Novel drug targets. The initial stage is to obtain the data set, which must meet certain conditions. It needs to be easy to produce and maintain in the lab, with minimal toxicity,

selectivity, and physical-chemical properties that promote absorption. This is because the pharmaceutical industry lacks large proteins or incredibly complex chemicals. It mostly acts on small compounds and peptides as its principal substrates. To make handling and research of these materials easier, the sequencing and structure of peptides and small molecules, respectively, are expressed in the FASTA and SMILES formats. The data set created by creating mathematical descriptors can be managed by the machine-learning model. This dataset was divided into two subsets: the model is trained on the larger subset, and tested on the smaller subset. The training set is searched for the optimal subset of variables using the appropriate and required data. Many numerical variables are typically provided while creating mathematical descriptors. This process's primary goal is to minimize the number of unnecessary or duplicate variables. The model is trained after determining the ideal subset of variables.

NOVEL DRUG TARGETS

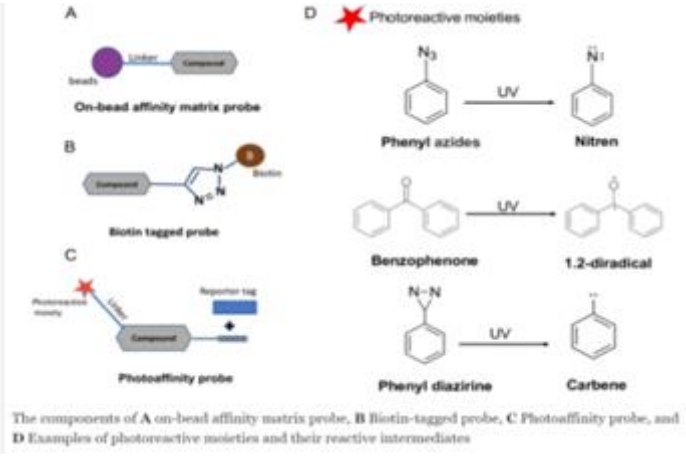
Protein-protein interactions (PPIs) are essential to life processes. Targeting PPIs is a way to cure diseases and a critical strategy for the development of new drugs. It's widely known that regulating PPIs has been one of the most difficult tasks in medication discovery in recent decades. Cells with PPIs form an extensive network called an "interactome." The interactome plays an important role in regulating numerous physiological and pathological processes, including signal transduction, cell growth, proliferation, differentiation, and death. Accordingly, abnormal PPIs have been linked to a wide range of human illnesses, including neurological disorders, cancer, and infectious infections. Finding PPI modulators presents challenges, because proteins like enzymes, ion channels, and receptors usually have a well-defined ligand-binding site that small compounds can interact with, the classic small-molecule drug discovery approach primarily focuses on protein-ligand interactions. Small-molecule PPI modulation is typically thought to be challenging, and PPIs were once thought to be "undruggable" targets.

PPIs do not naturally refer to tiny-molecule ligands. Current approaches to identifying *PPI modulators include* high-throughput screening, or HTS, which is a tried-and-true strategy for identifying traditional pharmacological targets. It has been used to identify compounds intended to target hot areas at the PPI interface. Structure-based design: Since the majority of PPIs lack naturally occurring small molecule ligands, designing logical PPI modulators is challenging. However, hot spots provide important structural information and act as a basis for PPI modulators' rational design. For PPI modulators with a structure-based design, there are presently two design methodologies accessible. The first is based on the hot-spot structure. Bioisosterism and de novo design can yield novel small molecule modulators.

MOLECULAR BIOLOGY TECHNIQUES

Researching the chemical and structural makeup of biological macromolecules like proteins and nucleic acids was the original definition of molecular biology. Nucleotide-based polymers include nucleic acids, deoxyribonucleic acid (DNA), and ribonucleic acid (RNA). Polymers

made up of several amino acids are called proteins. Genes defining the fundamental structure of the organism-specific proteins are encoded by DNA and RNA. Therefore, a study of the interactions between proteins and nucleic acids may shed light on a gene's biological role. Target identification is a critical step in the drug research and discovery process, and the effectiveness of any given therapy depends heavily on it. While label-free and affinity-based pull-down methods are useful for making important discoveries, protein target identification research can be difficult. Researchers can more effectively tailor a medication for a specific illness or condition by identifying the exact molecular target of the medication. Target identification is also important to optimize drug selectivity and reduce its potential side effects. Several types of biomolecules can serve as therapeutic targets, including enzymes, cellular receptors, ion channels, DNA, and transcription factors. Due to this vast diversity of proteins and other chemicals in a cell, identifying a specific biological target for a given drug can be extremely difficult. However, in the context of the biochemical approach at the experimental level, one can classify target identification methods into two main strategies, namely affinity-based pull-down methods and label-free techniques (as Illustrated in Fig. 3).



The components of **A** on-bead affinity matrix probe, **B** Biotin-tagged probe, **C** Photoaffinity probe, and **D** Examples of photoreactive moieties and their reactive intermediates

Fig 3: A-on bead affinity probe B-Biotin tagged probe C-Photoaffinity probe D-reactive intermediates

Affinity-Based Pull-Down Methods: These methods involve selectively isolating target proteins using small molecules conjugated with tags (such as biotin or fluorescent labels). Researchers label a small molecule and use it to capture binding partners from a cell lysate or protein mixture. By identifying specific proteins that interact with the labeled molecule, scientists gain insights into potential drug targets. Affinity-based pull-downs are valuable for discovering drug targets and understanding their mode of action.

Label-Free Techniques: Label-free approaches avoid using tags or labels and instead rely on small molecules in their natural state. Two common label-free methods are:

Surface Plasmon Resonance (SPR): SPR measures changes in refractive index near a sensor surface due to binding events. A ligand (e.g., protein) is immobilized on a sensor chip, and an analyte (e.g., a small molecule) flows over it. Binding causes a shift in the SPR angle, providing real-time information on binding kinetics and affinity.

Bio-Layer Interferometry (BLI): BLI uses optical interference to detect binding events. A biosensor tip (coated with a ligand) interacts with an analyte in solution. Changes in interference patterns reveal binding kinetics and specificity. Both SPR and BLI help characterize molecular interactions and identify potential drug targets.

CONCLUSION

Medicinal chemistry translates scientific knowledge into therapies by designing molecules targeting disease mechanisms while minimizing side effects. Key aspects include SAR, computational modeling, and AI. Innovations in pharmacology and bioinformatics drive personalized medicine and targeted therapies, addressing challenges like antibiotic resistance and cancer, promising improved patient outcomes.

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Chapter 4

PHYTOCHEMICALS: EMERGING TRENDS AND APPLICATIONS IN MEDICINE

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ABSTRACT

Phytochemicals, naturally occurring bioactive compounds in plants, have gained increasing attention for their therapeutic potential. This chapter explores emerging trends in phytochemical research, focusing on their roles in plant defense and health benefits for humans. Key phytochemicals such as alkaloids, flavonoids, terpenoids, and phenolic compounds are highlighted for their applications in cardiovascular health, cancer treatment, neuroprotection, diabetes management, and skin health. Advances in extraction techniques, such as supercritical fluid extraction and microwave-assisted extraction, have enhanced the efficiency of isolating these compounds. Moreover, the chapter delves into the mechanisms of action of phytochemicals, including antioxidant activity and modulation of cellular pathways. It discusses future prospects, such as the integration of phytochemicals with modern medicine, sustainable sourcing, and advanced delivery systems, to enhance bioavailability and therapeutic efficacy. Addressing challenges like standardization and regulatory approval is crucial to further unlock the potential of phytochemicals in modern healthcare.

KEYWORDS: Phytochemicals, Therapeutic Potential, Plant Defense, Alkaloids, Flavonoids, Terpenoids, Cardiovascular Health, Cancer Treatment, Neuroprotection, Diabetes Management, Extraction Techniques, Antioxidant Activity, Bioavailability, Sustainable Sourcing, Advanced Delivery.

INTRODUCTION

Phytochemicals, naturally occurring compounds in plants, have garnered significant attention for their therapeutic potential. These bioactive substances, including alkaloids, flavonoids, terpenoids, and phenolic compounds, play crucial roles in plant defense and offer diverse health benefits. This chapter explores the latest advancements in phytochemical research, focusing on their applications in medicine, mechanisms of action, and future prospects.

HISTORICAL BACKGROUND AND IMPORTANCE OF PHYTOCHEMICALS

Historically, plants have been a primary source of medicine. Ancient civilizations relied on plant-based remedies for various ailments, a practice that continues to influence modern drug discovery. Phytochemicals have been pivotal in the development of numerous drugs, underscoring their importance in medicine (Newman *et al.,* 2000).

EMERGING TRENDS IN PHYTOCHEMICAL RESEARCH

1) Advanced Extraction and Characterization Techniques

a. Recent advancements in extraction methods, such as supercritical fluid extraction and microwave-assisted extraction, have improved the efficiency and yield of phytochemical isolation (de la Luz Cádiz-Gurrea *et al.,* 2020).

b. High-resolution analytical techniques, including liquid chromatography-mass spectrometry (LC-MS) and nuclear magnetic resonance (NMR) spectroscopy, have enhanced the identification and structural elucidation of phytochemicals (Wolfender *et al.,* 2019).

2) Mechanisms of Action

a. Phytochemicals exert their effects through various mechanisms, such as antioxidant activity, modulation of signaling pathways, and inhibition of enzymes. For instance, flavonoids are known for their potent antioxidant properties, which help in neutralizing free radicals and reducing oxidative stress (Panche *et al.,* 2016).

b. Alkaloids like vincristine and vinblastine, derived from the Madagascar periwinkle, interfere with microtubule formation, making them effective in cancer treatment (Cragg & Newman, 2005).

THERAPEUTIC APPLICATIONS

1) Cardiovascular Health

a. **Polyphenols:** Found in tea, grapes, and berries, polyphenols have been shown to improve cardiovascular health by reducing blood pressure, improving endothelial function, and exerting anti-inflammatory effects (Rodrigo *et al.,* 2011).

2) Anti-Cancer Properties

a. **Curcumin and Resveratrol:** Numerous phytochemicals, such as curcumin from turmeric and resveratrol from grapes, have demonstrated anti-cancer properties by inducing apoptosis, inhibiting proliferation, and preventing metastasis (Aggarwal & Sung, 2009).

3) Neuroprotection

a. **Ginsenosides and Bacosides:** Compounds like ginsenosides from ginseng and bacosides from Bacopa monnieri have been studied for their neuroprotective effects, offering potential benefits in the management of neurodegenerative diseases (Yuan *et al.,* 2016).

4) Anti-Diabetic Effects

a. **Berberine:** Found in plants like Berberis, berberine has shown promise in lowering blood glucose levels, improving insulin sensitivity, and modulating gut microbiota, making it beneficial for diabetes management (Yin *et al.,* 2008).

5) Anti-Inflammatory and Immune Modulation

a. **Echinacea:** Phytochemicals in Echinacea species have been found to modulate the immune system, enhancing the body's resistance to infections and reducing inflammation (Hudson, 2011).

6) Skin Health

a. **Aloe Vera:** Phytochemicals in Aloe vera exhibit wound-healing, anti-inflammatory, and moisturizing properties, making them valuable in dermatology and cosmetic applications (Surjushe *et al.,* 2008).

7) Anti-Microbial Activity

a. **Tea Tree Oil:** Rich in terpenoids, tea tree oil has been extensively used for its antimicrobial properties against a broad spectrum of pathogens, including bacteria, fungi, and viruses (Carson *et al.,* 2006).

8) Hepatoprotection

a. **Silymarin:** Extracted from milk thistle (Silybum marianum), silymarin has hepatoprotective effects, offering protection against liver damage caused by toxins, alcohol, and other factors (Křen & Walterová, 2005).

9) Respiratory Health

a. **Quercetin:** Found in apples, onions, and tea, quercetin has shown potential in alleviating symptoms of respiratory conditions such as asthma and chronic obstructive pulmonary disease (COPD) through its anti-inflammatory and antioxidant effects (Boots *et al.,* 2008).

CASE STUDIES OF PHYTOCHEMICAL APPLICATIONS

1) Curcumin

a. Curcumin, a major constituent of turmeric, exhibits anti-inflammatory, antioxidant, and anticancer properties. Clinical studies have shown its efficacy in managing conditions such as arthritis, cancer, and Alzheimer's disease (Gupta *et al.,* 2013).

2) Resveratrol

a. Resveratrol, found in grapes and red wine, has been extensively studied for its cardioprotective and anti-cancer properties. It activates sirtuins, which play a role in cellular aging and metabolism (Baur & Sinclair, 2006).

FUTURE DIRECTIONS AND CHALLENGES

1. Integration with Modern Medicine

o The integration of phytochemicals with conventional therapies can enhance treatment efficacy and reduce side effects. However, challenges such as standardization, bioavailability, and regulatory approval need to be addressed (Williamson, 2001).

2. Sustainable Sourcing and Conservation

o Sustainable harvesting and conservation of medicinal plants are crucial to ensure a continuous supply of phytochemicals. Biotechnological approaches, such as plant cell culture and synthetic biology, offer promising solutions (Oksman-Caldentey & Inzé, 2004).

3. Advanced Delivery Systems

o Developing advanced delivery systems, such as nanoparticles and liposomes, can improve the bioavailability and targeted delivery of phytochemicals, enhancing their therapeutic potential (Sanna *et al.*, 2014).

CONCLUSION

Phytochemicals continue to play a vital role in medicine, offering a natural and potent source of therapeutic agents. Advances in extraction techniques, a better understanding of their mechanisms of action, and innovative delivery systems are paving the way for their enhanced application in modern medicine. Addressing the challenges associated with their use will further unlock their potential, contributing significantly to the future of healthcare.

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Chapter 5

THE IMPACT OF NUTRACEUTICALS ON HUMAN HEALTH

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ABSTRACT

Nutraceuticals, a blend of the terms "nutrition" and "pharmaceutical," are products derived from food sources that offer additional health benefits beyond basic nutritional value. Over recent decades, the consumption of nutraceuticals has gained substantial popularity due to their potential in promoting health, preventing chronic diseases, and delaying the aging process. Nutraceuticals are food products that provides health as well as medical benefits, including the prevention and treatment of disease. Plants play an important role in the daily life, which are essential not only for food, shelter and clothing but also for recreation world is colorful because of diversified flora of dye yielding plants. Plants are one of the most important resources of human foods and medicines. Few Nutraceuticals are being used as pharmaceutical and a number of other being used and purchased by the general public as self-medication. Such products may range from dietary supplements to genetically engineered foods, herbal products and processed foods. Nutritional therapy and phytotherapy have emerged as new concepts and healing systems have quickly and widely spread in recent years. Strong recommendations for consumption of Nutraceuticals, natural plant food, and the use of nutritional therapy and phytotherapy have become progressively popular to improve health, and to prevent and treat diseases.

KEYWORDS: Nutraceuticals, Nutrition, Pharmaceuticals, Chronic Diseases, Recreation, Phytotherapy, Nutritional Therapy, Dietary Supplements.

INTRODUCTION

The combined and concerted action of nutrient components and biologically active compounds is flagged as indicator of a possible beneficial role for health. Vitamins, minerals, amino acids, enzymes and certain components or derivatives of animal foods were classified as dietary supplements by the Dietary Supplement Health and Education Act of 1994. Nutraceuticals are chemical substance or group of substances that for legal purposes is defined as a nutrient but that is used for the prevention or treatment of disease. The term 'Nutraceutical' was first coined

by Dr. Stephen L. Defelice as "a product isolated or purified from foods and sold in medicinal forms. They have physiological benefit".

Nutraceutical is a combination of 2 words.

1) Nutrition and
2) Pharmaceutical

Nutraceuticals are food products that provide health as well as medical benefits including the prevention and treatment of disease. Phytochemicals and antioxidants are two specific types of Nutraceuticals. Research has proved that food with phytochemicals may help to provide protection from diseases such as cancer, diabetes, heart disease, and hypertension, e.g. carotenoids found in carrots. Anti oxidants may be helpful in avoiding chronic diseases by preventing oxidation damage in our body. Over the last 20 years numbers of pharmaceuticals are available for self medication or for sale.

There has been a boom in sale of Nutraceutical because of

1) Adverse effect of pharmaceuticals.
2) Increased tendency of patients for self medication
3) Aging population

CATEGORIES OF NUTRACEUTICALS

Nutraceuticals are non-specific biological therapies used to promote wellness, prevent malignant process and cause symptoms. These can be grouped into 3 broad categories.

1) Substances with established nutritional functions, such as vitamins, minerals, amino acids and fatty acids- nutrients.
2) Herbs or botanical products as concentrates and extracts – Herbals.
3) Products that contain nutrients derived from food products – dietary supplements.

NUTRIENTS

The most commonly known nutrients are anti oxidants, water and vitamins. Anti oxidants in general may be useful in the prevention of cancer and cerebro vascular disease. High dietary intake of vitamin E may prevent Parkinson's disease. Agus *et al.,* determined that oxidized form of vitamins C, Dehydro Ascorbic Acid, readily crosses the blood brain barrier. Jialal and fuller found that the combination of vitamin E, C and beta carotene has been useful in reducing low density lipoprotein oxidation and subsequent arthrosclerosis. Those suffering from asthma and skin cancer have also been evaluated with selenium for its potential use, although results have been inconclusive.

HERBALS

Herbals are as old as human civilization and they have provided a complete store house of remedies to cure acute and chronic diseases. The knowledge of herbals has accumulated over thousands of years so that today we possess many effective means of ensuring health care. It has been found that common herbal treatment is in the use of Echinacea for the prevention and

treatment of colds and flu. Echinacea may be helpful in the treatment or prevention of upper respiratory tract infections.

Table 1: Herbal Health Drink Formulation

Plant Nutraceutical Concentrate	Quantity per litre
Ashwagandha concentrate	400mg
Brahmi concentrate	400mg
Tulsi concentrate	200mg
Ginger concentrate	200mg
Awala concentrate	400mg
Shatavari concentrate	100mg
Gokharu concentrate	100mg
Arjuna concentrate	100mg
Giloy concentrate	100mg
Safed musli concentrate	100mg
Aloe vera concentrate	100mg
Haldi concentrate	50mg
Sugarcane	100ml

DIETARY SUPPLEMENTS

A dietary supplement is a product that contains nutrients derived from food products. The "dietary ingredients" present in these products are metabolites, vitamins, minerals, herbs and aminoacids.

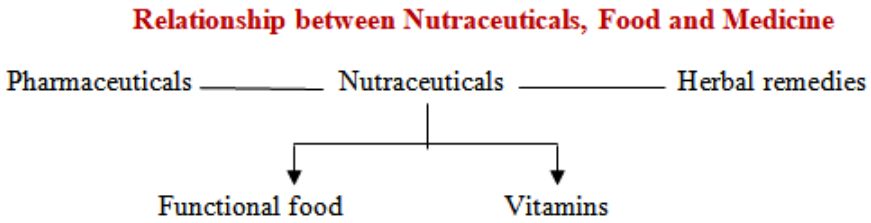

Fig. 1: Flow chart of Nutraceuticals, Food and Medicine

AREA OF CONCERN

The lack of quality control is a major area of concern of Nutraceuticals. The quality of plant materials and manufacturing processes used for Nutraceuticals are regulated by food laws which lack the specificity required for botanical drugs. This can have serious consequences. Contamination, for instance with toxins after fungal infection of raw plant material or with other ingredients has been repeatedly reported and can havepotential fatal consequences. Adulterations and numerous other types of impurity of nutraceuticals conceivably remain undetected simply because there is an almost total absence of specific quality control. New clinical applications of nutraceuticals are increasingly being reported.

BIO-AVAILABILITY

Bio availability is "absorption rate" of a supplement product. In development of effective Nutraceutical products bio-availability play important role. The bio availability of substance which is in natural state will be more as comparison manufactured product.

SAFETY AND EFFICACY

Nutraceuticals hold great potential as an alternative to substance obtained by plant yet, some time they also cause harmful effect as seen with ephedrine, a widely used botanical ingredient in weight loss products. Now a day's people are more conscious about their health and these products offer the promised health benefits. But danger is associated with some product due to lack of solid information about interaction and side effect.

CONCLUSION

Nutraceuticals are destined to play an important role in future therapeutic development but their success will be governed by control of purity, safety and efficacy without inhibiting innovation. Nutraceutical is growing health care industry in India. Nutraceuticals is playing important role in developments of future therapeutics but depends on control of purity, efficacy and safety. Nutraceutical products are used in prevention of disease not in cure of disease. Now "Nutraceutical a day may keep the doctors away "replace the old proverb" an apple a day will keep the doctor away"

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Chapter 6

EMERGING CONTAMINANTS: CURRENT ISSUES AND FUTURE PERSPECTIVES

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ABSTRACT

Emerging contaminants (ECs) represent a growing challenge in environmental chemistry, encompassing a diverse array of substances from pharmaceuticals and personal care products to industrial chemicals and microplastics. These contaminants are increasingly detected in various environmental compartments due to their persistence, bioaccumulative potential, and have adverse effects on ecosystems and human health. This abstract provides an overview of the current issues and future perspectives regarding ECs, focusing on their sources, environmental fate, analytical challenges, impacts and management strategies. The ECs originate from wastewater effluents, agricultural runoff, industrial emissions and improper disposal, entering the environment through various pathways. They can persist long-term, accumulate in organisms and biomagnify through food chains posing risks to wildlife and potentially impacting human health via exposure through air, water and food. Analyzing and monitoring ECs present significant challenges due to their low concentrations, complex mixtures and the need for advanced analytical techniques such as mass spectrometry and chromatography. Regulatory frameworks often struggle to keep pace with the rapid emergence of new contaminants and the evolving understanding of their impacts, necessitating adaptive and precautionary approaches to management. Future perspectives involve enhancing risk assessment methodologies, developing innovative remediation technologies, fostering global cooperation and raising public awareness to mitigate EC impacts effectively. By addressing these challenges comprehensively, we can safeguard ecosystems and public health ensuring sustainable environmental quality for current and future generations.

KEYWORDS: Emerging Contaminants, Pharmaceuticals, Personal Care Products, Endocrine-Disrupting Compounds, Nanomaterials, Microplastics, Per- and Polyfluoroalkyl Substances (PFAS), Environmental Fate, Analytical Techniques, Risk Assessment and Remediation Technologies.

INTRODUCTION

In recent decades, the field of environmental chemistry has expanded its focus to address a new category of pollutants known as emerging contaminants. Emerging contaminants (ECs) represent a pressing concern within environmental chemistry due to their increasing detection in various environmental matrices and the potential risks they pose to ecosystems and human health. These substances which include pharmaceuticals, personal care products, industrial chemicals and agricultural residues are often not fully removed by conventional wastewater treatment processes and can persist in the environment. This chapter explores the various types of emerging contaminants, their sources and pathways, environmental and health impacts, analytical challenges, and current regulatory and management strategies. It also addresses future challenges and innovative solutions for mitigating the risks associated with these contaminants.

TYPES OF EMERGING CONTAMINANTS

Emerging contaminants encompass a broad spectrum of chemicals with diverse sources and unique properties. The Key categories include:

1. **Pharmaceuticals and Personal Care Products (PPCPs):** This group includes a wide variety of substances such as antibiotics, hormones, painkillers, antidepressants and cosmetic products. PPCPs enter the environment through human excretion, bathing, and improper disposal.
2. **Endocrine-Disrupting Compounds (EDCs):** EDCs are chemicals that interfere with hormonal systems. Common EDCs include bisphenol A (BPA), phthalates and certain pesticides. These substances are prevalent in plastics and other consumer products and their presence has been linked to reproductive and developmental abnormalities in wildlife and also in human beings.
3. **Nanomaterials:** Engineered nanoparticles are used in a variety of applications including medicine, electronics and cosmetics. Their small size and high surface area-to-volume ratio impart unique reactivity and potential toxicity making them a significant concern in environmental chemistry.
4. **Microplastics:** These are small plastic particles that originate from the breakdown of larger plastic debris and consumer products such as synthetic fibers and exfoliating beads. Microplastics are pervasive in marine environments and pose risks to aquatic life and potentially to human health through the food chain.
5. **Per- and Polyfluoroalkyl Substances (PFAS):** PFAS are synthetic chemicals used in a variety of products such as non-stick cookware, water-repellent clothing and firefighting foams. They are known for their persistence in the environment and potential health risks, including cancer and developmental effects.

SOURCES AND PATHWAYS

Emerging contaminants enter the environment through diverse pathways, including:

Wastewater Treatment Plants (WWTPs): Many contaminants are not completely removed during wastewater treatment and are subsequently discharged into water bodies. This is a major source of PPCPs, EDCs and nanomaterials in the environment.

Agricultural Runoff: Pesticides, fertilizers and veterinary pharmaceuticals used in agriculture can leach into soil and water systems contributing significantly to environmental contamination.

Industrial Emissions: Manufacturing processes release a variety of chemicals into the air and water. This includes PFAS and other industrial chemicals that persist in the environment.

Household Waste: Improper disposal of pharmaceuticals, personal care products and plastic waste leads to contamination of soil and water. This pathway is particularly significant for PPCPs and microplastics.

ENVIRONMENTAL AND HEALTH IMPACTS

The presence of emerging contaminants in the environment raises several significant concerns due to their potential impacts on ecosystems and human health:

Ecotoxicological Effects: Many emerging contaminants affect wildlife, leading to reproductive, developmental and behavioral changes. For instance, EDCs can disrupt endocrine systems causing feminization in fish populations and affecting the reproductive success of various species.

Bioaccumulation and Biomagnifications: Persistent contaminants such as PFAS and certain pharmaceuticals can accumulate in organisms and magnify through food chains posing risks to top predators, including humans. This bioaccumulation can lead to high concentrations of toxic substances in organisms at higher trophic levels.

Human Health Risks: Continuous exposure to low levels of contaminants particularly through drinking water can lead to adverse health effects such as hormonal imbalances, cancer and antibiotic resistance. For example, the presence of antibiotics in the environment can promote the development of antibiotic-resistant bacteria posing a significant public health risk.

ANALYTICAL CHALLENGES AND ADVANCES

Detecting and quantifying emerging contaminants in the environment presents several challenges:

Low Concentration Levels: Many emerging contaminants are present at trace levels necessitating highly sensitive and accurate analytical techniques. Conventional analytical methods may not be sufficient to detect these low concentrations.

Complex Mixtures: Environmental samples often contain complex mixtures of contaminants complicating analysis and interpretation. The interactions between different contaminants can also affect their behaviour and toxicity.

Advanced Techniques: Advanced analytical techniques such as liquid chromatography-tandem mass spectrometry (LC-MS/MS) and high-resolution mass spectrometry (HRMS) are essential for identifying and quantifying emerging contaminants. These techniques offer the sensitivity and specificity needed to detect trace levels of contaminants in complex environmental matrices.

REGULATORY AND MANAGEMENT STRATEGIES

Current regulatory frameworks are often inadequate to address the complexities of emerging contaminants. Effective management of emerging contaminants requires robust regulatory frameworks and innovative strategies:

Precautionary Principle: Implementing precautionary regulations that restrict the use of chemicals with suspected harmful effects, even if full scientific certainty is not yet established. This principle is essential for preventing the introduction of potentially harmful substances into the environment.

Dynamic Regulations: Updating existing regulations to reflect new scientific findings and emerging threats ensuring they remain relevant and effective. This involves continuous monitoring and assessment of emerging contaminants and their impacts.

Global Standards: Developing international standards and agreements to address transboundary pollution and ensure consistent regulation across countries. This is particularly important for contaminants that can be transported over long distances through air and water.

INNOVATIVE REMEDIATION AND TREATMENT TECHNOLOGIES

To address the challenges posed by emerging contaminants innovative treatment technologies and approaches are essential:

Advanced Wastewater Treatment: Upgrading existing wastewater treatment plants with technologies such as advanced oxidation processes, membrane filtration and bioreactors to improve contaminant removal. These technologies can enhance the efficiency of contaminant degradation and removal, reducing their discharge into the environment.

Green Chemistry: Promoting the design and use of safer chemicals and processes that minimize the production and release of harmful substances. Green chemistry principles can help in developing environmentally benign alternatives to traditional chemicals.

Bioremediation: Utilizing biological organisms such as bacteria and plants to degrade or absorb contaminants from polluted environments. Bioremediation is a cost-effective and sustainable approach to managing environmental contamination.

PUBLIC AWARENESS AND EDUCATION

Raising public awareness and promoting education are crucial for managing emerging contaminants:

Education Campaigns: Conducting public education campaigns to raise awareness about the proper disposal of pharmaceuticals and the environmental impacts of consumer products.

Informing the public about the risks associated with emerging contaminants can encourage responsible behaviour.

Community Involvement: Engaging communities in monitoring and managing local pollution empowering them to take action and advocate for cleaner environments. Community involvement can enhance the effectiveness of local environmental management efforts.

Informed Consumer Choices: Encouraging consumers to make environmentally friendly choices such as reducing plastic use and opting for green products. Informed consumer choices can reduce the demand for products that contribute to environmental contamination.

FUTURE PERSPECTIVES

As the list of emerging contaminants continues to grow, several future challenges must be addressed:

Comprehensive Risk Assessment: Developing standardized methods for assessing the combined effects of multiple contaminants. Understanding the cumulative impacts of multiple contaminants is crucial for effective risk assessment and management.

Regulatory Adaptation: Updating regulations to keep pace with new scientific findings and emerging threats. Regulatory frameworks must be flexible and adaptive to respond to the dynamic nature of emerging contaminants.

Innovative Remediation Technologies: Advancing technologies such as nanofiltration, advanced oxidation processes and bioremediation are essential for effectively removing contaminants from the environment. Continued research and development in these areas are essential for improving contaminant management.

Global Collaboration: Fostering international cooperation to address transboundary pollution and share best practices in monitoring and management. Global collaboration is vital for tackling the widespread and interconnected nature of emerging contaminants.

CONCLUSION

Emerging contaminants present a complex and evolving challenge in environmental chemistry. Addressing these threats requires a multidisciplinary approach, combining advanced analytical techniques, innovative management strategies, robust regulatory frameworks, and public engagement. By understanding the complexities of emerging contaminants and proactively mitigating their impacts we can better protect our ecosystems and public health ensuring a sustainable future for generations to come.

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Chapter 7

ENHANCING FAMILY NUTRITION THROUGH SMALL-SCALE ANIMAL HUSBANDRY

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INTRODUCTION

The practice of dairy farming on a homestead scale has been a cornerstone of rural life for generations. In today's context, with increasing emphasis on self-sufficiency and sustainable living, small-scale dairy farming is gaining renewed interest. This chapter examines how producing dairy products on a homestead can boost family nutrition and enhance overall well-being, focusing on practical aspects of managing dairy animals and processing milk.

NUTRITIONAL VALUE OF DAIRY PRODUCTS

Dairy products, including milk, cheese, yogurt, and butter, are packed with essential nutrients such as calcium, protein, vitamins D and B12, and phosphorus. These nutrients are crucial for maintaining strong bones, supporting muscle function, and promoting overall health. For families, having a direct source of fresh, home-produced dairy ensures a consistent supply of these important nutrients.

CHOOSING DAIRY ANIMALS FOR YOUR HOMESTEAD

Selecting the right dairy animals is vital for a successful homestead dairy operation. Considerations include the available space, resources, and the family's dairy consumption needs. Common options for small-scale dairy include:

Cows: Suitable for larger homesteads, cows offer substantial milk yields. Breeds such as Jersey and Guernsey are favored for their high butterfat content, ideal for making rich cream and butter.

Goats: Goats are well-suited to smaller spaces and are easier to manage compared to cows. Goat milk is easier to digest and is a popular choice for those with lactose intolerance.

Sheep: Although less common, sheep can be used for dairy production. Their milk is high in fat and protein, making it excellent for cheese production.

Buffaloes: In some regions, buffaloes are preferred for their substantial milk output and rich milk, suitable for making traditional dairy products like ghee.

SETTING UP A SMALL-SCALE DAIRY OPERATION

Establishing a homestead dairy operation involves several key elements:

Housing: Adequate housing is crucial for the health and comfort of dairy animals. Shelters should protect animals from harsh weather, provide proper ventilation, and be kept clean to prevent disease.

Feeding and Nutrition: Providing a balanced diet is essential for the productivity and health of dairy animals. This includes high-quality forage, such as hay and pasture, along with grains and minerals. Access to clean water is also important.

Milking Practices: Regular milking, typically twice a day, should be done with hygienic methods to ensure milk quality. Proper cleaning and sterilization of milking equipment are critical to prevent contamination.

Health Care: Routine veterinary care, including vaccinations and deworming, helps maintain animal health. Early detection and treatment of illnesses are necessary to ensure consistent milk production.

PROCESSING DAIRY PRODUCTS AT HOME

Turning milk into various dairy products can diversify your diet and make use of the milk produced. Common processes include:

Milk Storage: Fresh milk should be stored in a cool, clean environment to extend its shelf life. Pasteurization at home can also be an option for ensuring milk safety.

Cheese Making: Homemade cheese, such as paneer or cottage cheese, can be a great way to preserve milk and create nutritious products. The process can be simple and requires minimal equipment.

Yogurt and Butter: Making yogurt and butter at home provides additional health benefits and is a straightforward process. Yogurt is rich in probiotics, while butter is a source of essential fats.

Ghee and Clarified Butter: Ghee, made by simmering butter to remove moisture, has a long shelf life and is valued for its flavor and nutritional benefits.

BENEFITS TO FAMILY HEALTH AND WELL-BEING

Homestead dairy production offers numerous advantages beyond providing nutritious food:

Food Security: Home-produced dairy ensures a reliable and consistent source of nutrition, reducing dependence on external sources and contributing to food sovereignty.

Cost Efficiency: Producing your own dairy products can lead to significant savings on grocery expenses, especially in areas where dairy prices are high.

Educational Value: Engaging in dairy production provides valuable life skills and a deeper understanding of food sources for all family members.

Sustainable Practices: Small-scale dairy farming supports sustainability by reducing food miles, utilizing organic waste, and fostering self-sufficiency.

ADDRESSING CHALLENGES

While the benefits are considerable, there are challenges associated with homestead dairy farming:

Time and Effort: Managing dairy animals and processing milk requires time and effort. Sharing responsibilities among family members and optimizing processes can help manage this.

Initial Investment: Starting a dairy operation involves costs for animals, housing, and equipment. Gradually scaling up and careful planning can help manage financial investment.

Regulatory Issues: Compliance with local regulations regarding dairy production is essential. Understanding and adhering to these regulations can prevent legal issues.

CONCLUSION

Homestead dairy production can significantly enhance family nutrition, promote sustainable living, and provide educational opportunities. By selecting suitable dairy animals, implementing effective management practices, and exploring various processing techniques, families can enjoy the benefits of fresh, home-produced dairy. While challenges exist, careful planning and commitment to small-scale animal husbandry principles can lead to a rewarding and healthy lifestyle.

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Chapter 8

DISTRIBUTIONAL RECORDS OF SOME NOTEWORTHY SPECIES OF GENUS *HYMENOCHAETE* OF CORTICIOID FUNGI FROM DISTRICT CHAMBA OF HIMACHAL PRADESH

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ABSTRACT

The present chapter deals with 9 taxa of *Hymenochaete* belonging to family *Hymenochaetacea* based on the specimens collected from various localities of Chamba district (Himachal Pradesh). This chapter describes *Hymenochaete cruenta*, *H. fuliginosa*, *H. leonine*, *H. macrospora*, *H. minuscule*, *H. rheicolor*, *H. rubiginosa, H. semistupposa* and *H. tabacina*. of the taxa recorded, *Hymenochaete macrospora* and *H. tabacina* are new additionto the fungal diversity from Chamba district of Himachal Pradesh.

KEYWORDS: *Agaricomycetes*, *Basidiomycota*, Corticioid Fungi, *Hymenochaete*, Western Himalayas**.**

INTRODUCTION

Genus *Hymenochaete* is a unique assemblage of corticioid fungi and is characterised by many peculiar features. Sporophores are usually resupinate, adnate, effused, reflexed to pileate; hymenial surface varies from smooth to tuberculate to sometimes cracked, corky, dark brown to blackish in KOH soluton. Hyphal system monomitic or dimitic. Generative hyphae without clampes, thin- to thick-walled. Setal elements present. Hyphidia present or absent. Basidia clavate to subclavate, 4–sterigmate, without clamp at the base. Basidiospores ellipsoid to broadly ellipsoid to cylindrical to subcylindrical to suballantoid, smooth, thin-walled, negative to both Melzer's reagent and Cotton blue, with or without oily contents.

Fungal forays were conducted in various sub divisions of Chamba district in the years 2013-2018 and quite a good number of specimens of Genus *Hymenochaete* were collected. These were identified and described as 9 taxa belonging to Genus *Hymenochaete* on the basis of macromorphological as well micomorphological features and comparison with the literature (Banerjee, 1935; Bagchee and Bakshi, 1954; Thind and Adlakha, 1956; Chaudhuri, 1959; Rattan, 1977; Kornerup and Wanscher, J.H. 1978; Natrajan and Kolandavelu, 1998; Bhosle *et al.,* 2005; Dhingra *et al.,* 2011 & 2014; Kaur, 2012; Ranadive, 2013; Kaur *et al.,* 2015; Kaur, 2018; Devi, 2019; Samita, 2014; Sharma, 1995, 2012 & 2015; Sharma & Mishra, 2015; Sharma, 2017).

The present chapter aims to provide an account of genus *Hymenochaete* from Chamba district (Himachal Pradesh) based on nine species. of the nine taxa described *Hymenochaete macrospora*

and *H. tabacina* are new additions to the fungal diversity from Chamba district of Himachal Pradesh.

MATERIALS AND METHODS

Present studies comprise of collections made from different localities of district Chamba (Himachal Pradesh) during fungal forays conducted in different localities of district Chamba in the years 2012-2018. The sporophores along with a portion of the host substrate were collected with the help of a hammer and a chisel. The details pertaining to type of hymenium, colour, margins etc., were noted attentively with the help of a hand lens. A wet piece of the sporophore was used to get the spore print on a glass slide. These speciemens were dried either in sun or using an electric drier. The dried sporophores were packed in bond paper envelops carrying a standard herbarium label with required information. All the specimens have been deposited at the Herbarium, Department of Botany, Punjabi University, Patiala (PUN). The micromorphological details of the collected specimens were observed by making crush mounts/vertical sections of the sporophores in water, 3% KOH solution, 1% pholxine, 1% cotton blue, 1% congo red and Melzer's reagent (0.5gm Iodine + 1.5gm KI + 20gm Chloral hydrate + 20ml Distilled water). The outline of the microscopic structures was drawn with the help of a camera lucida mounted on compound microscope at 100X, 400X and 1000X magnifications. The colour citations are as per Kornerup and Wanscher (1978).

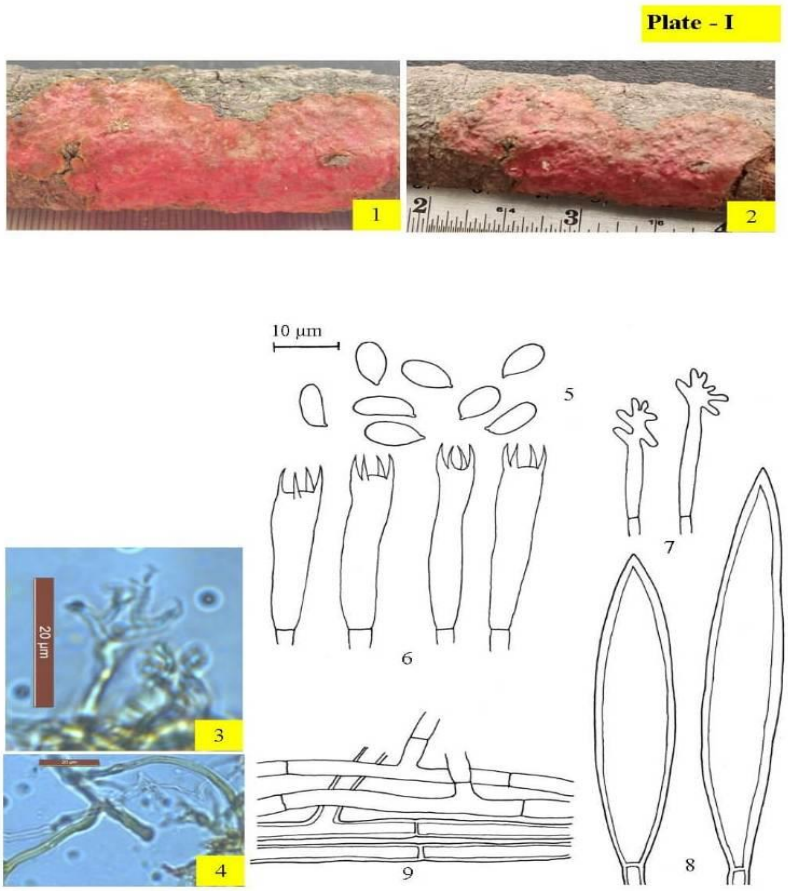
Family – *Hymenochaetaceae* Imazeki & Toki, Bulletin of the Government Forest Experimental Station Meguro 67: 24 (1954).

Sporophores resupinate, adnate, effused to reflexed to pileate, corky to leathery; hymenial surface smooth to tuberculate to grandinoid to odontoid to poroid. Hyphal system monomitic or dimitic. Generative hyphae septate, with or without clamps. Ancillary elements present or absent. Setal elements present or absent. Hyphidia present or absent. Basidia clavate to subclavate, 4–sterigmate, with or without clamp at the base. Basidiospores narrowly ellipsoid to ellipsoid to subcylindrical to suballantoid, smooth, +ve/-ve to Cotton Blue and inamyloid to dextrinoid to amyloid in Melzer's reagent.

Hymenochaete Lév., Annales des Sciences NaturellesBotanique 5: 150 (1846).

Sporophores resupinate, adnate, effused, reflexed to pileate; hymenial surface smooth to tuberculate to sometimes cracked, corky, dark brown to blackish in KOH soluton. Hyphal system monomitic or dimitic. Generative hyphae without clampes, thin- to thick-walled. Setal elements present. Hyphidia present or absent. Basidia clavate to subclavate, 4–sterigmate, without clamp at the base. Basidiospores ellipsoid to broadly ellipsoid to cylindrical to subcylindrical to suballantoid, smooth, thin-walled, negative to both Melzer's reagent and Cotton Blue, with or without oily contents.

1. *Hymenochaete cruenta* (Pers.) Donk, Persoonia 1 (1): 51, (1959). *Thelephoracruenta*Pers., Synopsis Methodica Fungorum: 575 (1801). Plate–I



Figs. 1– 9. *Hymenochaete cruenta* :1-2. Sporophore showing hymenial surface (1. Fresh, 2. Dry); 3-4. Photomicrographs (3. Dendrohyphidia, 4.Generative hyphae); 5-9. Line diagrams [5. Basidiospores; 6. Basidia, 7. Dendrohyphidia, 8. Setae, 9.Generative hyphae]

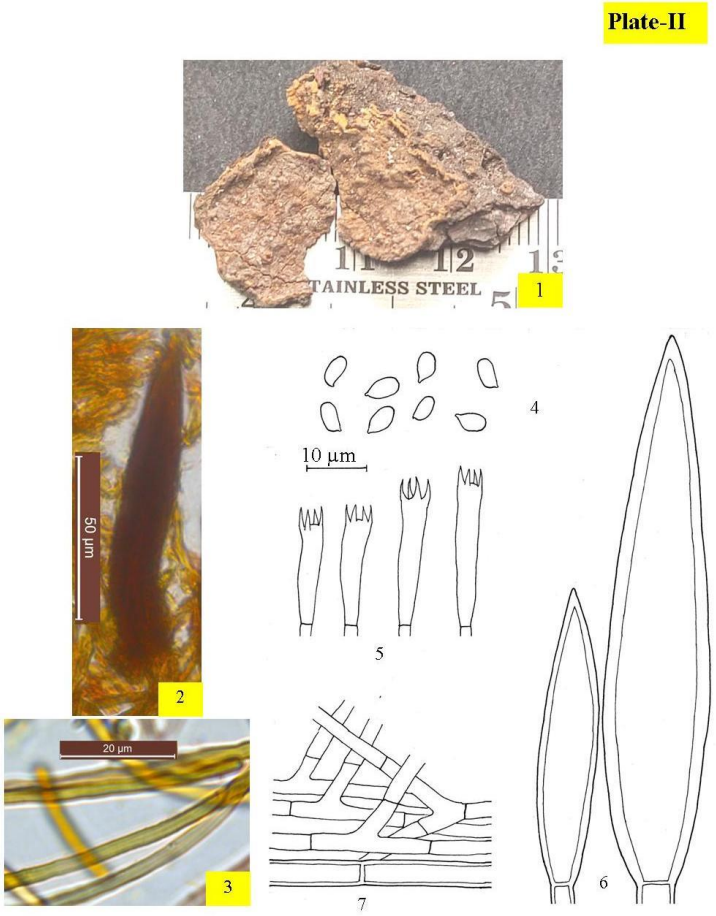
Fig. 1– 9: *Hymenochaete cruenta*: 1-2. Sporophore showing hymenial surface (1. Fresh, 2. Dry); 3-4. Photomicrographs (3. Dendrohyphidia, 4. Generative hyphae); 5-9. Line diagrams [5. Basidiospores; 6. Basidia, 7. Dendrohyphidia, 8. Setae, 9. Generative hyphae]

Sporophore annual, resupinate, adnate, effused that can reach a thickness of ≤350 µm in section; hymenium smooth to tuberculate both in fresh and dry state, red to deep red when fresh and greyish red to brownish red after drying; margins thinning, concolorous to reddish brown when determinate.Generative hyphaesimple septate, smooth; light brown, horizontal, ≤ 3.8 µm wide, less branched, thick-walled in the subicularzone; subhyaline to pale yellow, vertical, ≤ 2.8 µm wide, richly branched, thin-walled in the subhymenial zone. Setae fusiform to subfusiform, with acute apices, simple septate at the base, arising from subhymenium, brown, 58–73 × 9.3–11.6 µm, smooth, thick-walled; projecting up to 38 µm out of the hymenium. Dendrohyphidiairregularly branched at the apex, abundant in the hymenium, 22–28 µm long. Basidia clavate to subclavate, 27–31 × 4.9– 6.6 µm; sterigma ≤ 5.5 µm long. Basidiospores ranges from 7.7–9.1 × 2.9– 4.4 µm, subcylindrical to ellipsoid, thin-walled, smooth, acyanophilous, inamyloid.

Collection examined – India, Himachal Pradesh: Chamba; Dalhousie, Jandrighat, on stick of *Quercus leucotrichophora*, Poonam10558 (PUN), August 29, 2015.

Remarks –It is being described for the first time from tehsil Chowari in district Chamba (H.P.). It was earlier reported from Maharashtra (Ranadive, 2013); district Chamba of H.P. (Kaur *et al.*, 2015); district Kangra of H.P. (Devi, 2019).

2. *Hymenochaete fuliginosa* (Pers.) Lév., Annales des Sciences Naturelles Botanique 5: 152 (1846). - *Thelephorafuliginosa* Pers., MycologiaEuropaea 1: 145 (1822). Plate–II



Figs. 1– 7. *Hymenochaete fuliginosa* :1. Sporophore showing hymenial surface; 2-3. Photomicrographs (2. Seta, 3. Generative hyphae); 4-7. Line diagrams [4. Basidiospores; 5.Basidia, 6. Setae, 7.Generative hyphae]

Figs. 1– 7. *Hymenochaete fuliginosa*:1. Sporophore showing hymenial surface; 2-3. Photomicrographs (2.Seta, 3.Generative hyphae); 4-7. Line diagrams [4. Basidiospores; 5. Basidia, 6. Setae, 7. Generative hyphae]

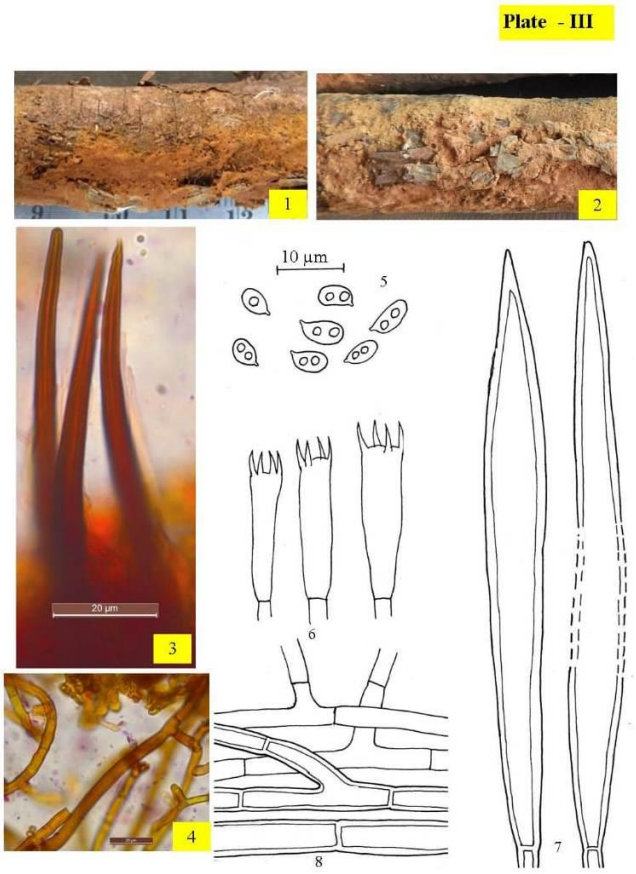
Sporophore annual, resupinate, adnate, effused, reflexed, soft that can reach a thickness of ≤350 µm thick in section; hymenium smooth, cracked both in fresh and dry state, brownish grey to greyish brown both in fresh and dry state; margins thinning, concolorous to reddish brown when determinate. Generative hyphaesimple septate, smooth; light brown, horizontal, ≤ 4.2 µm wide, less branched, thin- to thick-walled in the subicularzone; subhyaline to pale yellow, vertical, ≤ 2.1 µm wide, richly branched, thin-walled in the subhymenial zone. Setae subfusiform, with acute apices, simple septate at the base, arising from the subhymenium,

brown, 48–89 × 11–18 µm, smooth, thick-walled; projecting up to 30 µm out of the hymenium. Basidia narrowly clavate, 18–23 × 4–5 µm; sterigma ≤ 5.5 µm long. Basidiospores ranges from 4.2–6.3 × 2.1– 3.1 µm, ellipsoid to subcylindrical, thin-walled, smooth, acyanophilous, inamyloid.

Collection examined – India, Himachal Pradesh: Chamba; Dalhousie, Ahla, on *Cedrusdeodara* stump, Poonam10764 (PUN), August 29, 2015.

Remarks –*H. fuliginosa*is a rereported taxon from district Chamba (H.P.). Earlier It was earlier described from Tamil Nadu (Natarajan and Kolandavelu, 1998); Uttarakhand (Samita, 2014) and district Chamba of H.P. (Kaur, 2018).

3. *Hymenochaete leonine* Berk. & M.A. Curtis, Journal of the Linnean Society. Botany 10: 334 (1869). Plate–III



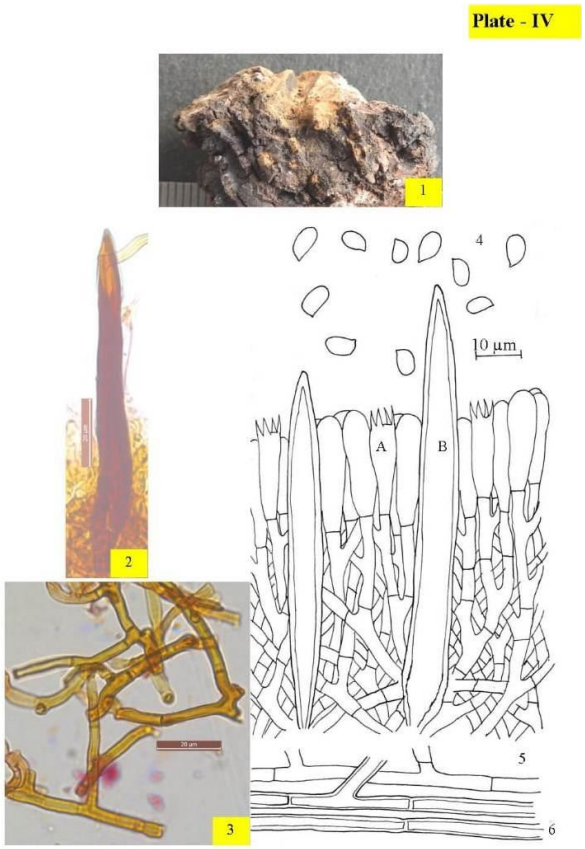
Figs. 1– 8. ***Hymenochaete leonina*** **:1-2. Sporophore showing hymenial surface (1. Fresh, 2. Dry); 3-4. Photomicrographs (3. Setae, 4.Generative hyphae); 5-8. Line diagrams [5. Basidiospores; 6. Basidia, 7. Setae, 8.Generative hyphae]**

Figs. 1– 8. *Hymenochaete leonina* :1-2. Sporophore showing hymenial surface (1. Fresh, 2. Dry); 3-4. Photomicrographs (3. Setae, 4. Generative hyphae); 5-8.Line diagrams [5. Basidiospores; 6. Basidia, 7. Setae, 8. Generative hyphae]

Sporophore annual, resupinate, loosely adnate, effused, separable from the substrate when fresh, turns hard on drying that can reach a thickness of ≤ 280µm thick in section; hymenium smooth both in fresh and dry state, brownish orange when fresh and light brown on drying; margins thinning, fibrous, paler concolorous when determinate. Generative hyphaesimple

septate, smooth; light brown, horizontal, ≤ 5 µm wide, less branched, thick-walled in the subicular zone; subhyaline to pale yellow, vertical, ≤ 2.6 µm wide, richly branched, thin-walled in the subhymenial zone. Setae subfusiform with subulate apices, simple septate at the base, arising from subiculum and subhymenium, brown, 83–100 × 7.5–8.5 µm, smooth, thick-walled; projecting up to 60 µm out of the hymenium. Basidia clavate to subclavate,
18–21 × 4.4– 6.1 µm; sterigma ≤ 5 µm long. Basidiospores ranges from 4.8–6 × 2.5– 3 µm, ellipsoid, with oly contents, thin-walled, smooth, acyanophilous, inamyloid.
Collection examined – India, Himachal Pradesh: Chamba; Pangi, Sural, on angiospermic sticks, Poonam 10173 (PUN), September 13, 2016.
Remarks –*H. leonina*is being described for the first time from tehsil Pangi in Chamba (H.P.). Earlier It has been reported from district Shimla of H. P. (Rattan (1977); Uttarakhand (Lalji; 2003 and Samita; 2014); districts Shimla and Sirmaur of H.P. (Sharma 1995 and 2012); Maharashtra (Ranadive, 2013); district Chamba of H.P. (Kaur, 2012 and Dhingra *et al.,* 2014); districts ChambaandShimla of H. P. (Kaur, 2018) and district Kangra of H.P. (Devi, 2018).

4. *Hymenochaete macrospora* Y.C. Dai, Mycotaxon 76: 446 (2000). Plate–IV



Figs. 1– 6. H*ymenochaete macrospora*:1. Sporophore showing hymenial surface; 2-3. Photomicrographs (2. Seta 3. Generative hyphae); 4-6. Line diagrams [4. Basidiospores; 5. Reconstruction showing a portion of hymenium and subhymenium (A. Basidium, B. Seta); 6. Generative hyphae]

Sporophore annual, resupinate, loosely adnate, effused that can reach a thickness of ≤300μm in section; hymenium smooth both in fresh and dry state, golden yellow to brownish yellow both when fresh as well as on drying; margins thinning, paler concolorous when determinate. Generative hyphae simple septate, smooth; light brown, horizontal, ≤ 3.3 μm wide, less branched, thin- to thick-walled in the subicularzone; subhyaline to pale yellow, vertical, ≤ 2.7 μm wide, richly branched, thin-walled in the subhymenial zone. Setae subfusiform, with acute apices, simple septate, arising from the subhymenium, brown, 70–88× 7.2–7.7 μm, smooth, thick-walled, projecting up to 35 μm out of the hymenium. Basidia clavate to subclavate, 17–20 × 4.4–4.9 μm; sterigma ≤ 5 μm long. Basidiospores ranges from 5–7.7 × 3.2– 4 μm, ellipsoid to broadly ellipsoid, with oily contents, thin-walled, smooth, acyanophilous, inamyloid.

Collection examined – India, Himachal Pradesh: Chamba; on way from Dalhousie to Banikhet, on stump of *Rhododendron arboreum*, Poonam 10117 (PUN), September 10, 2017.

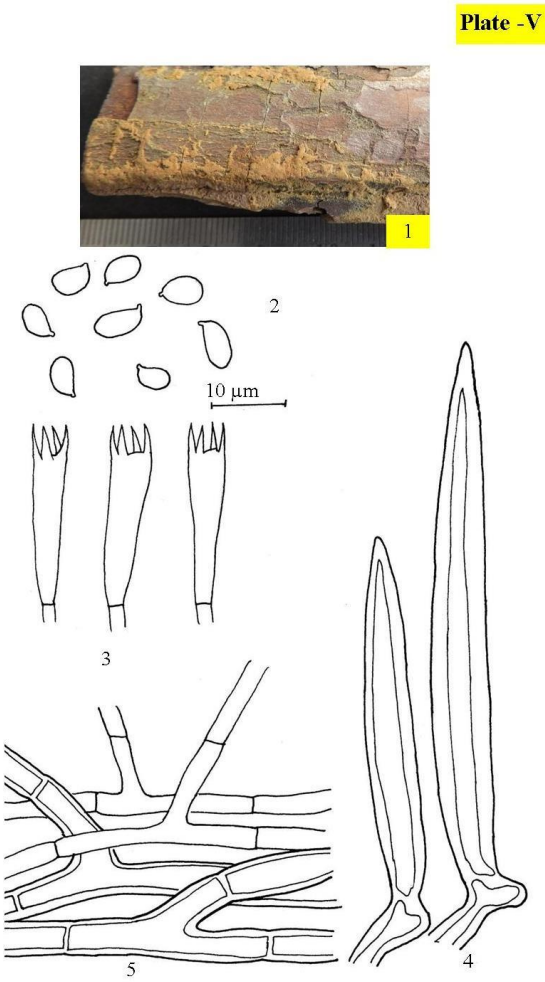
Remarks –*H. macrospora*, an addition to the corticioid fungi of district Chamba, is earlier reported only from district Solanof Himachal Pradeshby Kaur et al. (2015).

5. *Hymenochaete minuscula* G. Cunn., Transactions and Proceedings of the Royal Society of New Zealand 85 (1): 48 (1957). Plate–V

Sporophore annual, resupinate, loosely adnate, effused that can reach a thickness of ≤300μm in section; hymenium smooth both in fresh and dry state, golden yellow to pale orange both when fresh and on drying; margins fibrillose, paler concolorous when determinate. Generative hyphae simple septate, smooth; light brown, horizontal, ≤ 4.5 μm wide, less branched, thick-walled in the subicularzone; subhyaline to pale yellow, vertical, ≤ 2.5 μm wide, richly branched, thin-walled in the subhymenial zone. Setae subfusiform, with acute apices, simple septate, arising from the subhymenium, brown, 42–68 × 6.1–7.7 μm, smooth, thick-walled, smooth; projecting up to 35 μm out of the hymenium. Basidia clavate, 18–20 × 3.3–3.9 μm; sterigma ≤ 3.3 μm long. Basidiospores ranges from 3.5–6.1 × 2.5– 3.4 μm, ellipsoid to broadly ellipsoid, with oly contents, thin-walled, smooth, acyanophilous, inamyloid.

Collection examined – India, Himachal Pradesh: Chamba; Nanikhad, Magjeen, on angiospermous stump, Poonam 10118 (PUN), January 10, 2016.

Remarks –It is being redescribed from district Chamba (H.P.). Earlier it has been reported from District Shimla, H.P (Sharma, 2015) Andaman (Sharma &Mishra, 2015); Jammu & Kashmir (Sharma, 2017).



Figs. 1– 5. ***Hymenochaete minuscula*** **:**1. Sporophore showing hymenial surface; 2-5. Line diagrams [2. Basidiospores; 3. Basidia, 4. Seta, 5. Generative hyphae]

Figs. 1– 5. ***Hymenochaete minuscula*****: 1. Sporophore showing hymenial surface; 2-5. Line diagrams [2. Basidiospores; 3. Basidia, 4. Seta, 5. Generative hyphae]**

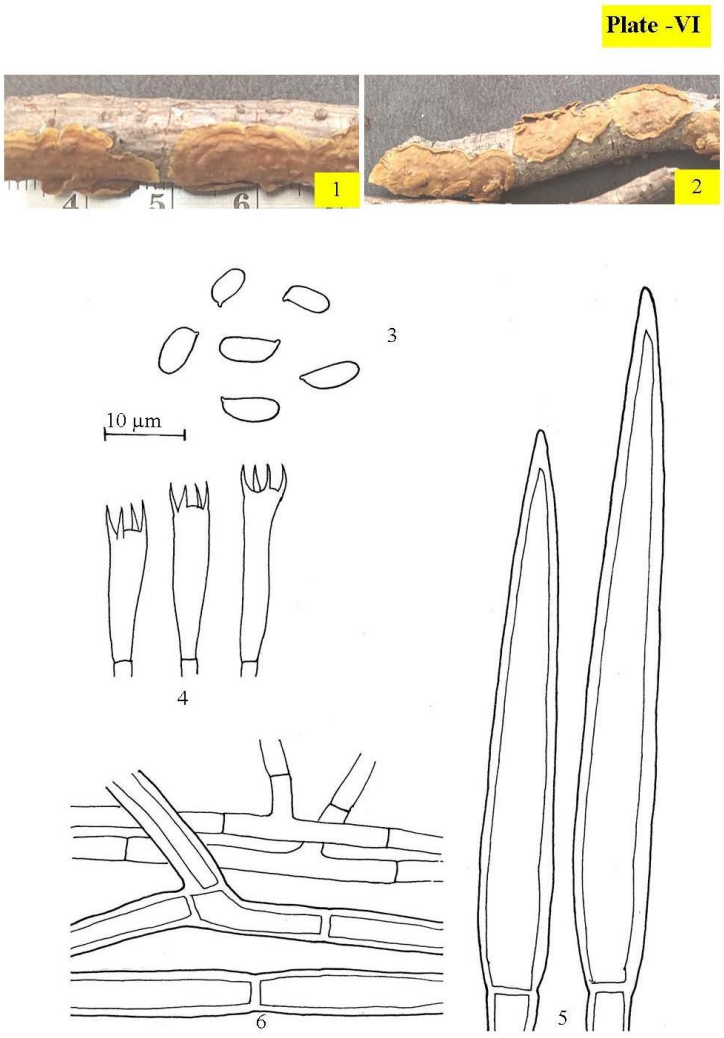
6. ***Hymenochaete rheicolor*** **(Mont.) Lév., Annales des Sciences NaturellesBotanique 5: 151 (1846). -** ***Stereumrheicolor*** **Mont., Annales des Sciences NaturellesBotanique 18: 23 (1842). Plate – VI**

Sporophore annual, resupinate, effused, papery, reflexed to pileate that can reach a thickness of ≤ 330µm in section; Abhymenial surface tomentose, concentrically zonate and sulcate when collected, not changing much on drying. Hymenial surface smooth, when collected, not changing much on drying; brownish orange to brownboth when fresh and on drying; wavy to somewhat lobed; paler concolorous on both abhymenial and hymenial surfaces. Generativehyphaesimple septate, smooth; light brown, horizontal, ≤ 5.5 µm wide, less branched, thick-walled in the subicularzone; subhyaline to pale yellow, vertical, ≤ 2.5 µm wide, richly branched, thin-walled in the subhymenial zone. Setae subfusiform, with acute apices, simple septate at the base, arising from the subhymenium, brown, 64–80 × 8.3–9.9 µm, smooth, thick-walled; projecting up to 50 µm out of the hymenium. Basidia narrowly clavate, 15–20 ×

3.8– 4.4 µm; sterigma ≤ 5.5 µm long. Basidiospores ranges from 5–6.5 × 2.5– 3 µmellipsoid to subcylindrical, thin-walled, smooth, acyanophilous, inamyloid.

Collection examined – India, Himachal Pradesh: Chamba; Salooni, on sticks of *Quercusleucotrichophor*, Poonam 10763 (PUN), August 29, 2015.

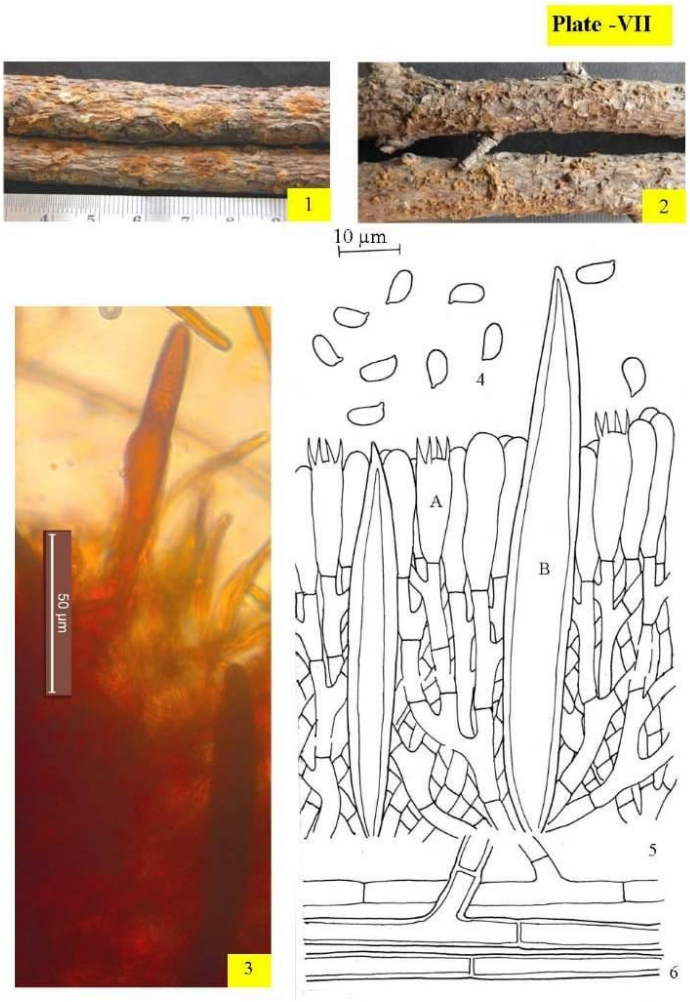
Remarks –*H. rheicolor*is a rereport from district Chamba (H.P.). Earlier it was described fromWest Bengal (Banerjee, 1935 and 1947); Maharashtra (Ranadive, 2013); Uttarakhand (Sharma 1995& 2012 and Samita, 2014); Andaman (Sharma and Mishra, 2015); districts Chamba, Shimla, Sirmaur and Solan of H.P. (Kaur, 2018).



Figs. 1– 6. ***Hymenochaete rheicolor*** **:**1-2. Sporophore showing hymenial surface (1. Fresh, 2. Dry); 3-6. Line diagrams [3. Basidiospores; 4. Basidia, 5. Setae, 6.Generative hyphae]

Figs. 1– 6. *Hymenochaete rheicolor*:1-2. Sporophore showing hymenial surface (1. Fresh, 2. Dry); 3-6. Line diagrams [3. Basidiospores; 4. Basidia, 5. Setae, 6. Generative hyphae]

7. *Hymenochaete rubiginosa* (Dicks.) Lév., Annales des Sciences NaturellesBotanique 5: 151 (1846). –*Helvellarubiginosa*Dicks., Fasciculus plantarumcryptogamicarumBritanniae 1: 20 (1785). Plate–VII



Figs. 1– 6. *Hymenochaete rubiginosa* :1-2. Sporophore showing hymenial surface (1. Fresh, 2. Dry); 3. Photomicrograph showing setae in V.S. of sporophore; 4-6. Line diagrams [4. Basidiospores; 5. Reconstruction showing a portion of hymenium and subhymenium (A. Basidium, B. Seta); 6.Generative hyphae]

Figs. 1– 6. *Hymenochaete rubiginosa*:1-2. Sporophore showing hymenial surface (1. Fresh, 2. Dry); 3. Photomicrograph showing setae in V.S. of sporophore; 4-6. Line diagrams [4. Basidiospores; 5. Reconstruction showing a portion of hymenium and subhymenium (A. Basidium, B. Seta); 6. Generative hyphae]

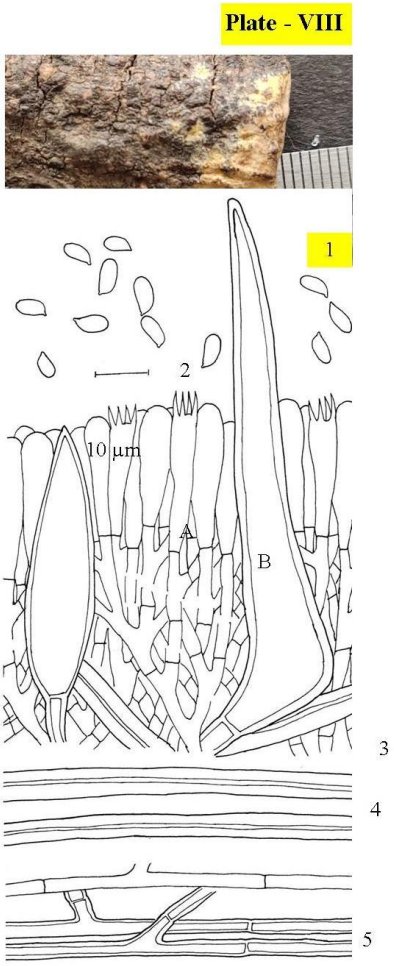
Sporophore annual, resupinate, adnate, effused, soft, that can reach a thickness of ≤300µm in section; hymenium smooth both in fresh and dry states, brownish orange to light brown when fresh and somewhat darkening on drying; margins wavy to lobed, thinning, paler concolorous when determinate. Generative hyphae≤ 3.3 µm wide, simple septate, smooth; light brown, horizontal, less branched, thin- to thick-walled in the subicularzone; subhyaline to pale yellow, vertical, richly branched, thin-walled in the subhymenial zone. Setae fusiform to subfusiform, simple septate at the base, arising from subhymenium, brown, 71–85 × 9.4–12.2 µm, smooth, thick-walled; projecting up to 50 µm out of the hymenium. Basidia clavate, 13–20 × 4.9–6.1 µm;

sterigma ≤ 3.8 µm long. Basidiospores ranges from 5–6.3 × 2.3– 2.7 µm, ellipsoid tosuballatoid, thin-walled, smooth, acyanophilous, inamyloid.

Collection examined – India, Himachal Pradesh: Chamba; Udaipur, on sticks of *Cedrusdeodara*, 10492 Poonam (PUN), November 07, 2013.

Remarks –*H. rubiginosa* is being redescribed from district Chamba. It was earlier reported from India from West Bengal (Banerjee, 1935 & 1947 and Chaudhary, 1959); Uttarakhand (Bagchee *et al.*, 1954, Rattan 1977 and Sharma 1995, 2012); Maharashtra (Bhosle et al. 2005 and Ranadive *et al.*, 2011); districts Solan and Shimla of H.P. (Kaur *et al.*, 2015).

8. *Hymenochaete semistupposa*Petch, Annals of the Royal Botanic Gardens Peradeniya 9 (3): 278 (1925). Plate–VIII



Figs. 1– 5. ***Hymenochaete semistupposa*** **:**1. Sporophore showing hymenial surface; 2-5. Line diagrams [2. Basidiospores; 3. Reconstruction showing a portion of hymenium and subhymenium (A. Basidium, B. Seta); 4. Skeletal hyphae; 5.Generative hyphae]

Figs. 1– 5. *Hymenochaete semistupposa*:1. Sporophore showing hymenial surface; 2-5. Line diagrams [2. Basidiospores; 3. Reconstruction showing a portion of hymenium and subhymenium (A. Basidium, B. Seta); 4. Skeletal hyphae; 5. Generative hyphae]

Sporophore annual, resupinate, adnate, effused, soft, that can reach a thickness of ≤ 350μm in section; hymenium smooth both in fresh and dry state, grayish orange to brownish orange when collected as well as on drying; margins fibrillose, paler concolorous when determinate. Hyphal systemdimitic. Generative hyphaesimple septate, smooth; light brown, horizontal, ≤ 3.2 μm wide, less branched, thick-walled in the subicularzone; subhyaline to pale yellow, vertical, ≤ 2.4 μm wide, richly branched, thin-walled in the subhymenial zone. Skeletal hyphae ≤ 4.8 μm wide, thick-walled, aseptate. Setae fusiform to subfusiform, simple septate at the base, arising from the subhymenium, brown, 49–108 × 12–16 μm, smooth, thick-walled; projecting up to 40 μm out of the hymenium. Basidia clavate to subclavate, 21–29 × 4.4– 5.5 μm; sterigma ≤ 5.5 μm long. Basidiospores ranges from 4.9–6.4 × 2.4– 3.2 μm, ellipsoid to subcylindrical tosuballantoid, thin-walled, smooth, acyanophilous, inamyloid.

Collections examined – India, Himachal Pradesh: Chamba, Udaipur, on angiospermous stump, Poonam 10557PUN), August 29, 2015.

Remarks –*H.semistupposa*is peculiar in having dimitichyphal system and ellipsoid to subcylindrical tosuballantoidbasidiospores.It was earlier reported from Uttarakhand (Thind &Adalakha, 1956); district Shimla (Rattan, 1977); district Chamba of H.P. (Sharma, 1995 & 2012); Tamil Nadu (Natrajan&Kolandvelu, 1998); Maharashtra (Bhosle *et al.,* 2005 and Ranadive *et al.,* 2011); district Sirmaurof H.P. (Kaur, 2012); districts Chamba, Sirmaur and Shimla of H.P. (Dhingra *et al.,* 2014); Uttarakhand (Samita, 2014); district Solan of H.P. (Kaur, 2012)

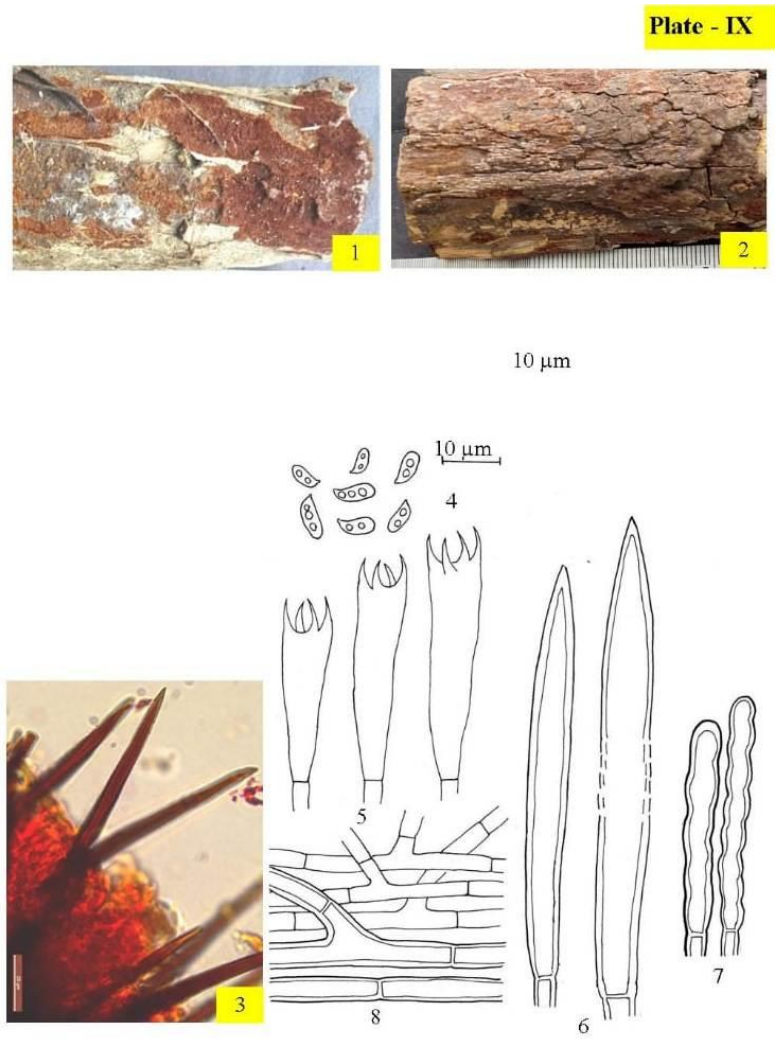
9. *Hymenochaete tabacina* (Sowerby) Lév., Annales des Sciences NaturellesBotanique 5: 152 (1846). – *Auricularia tabacina* Sower by, Coloured Figures of English Fungi 1: 14, t. 25 (1797). Plate–IX

Sporophore annual, resupinate, adnate, effused, soft, that can reach a thickness of ≤ 300μm in section; hymenium smooth both in fresh and dry state, brown to reddish brown when collected dark brown on drying; margins fibrillose, whitish to paler concolorous when determinate. Generative hyphaesimple septate, smooth; light brown, horizontal, ≤ 4 μm wide, less branched, thick-walled in the subicularzone; subhyaline to pale yellow, vertical,

≤ 3 μm wide, richly branched, thin-walled in the subhymenial zone. Setae fusiform to subfusiform, acute, simple septate, arising from the subhymenium, brown, 72–85 × 6–8.3 μm, smooth, thick-walled; projecting up to 20 μm out of the hymenium. Hyphidia37–41 × 4.8– 5.6 μm, wavy in outline, thick-walled. Basidia clavate to subclavate, 27–46 × 7.7– 8.3 μm; sterigma ≤ 5.5 μm long. Basidiospores ranges from 4.9–8 × 2.2– 2.7 μm, to suballantoid, with oily contents, thin-walled, smooth, acyanophilous, inamyloid.

Collection examined – India, Himachal Pradesh: Chamba; Bhatiyat, Jot, on *Quercus leucotrichophora* stump, Poonam 10762 (PUN), August 29, 2015.

Remarks – *H. tabacina*is a newtaxon for the study area. It was earlier reported from India from Uttarakhand (Bagchee *et al.*,1954); Maharashtra (Bhosle *et al.* (2005); district Kangraof H.P. (Devi, 2019)



Figs. 1– 8. ***Hymenochaete tabacina*** **:1-2. Sporophore showing hymenial surface (1. Fresh, 2. Dry); 3. Photomicrograph showing setae; 4-8. Line diagrams [4. Basidiospores; 5. Basidia, 6. Setae, 7. Hyphidia); 8. Generative hyphae]**

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Chapter 9

A GREEN MANURE: THE PRESENT PERSPECTIVE

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ABSTRACT

Green manuring is a cost effective and efficient way of increasing the fertility of soil by adding fresh plant residues without rotting in the soil. It involves the practice of quick growing crop which is cultivated and ploughed under, to incorporate it into the soil for the purpose of improving its physical structure and fertility. Green manure crops can fix atmospheric nitrogen, add organic matter, suppress weeds, managing pests, enhance soil biodiversity and contributing to environmental sustainability is irreplaceable. This agricultural practice is gaining renewed interest due to its numerous environmental and economic benefits. We highlight the potential of these practices to increase/sustain productivity by providing nutrients, emphasizing its benefits, practices, challenges, and future prospects. This holistic perspective is crucial for understanding and promoting green manure in modern agriculture.

KEYWORDS: Green Manure, fertility, Biodiversity, Modern Agriculture.

INTRODUCTION

The value of green manure was recognized by farmers in India for thousands of years, as mentioned in treatises like Vrikshayurveda. In Ancient Greece too, farmers ploughed broad bean plants into the soil. Chinese agricultural texts dating back hundreds of years refer to the importance of grasses and weeds in providing nutrients for farm soil. It was also known to early North American colonists arriving from Europe. Common colonial green manure crops were rye, buckwheat and oats. (Lawrence, 1980). Traditionally, the incorporation of green manure into the soil is known as the fallow cycle of crop rotation, which was used to allow the soil to regain its fertility after the harvestation needed.

Green manure can be defined as the practice of plant cultivation until the flowering stage or until the incomplete development of seeds, with subsequent cutting and/or incorporation of its biomass into soil (Rafael, 2016). The basic purpose of this technique is to improve chemical, physical, and biological soil characteristics in order to increase or stabilize the production of one or more crops in an area. Famers usually use legumes as green manure because of the high biomass yield, biological nitrogen fixation (BNF), and cycling of nutrients from deeper soil layers.

The global demand for food will grow considerably in the coming years due to the increasing global population that is supposed to reach 9 billion people by 2050. The agriculture practiced in the tropics has key importance on food supply for much of the current global population and may become even more important for future generations. The soils in most of these tropical environments have high acidity and aluminum toxicity, and are rich in oxides and poor in nutrients. Therefore, the use of lime and fertilizers accounts for a large part of the agricultural production cost. Thus, to increase the environmental and economic sustainability of these environments, it is important to make rational use of fertilizers and find viable alternatives to maintain a good physical, chemical, and biological soil characteristics. We highlight the use of green manures and crop residues as practices that can help maintain or increase the productivity capacity of the soils, since they act as conditioners of the physical, chemical, and biological characteristics.

In this chapter, we present examples of the main green manure crops grown in the tropics. Subsequently, we discuss the preparation of green manure, its management, the amount of nutrients potentially accumulated and their advantages, disadvantages and Future prospect. In the last part, we present some of the benefits of management of green manure and crop residues, mainly the nutrient supply potential for crops of economic interest. We discuss the factors that most influence the fresh organic matter decomposition and nutrient mineralization in tropical areas.

REVIEW

The use of leguminous green manure is effective for the region agricultural systems due to its ability to incorporate significant amounts of nutrients into the soil through decomposition and nutrient release from biomass. This study aimed to evaluate the decomposition rates and nutrient release of six leguminous green manure species (*Crotalaria juncea, Canavalia ensiformes, Cajanus cajan, Crotalaria spectabilis, Dolichos lablab and Mucuna deeringiana*) in an area of the Jaguaribe-Apodi agricultural region, Brazil. Experiment was carried out under field conditions in a randomized block design with five replications. Decomposition and nutrient release from leguminous biomass were monitored by sampling at 30, 60, 90, 120, 150 and 180 days after installing litter bags. In general, *Canavalia ensiformes*and *Crotalaria spectabilis* showed higher decomposition and nutrient release rates and they are the most promising for the region in the conditions of this study. However, for greater persistence of residues in the soil, *Crotalaria juncea* is more recommended (Natanael *et.al*.,2016).

Swaminathan (2019) reported *Pongamia pinnata* is one of the few NFTs containing 30-40 percent oil. The incorporation of *Pongamia* leaves improves soil fertility and has favorable effect on crop growth. This research focused on influence of *Pongamia* leaves on growth and yield of barnyard millet. (*Echinocloa frumentaceae*). The study revealed that the plant height and yield attributes were favorable influenced. Leaf incorporation at 2000 kg/ha and allowing 45 days for

decomposition produced 1216 kg of grains in barnyard millet in a ha while it was only 861 kg/ha under zero input management.

Agriculture at present focuses on crop productivity with a balance on soil health. In dry land areas application of green leaf manures in addition to the regular dose of fertilizers, which proves to ensure soil health and cost economics without affecting the yield parameter. *Gliricidia* based alley cropping with Ragi, Barnyard millet and Groundnut intercrops was experimented to understand the influence of *Gliricidia*green manure application on the intercrops. The resultant of incorporating *Gliricidia* green leaf manure into the soil was found to increase the yield of intercrops than the mulching technique, which would help the dry land farmers to increase productivity (Ramesh *et al.*, 2020).

Swaminathan *et.al*. (2019) were conducted field experiment at Agricultural College and Research Institute, TNAU Madurai with an objective of studying the influence of green leaf manures and leaf extracts of selected trees on vegetative growth, flowering and yield attributes and yield of black gram and the best combination of green leaf manure and tree leaf extracts that ensure high yield in black gram. The experiment was carried out on a sandy clay loam soil at the Central Farm of Agricultural College and Research Institute, TNAU Madurai from 2010 to 2011 in a split plot design replicated twice. The experiment consisted of 20 treatments: five different green leaf manures (*Albizia lebbek, Gliricidia sepium, Pongamia pinnata, Delonix regia, Peltophorum ferrugineum*) at 2 t ha-1 in main plots and four different green leaf extracts (*Moringa oleifera, Aegle marmellos, Morinda tinctoria, Annona squamosa*) at 5% in the form of four foliar sprays at 30, 37, 44 and 51 DAS in sub plots. The results indicated that there were significant differences in growth attributes, yield attributes due to the application of green leaf manure and foliar sprays of tree leaf.

MATERIAL AND METHOD

PLANT SPECIES USEFUL FOR GREEN LEAF MANURES

To produce green leaf manures a number of trees and plants are used; among them trees like- *Pungam Erukku, Gliricidia, Mahua, Subabul, Vahai, Karanji, Wild indigo, Wild dhaincha, Neem, Colatropis,* etc. and weeds like Water hyacinth, *Calotrophis, Trianthema, Cassia, Ipomoea, Parthenium*, etc. are used widely.

GREEN MANURING CROPS

Green manuring is the action of agronomic practices and assimilation of legume and non-legume green plants into the soil either by adopting in-situ or the plants developed abroad and congenital into the soil for abundance improvement. (Sagar Maitra, *et.al*.2018).

Abiding coarse multipurpose shrubs and crops acclimated for green leaf manuring, namely, *Leucaena leucocephala* (Subabul), *Gliricidia spp.*, *Cassia siamea* (Kassod tree), *Cassia auriculata, Derris indica, Azadirachta indica* (neem), *Cassia tora, Cassia accidentalis, Tephorsia candida, Dodonea*

viscosa, Hibiscus viscosa, Delonix elata, Delonix regia, Peltophorum ferrugenum, Cassia nigricans, Vitex negundo.

Green admixture crops may be the plants of legume crops such as pigeon pea (*Cajanus cajan)*, green gram (*Vigna radiata*), soybean (*Glysine max*), cowpea (*Vigna unguiculata*) or groundnut (*Arachis hypogea*), cluster bean (*Cyamopsis tetragonoloba*); non-grain, aroma and beat legumes like sunhemp (*Crotalaria juncea*), dhaincha (*Sesbania species, S. aculeata*), wild indigo (*Tephrosia purpurea*), black henna (*Indigofera tinctoria*), Barseem (*Trifolium alexandrinum*), broadbean (*Vicia faba*), white *lupin Lupinus albus*), blue lupin (*Lupinus angustifoilus),* yellow lupin (*Lupinus luteus*), (*Vicia sativa*), vetch common fenugreek (*Trigonella foenumgraecum*), candied clover (*Melilotus spp*.), trefoil (Lotus spp.), black medic (*Medicago lupulina*), lucerne or alfalfa (*Medicago satvia*), subclover (*Trifoliumsubterraneum*), strawberry clover (*T. fragiferum*), Persian clover (*Rifolium resupinatum*), red clover (*Trifolium pratense*), white clover (*Trifolium repens*), *Centosemia, Shylosanthes* and *Desmodium.*

Aswell close and subtropical grasses and weeds like *Panicum maximum, Fennisetum purpureum, Trips acumlaxum, Adathoda vesica, Eicchornia crassipes, Trianthema portulacastrum, Ipomoea Carnea, Calotropis gigantea* can aftermath sample abundance of biomass and may be advised for green manuring. There are evidences of appliance non-legume crops and forages like agricultural rye (*Secale cereale*), oats (*Avena sativa),* barley (*Hordeum vulgare*), abiding ryegrass (*Lolium perenne*), Italian ryegrass (*Lolium multiflorum*), Westerwolds ryegrass (*Lolium multiflorum*), cocksfoot or orchard grass (*Dactylisglomerata*), altered Brassicas, namely, white alacrity (*Sinapis alba),* bristles turnips (*Brassica rapa*), beat abduction (*Brassica napus*), fodder raddish (*Raphanus sativus*), Phacelia (*Phacelia tanacetifolia*), buckwheat (*Fagopyrum esculentum*), chicory (*Chichorum intybus*) as green manures . Dhaincha (*Sesbania spp*.), sunhemp (*Crotalaria juncea*), berseem (*Trifolium alexandrinum*) and green gram (*Vigna radiata*) are the lot of frequently developed crops as green admixture legumes. Legumes accept a continued history of use as green admixture crops. High energy costs and adverse ecology impacts of fertilizer N accept led to renewed absorption in legumes for green manuring as an N antecedent for crops.

Green leaf manuring: Green leaf manuring refers to turning into the soil green leavesand tender green twigs collected from shrubs and trees grown on bunds, wastelands and nearby forest areas. This system is generally followed in the central and eastern India. Suitable green leaf manuring crops:

1. Gliricidia (*Gliricidia maculata*)

It is a shrub, which takes up a tree habit under favorable conditions of soil and climate. For green leaf purposes, the shrub should be kept low by pruning or lopping at a height of 2-5 m. The shrub can be pruned two or three times a year and it withstands repeated lopping. Within two years after planting, the plants are

ready for lopping. Each plant gives 5 to 10 kg of green leaves annually.

2. Subabul (*Leucaena leucocephala*)

This species, a native of Central America, occurs as a branched shrub. It is a promising forage tree crop, the leaves of which contain about 3-4% of N. Leucaena fixes about 500-600 kg N/ha/year. Sharma and Behra (2009) reported that combined use of green leaf manuring with Leucaena pruning and urea fertilizer on equal N basis resulted in higher productivity, profitability and more efficient utilization of N, leading to fertility build-up and thus sustainability of maize-wheat cropping system in the long-run.

3. Cassia (*Cassia auriculata*)

It propagated by seeds. During flowering tree is topped (stem and branches cut) and loppings used for green leaf manuring. Techniques of green manuring in the field: The maximum benefit from the green manure crop cannot be obtained without knowing the When it should be grown. When it should be buried into the soil. How much time should be given between the burying of the green manure crop and the sowing of the next crop.

4.Dhaincha (*Sesbania aculeata* and *S. rostrata*)

It is a vigorous growing green manure crop, which can be incorporated at 10 weeks after sowing. It does not withstand water logging. The seed rate is 25-35 kg/ha. The green matter yield is 15-20 t/ha. Quantity of nitrogen fixed by the crop is 75-80 kg/ha. Sun hemp is the most outstanding green manure crop and is well suited in almost all parts of the country and fits in well with the sugarcane, potato, garden crops and the second season paddy in southern India and with irrigated wheat in the north India.Dhaincha is also an outstanding green manure crop. It does well in the waterlogged and alkaline soil for its reclamation programme. Green manuring is in common use in irrigated lands, but its popularity in baran or rainfed land is hindered by the lack of irrigational facilities.

a. Sesbania aculeata

lt is a quick growing succulent green manure crop, which can be incorporated at about 8 to 10 weeks after sowing. This crop adapts to varying conditions of soil and climate. It can be grown even under adverse conditions of drought, water logging, salinity etc. Recommended seed rate is 20 to 25 kg/ha. The green matter yield is 10-20 kg/ha. Quantity of nitrogen fixed is 75 to 80 kg/ha.

b. Sesbania rostrata

lt is a green manure crop, which has nodules both on the stem and root. It thrives wellunder waterlogged condition. The normal seed rate is 30 to 40 kg/ha. To get early, uniform germination and vigorous seedlings, seeds have to be scarified with concentrated sulphuric acid for 15 minutes and then washed thoroughly with fresh water and sown immediately. A green matter yield of 15 to 20 t/ha which is equivalent to 150-180 kg N/ha and obtained within a period of 8 to 10 weeks.

5. Wild indigo or kolingi (*Tephrosia purpurea*):

It is a slow growing green manure crop. It is not grazed by cattle and is suitable for light soils. It resists drought but does not withstand water stagnation. The seed have a waxy, impermeable hard seed coat and do not quickly germinate. To hasten germination, the seeds are to be abraded with sand or steeped in hot water at 55°C for two to three minutes. The seed rate is 20-25 kg/ha and the green matter yield varies from 8 to 10 t/ha. When kolingi is sown in an area for two or three seasons continuously, scattered seeds will give rise to volunteer plants and there is no need for further sowing

6. Indigo/Bengal indigo (*Indigofera tinctoria):*

Indigo resembles kolingi, but has a more leafy habit. It shows resistance to drought. Better yield is obtained when two irrigations are given and when grown in clayey soil. Seed rate is 20 kg/ha. Green matter production is 8-10 t/ha. Sharma and Dadhwal (2011) reported that in-situ sun hemp growing in between maize rows during rainy season and it's recycling as surface mulch after 30-35 days as green manuring. Nitrogen fixing leguminous green manures offers an environmentally sound means of reducing external inputs (Ladha *et al.*, 1992). The continuous use of green manures may improve the soil fertility and physical conditions leading to beneficial effects on subsequent rice or wheat crops (Becker *et al.*, 1994; Sharma *et al.*, 1995).

PREPARATION OF GREEN LEAF MANURES

Producing green leaf manures is very easy and cheap. Different green manuring trees and plants are grown in live fences or on barren lands. When they are well grown, their leaves are simply cut and brought to the crop fields in bundles. Leaves of green manuring crop like Thespesia are needed to wither for two days before incorporating them into the soil.

1.Good leaves for composting: The best leaves for composting are those lower in lignin and higher are calcium and nitrogen. These leaves include ash, maple, fruit tree leaves, poplar, and willow these 'good' leaves will typically break down in about a year.

2.Bad leaves for composting: Bad leaves are those higher in lignin and lower in nitrogen and calcium. These include beech, oak, holly, and sweet chestnut. Also, make sure to avoid using leaves of black walnut and eucalyptus as these plants contain natural herbicides that will prevent seeds from germinating.

Leaves provide a high carbon source or "browns' for your compost. The carbon/nitrogen (or C/N) ratio of leaves is usually over 30, often around 50. That is, they are low in nitrogen which is often hard to find in other sources of composting material. Leaves are great sources of nutrients and minerals. Up to 80% of a tree's nutrients and minerals end up in its leaves. Leaves are often referred to as nature's nutrient recyclers. By composting leaves, you have a perfect way of getting these valuable nutrients and minerals back into your soil.

Firstly, shred or grind the leaves. This will significantly speed up the composting process. If you don't have a shredder, you can simply mow the leaves to collect them. Alternatively, a garbage can and a string trimmer will work (be sure to wear eye and ear protection). Fill your garbage can approximately three quarters full with leaves. Put your string trimmer in, turn it on and move it through the layers of leaves. Leaves are considered 'browns' in your compost pile. Therefore you need to add liberal amounts of 'green' materials, high in nitrogen, such as grass clippings or kitchen waste. To prevent attracting pests to your compost pile and to speed up the composting process, bokashi composting is a great way to pre-compost your food waste. Mix 4-5 parts leaves to one part green waste.

Adding compost accelerator to your pile will add a boost of microbes to help the composting process. Turn your pile 1-2 times a week. Add more green waste (grass clippings, kitchen waste etc.) as you turn. Turning the pile and mixing in oxygen will get it to heat up and compost more quickly Remember to keep the pile moist. It wants to be the consistency of a sponge. Covering the pile with a plastic sheet will help to keep the pile warm and prevent it from drying out. If you keep up the regime of regularly turning and aerating your pile you should have high quality leaf compost by the following spring.

TIME OF SOWING OF THE GREEN MANURE CROP

Normally the green manure crop should be grown immediately after the monsoon rains. As far as cultivation practice involved, no special care is needed in the preparation of the seedbed. Soil must have sufficient moisture for the quick germination and rapid early growth. Phosphate fertilizers, if applied, should be evenly broadcast. Usually the seed of the green manure crop is broadcast preferably with higher seed rate.

Stage of burying of the green manure crop:

From the results of the several experiments, it is observed that best results of the green manuring are obtained if it is buried at the flowering stage. Majority of the crops take about 6 to 8 weeks to reach at the flowering stage from sowing. Stage at which sun hemp was o made a significant effect on the wheat yield (Figure 1). However basic principle is in green manuring crops, should aim at maximum succulent green matter at burial.

6 Advantages of green manures

The main advantages and disadvantages of green manures to tropical weathered soils [Wutke, *et al.*, 2009, Souza *et al*., 2012, Carvalho *et al*., 2006] are listed below.

CHEMICAL ASPECTS

1. Nitrogen input to the soil because of the green manure association with nitrogen-fixing bacteria;
2. Green manures with deep root systems allow cycling of nutrients that have been leached to deep layers;
3. Increased cation exchange capacity (CEC) due to an increase in soil organic matter content;
4. Green manures make possible to increase or stabilize the content of soil organic matter;
5. The release of organic acids allows the solubilization of more stable forms of phosphorus.
6.Green manure enriches soil fertility by adding organic matter, which improves soil structure, water retention, and nutrient availability

BIOLOGICAL ASPECTS

1. They favor the microflora and macroflora and fauna through carbon supply;
2. Some species control nematodes population;
3. They can serve for attracting insect pests and stop disease cycles;
4. They release compounds with allelopathic effect on weeds;
5. They compete for growth resources with weeds.
6. Certain green manure crops attract beneficial insects and microbes, promoting a balanced ecosystem within the soil.

PHYSICAL ASPECTS

1. The dense root systems of green manure crops help prevent soil erosion, especially valuable in sloped or vulnerable areas.
2. They enhance stability of aggregates and porosity by adding organic matter and growthand death of roots;
3. They increase water retention by cover the soil and by add organic matter;
4. They allow natural decompression of the soil, when using species with deep root system;
5. They reduce the thermal soil amplitude.

ECONOMIC ASPECTS

1. Cost Savings: Reduced fertilizer and pesticide use can lower production costs in the long term, offsetting initial investments in green manure crops.

2. Market Demand: Consumer preferences for sustainably grown produce may enhance marketability and pricing for farmers employing green manure practices.

3. Policy Support: Government incentives or subsidies for sustainable agriculture practices may further encourage adoption of green manure.

Disadvantages of green manures

1. Inadequacy of some green manure species to the production system or the soil and weather conditions;
2. Lack of interest from consultants and farmers in this technology, which adopt immediate postures;
3. Sometimes, green manure involves costs with no direct financial return;
4. Low development of breeding technologies of green manure species;
5. Some green manures can host diseases and pests that attack the commercial crop;
6. Possibility of negative allelopathic effect of green manure residues on the commercial crop;
7. Possibility of competition between green manure plants and the commercial crop by inadequate management of the technology in intercropping systems;
8. Some green manures have incompatible decomposition rates with the nutrient requirements of crops; underrain fed conditions, it is feared that proper decomposition of the green manure crop and satisfactory germination of the succeeding crop may not take place if sufficient rainfall is not received after burying the green manure crop.
9. Uneven seed germination of some species of green manure;
10. Difficulty of obtaining seeds for sowing
11. Lack of functional decomposition models to predict nutrient release.
12. A risk is involved in obtaining a satisfactory stand and growth of the green manure crops, if sufficient rainfall is not available.
13. Knowledge Gap: Farmers may need support in adopting and optimizing green manure practices, including access to research and extension services.

FUTURE PERSPECTIVES

1.Research and Development-

Innovative Crop Breeding: Development of green manure crops with improved traits for specific conditions.

Integrated Systems: Research on integrating green manure with other sustainable practices like agroforestry and permaculture.

2. Policy and Incentives

Supportive Policies: Governments and institutions can support green manure use through subsidies, training programs, and research funding.

Market Mechanisms: Creating markets for ecosystem services provided by green manure, such as carbon credits.

3. Technological Advancements

Precision Agriculture: Use of technology to optimize the use of green manure in farming systems.

Bioinformatics: Leveraging bioinformatics to better understand the microbial interactions and improve nitrogen fixation efficiency.

4. Education and Outreach

Farmer Training: Increasing farmer awareness and training on the benefits and management of green manure.

Public Awareness: Educating consumers on the environmental benefits of green manure to create market demand for sustainably produced food.

CONCLUSION

Green manures play a cardinal role as it has able impacts on physical, metabolical and biological superior of the soil and appropriately apology of soil fertility. Green manuring not alone improves soil quality, but as well fixes atmospheric nitrogen in the soil if legumes are considered. Green manure is increasingly recognized as a cornerstone of sustainable agriculture, aligning with global efforts towards environmental stewardship and food security. Continued research and innovation are crucial to overcoming challenges and maximizing its benefits across diverse agricultural landscapes. In the present perspective on green manure underscores its multifaceted benefits for soil health, crop productivity, and environmental sustainability. As agriculture evolves towards more sustainable practices, green manure plays a pivotal role in shaping the future of farming.

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Chapter
10

MEDICINAL PLANTS AND TRADITIONAL HEALING PRACTICES BY VARIOUS TRIBES IN INDIA

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ABSTRACT

This study delves into the traditional healing practices and the utilization of medicinal plants by diverse tribes in India, specifically focusing on the states of Uttarakhand, Nagaland, Telangana and Odisha. Each region is home to unique tribal communities with rich traditional knowledge of medicinal plants and their healing properties. Through an in-depth exploration of the medicinal plants used by these tribes and the traditional healing methods employed, this study aims to uncover the cultural significance and effectiveness of these age-old practices.

KEYWORDS: Medicinal Plants, Traditional Healing Practices, Tribes, India.

INTRODUCTION

Objective:

The main objective of this research is to investigate and analyze the traditional healing practices and the application of medicinal plants by various tribes in the states of Uttarakhand, Nagaland, Odisha, and Telangana in India.

To study the specific medicinal plants utilized by different tribal communities for healing purposes and understand the traditional healing techniques passed down through generations, this study aims to contribute to the documentation and preservation of indigenous knowledge and biodiversity.

When treating illnesses, traditional medicine (TM) is frequently the most widely available and reasonably priced option for the underprivileged in underdeveloped nations. Numerous states in India are home to substantial populations of economically challenged and socially backward aborigines. Natives have evolved unique methods of employing plants for medicinal purposes in addition to adhering to their own traditions, customs, folk music, and dietary practices. Oral transmission of this knowledge from one generation to the next occurs. Due to their affordability and accessibility, traditional plant-based healing methods continue to be used by people all over the world. The majority of rural residents and tribal populations living in forested areas rely on locally accessible medicinal plants to maintain their health.

MEDICINAL PLANTS USED FOR HEALING BY VARIOUS TRIBES IN INDIA

1. UTTARAKHAND

Medicinal plants and their uses vary from community to community depending on the tribal community's location and the accessibility of nearby medicinal plants. The five main tribal communities in this state are the Bhotia, Jaunsari, Raji, Tharu, and Buksa. About 17% of the 15,000 species of flowering plants that are found in India have therapeutic benefits. Of these, 1,745 species are native to the Indian Himalayan region, with Uttarakhand hosting a large number of these species. The local population in this area depends entirely or largely on forest resources for fuel, food, and medicine, and the number of medicinal species is progressively declining as a result of human activity. Uttarakhand is located in the Central Himalayan Region, which offers excellent chances for researching traditional knowledge systems. There are many different kinds of fragrant, medicinal, and herbaceous plants in Uttarakhand. One of the most prolific floral regions is the Garhwal Himalaya.The following is a list of Bhotia tribe's traditional healing methods and medicinal plants:

Table 1: Medicinal Plants and their Uses:

Medicinal Plant	Remedy For	Traditional Healing Practice
Aconitum heterophyllum	Fever, Abdominal pain and vomiting	When suffering from a fever, take half a spoonful of ground dry root with hot water. In addition, the root is chewed and swallowed twice a day to reduce nausea and upset stomach.
Acorus calamus	Sprain	The sprain area is treated with boiled dry root mixed with mustard oil.
Morus alba	Cough and cold	Fruit juice is consumed to treat colds and coughs.
Allium sativum	Earache	To relieve earache, warm sesame seed oil mixed with spilled garlic bulbs is put into the ear and allowed to cool.
Allium stracheyi	Wound	The wound is cleaned with a clean towel dipped in leaf decoction.

2. NAGALAND

The Angami, Aos, Sema, Lotha, Rengma Chakheang, Sangtam, Ronyak, Phom, and Chang Naga tribes comprise the state's population. In the state, a lot of people use the locally grown herbs in the traditional healing system. The majority of plants utilized in traditional medicine are from the Ayurvedic, Siddha, and Unani systems of medicine in India; however, the

application process varies slightly. Plant distribution was shown to be common in the family's Acanthaceae, Amaranthaceae, Asclepiadaceae, Caesalpiniaceae, Euphorbiaceae, Malvaceae, and Zingiberaceae upon methodical placement of the plants utilized in the treatment system. The population is progressively losing this traditional knowledge due to modernity and advancements in health procedures. A few precious medicinal plants are also disappearing from their natural habitat as a result of overuse and sourcing them exclusively from wild sources for commercial purposes.

Table 2: A List of medicinal plants used by the tribes are given below:

Medicinal Plant	Remedy For	Traditional Healing Practice
Abroma augusta	Leucorrhoea	Leucorrhoea is treated using an oral root decoction.
Achyranhes bidentata	Rheumatic disease	Root used to treat rheumatic illnesses and severe pain.
Acorus calamus	Asthma	Paste made from rhizomes for asthma.
Bauhinea purpurea	Digestion	Vegetables made from tender leaves are thought to aid in better digestion.
Centella asiatica	Worm infestation	Plant used as a starter and when worm infestation occurs.

3. TELANGANA

The native customs of Koyas (Dorasattamu) of Telangana state located in Eturnagaram Mandal Warangal District (previous Andhra Pradesh). The preparations used by tribal healers are either based on a single plant part or a combination of parts from other plant species. Aqueous extracts, pastes, and oils are just a few of the forms that ethnomedicine is used for. Moreover, components employed in the administration of ethnomedicine include milk, ginger, pepper, oil, turmeric, and jaggery, among others (Sdhakar Reddy *et al.*, 2008). According to Ishwari Prasad *et al.* (2009), the ethnic tribe known as the Koya, who live in these villages, are in good health and do not suffer from common ailments like diabetes, high blood pressure, or depression. a list of commonly utilized medicinal herbs.

Table 3: A List of medicinal plants used by the tribes for healing are given below:

Medicinal Plant	Remedy For	Traditional Healing Practice
Acacia intsia	Cough	The root's aqueous extract is used to treat coughs.
Bassia latifolia	Vipers bite	Bark extract is applied to prevent vipers from biting, while oil derived from seeds is administered to the head as a cooling agent.
Calycopteris floribunda	Wounds of soaked legs	Legs bathed in water are treated with a paste made from leaves.
Dichrostachys cinerea	Cough	A teaspoonful of bark extract in water administered as a cough remedy.
Evolvulus alsinoides	Impotency	For impotency, the root extract is used orally.

4. ODISHA

With 62 distinct tribal clans and roughly 74 languages, Odisha is home to the third-largest tribal population in all of India. The thirty districts of the state contain these indigenous communities. The majority of tribal communities rely mostly on forest products for their everyday requirements, including food, medicine, fiber, wood, and fodder. They are knowledgeable about the edible wild plants, mushrooms, and plant components that can be utilized for both food and medicinal purposes, such as fruit, seeds, flowers, leaves, stems, rhizomes, and tubers. The primitive tribes of Bonda, Didayi, Koya, Paroja, Bhatoda, and Khondh are located in this district of Malkangiri, Odisha.

Table 4: The tribes use the following medicinal plants:

Medicinal Plant	Remedy For	Traditional Healing Practice
Pterocarpus marsupium	Diabetes	2g of stem bark decoction given orally every day.
Aegle marmelos	Dysentery	10–15 ml of fruit infusion taken orally twice daily.
Andrographis paniculata	Fever	50 ml of leaf infusion taken orally for 3 days.
Casearia elliptica	Fish poison	The milky juice is mixed with water and used for treating fish poison.
Achyranthes aspera	Gastro-intestinal disorders	A half-glass of decoction of aerial parts taken orally for two days.

CONCLUSION

In conclusion, the coventional healing practices and medicinal plant knowledge of various tribes in India reflect centuries of accumulated wisdom and cultural heritage. These practices are rooted in a deep understanding of local ecosystems and have sustained these communities for generations. As we acknowledge the significance of these traditions, it becomes imperative to preserve and protect the biodiversity that supports these medicinal plants. Additionally, integrating traditional healing practices with modern healthcare systems could potentially offer comprehensive healthcare solutions. By fostering respect for and research into these traditional practices, we can create a large inclusive and sustainable approach to healthcare for all.

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Chapter
11

AN BRIEF OVERVIEW OF TRANSDERMAL DELIVERY SYSTEMS IN INFECTIOUS DISEASES

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ABSTRACT

Transdermal drug delivery has several advantages over other routes of administration, for instance, it is less invasive, patient-friendly, and has the ability to bypass first-passmetabolism and the destructive acidic environment of the stomach that occurs upon the oral ingestion of drugs. For decades, transdermal patches have attracted attention and were used todeliver drugs such as nicotine, fentanyl, nitroglycerin, and clonidine to treat various diseases or conditions. Transdermal patches are a type of drug delivery systems that are used to introduce medications through the skin for curative purposes and to replace other drug delivery systems. For many centuries, people have used different materials to treat various skin diseases.Nowadays, a wide range of topical products has been introduced to achieve therapeutic effects. Therefore, drug delivery systems have drawn great attention in recent decades in oral infectious diseases. In this review, emerging recent applications TDDS in the treatment for oral infectious diseases have been summarized, including dental caries, periodontitis, peri- implantitis and oral candidiasis. In this review focus on the recent work and emerging applications of TDDS in the prevention and treatment of common oral infectious diseases, including dental caries, periodontitis, peri-implantitis, and oral candidiasis, in order to find outthe current challenges and opportunities for future research.

KEYWORDS: Transdermal, Drug Delivery, Medical Patch, Skin Diseases and Infectious.

INTRODUCTION

Human societies have used substances to the skin as cosmetic and therapeutic agents for thousands of years. The skin, on the other hand, was not broken as a drug delivery methoduntil the twentieth century. The term "transdermal" was first used in 1944 by Merriam Webster, indicating that it is a relatively new notion in medicinal and pharmacological practice. Transdermal medicines are doses that are self-contained and different.

Definition: Transdermal drug delivery systems are defined as self-contained, separate dosage forms which, when applied to the intact skin, deliver the drug, through the skin, at a controlled rate to the systemic circulation (Tyle P, 1998).

Transdermal drug delivery systems (TDDS) have many advantages and signify an excellent alternative to oral delivery and hypodermic injections. TDDS are more convenient and less aggressive tools for disease and viral infection treatment, prevention, detection, and surveillance. As an alternative, different types of transdermal drug delivery systems (TDDS) have been developed to deliver systemic medication by request to the skin surface(M. Hashida, 2020). Historically, the earliest transdermal drug delivery system was a drug- loaded patch (V.R. Jayaneththi *et al.,* 2019).

Patches have been manufactured for surface applications, and generally consist of some natural adhesive materials bonded to a backing layer (N. Iwata *et al.,* 2020). Therefore, drug delivery systems have drawn great attention in new decades in oral infectious diseases. Drug delivery systems (DDS) are devices that can transport and release the therapeutic agents or bioactive substances to certain sites at certain rates in vivo (Allen, T.M.;2004; Cullis, P.R. Jain & K.K. 2014) usually composed of the transporters and associated therapeutics (Fenton, O.S. *et al.,* 2018).

"Transdermal drug delivery (TDD) involves transporting medicinal substances across the skin, commonly for systemic administration, and has gained widespread acceptance in medical practice. Presently, the FDA has approved over twenty transdermal drugs, offering advantages such as sustained and controlled drug delivery, ease of termination, suitability for self-administration, and bypassing hepatic metabolism and gastrointestinal issues Changsheng(Wu, *et al.,* 2019; M. R. Prausnits, R. Langer, 2008; O. S. Fenton, *et al.,* 2018). Transdermal delivery mainly depends on the skin nature. Skin is the main route of administration of drug to body. Skin is the largest organ in the body. It provides microbial protection and produces sense.

Mainly human body consists of three different types of skin layers, these layers are responsible for the drug delivery to body.

1. Epidermis (20-89 μm)
2. Dermis (0.3-3 mm)
3. Hypodermis.

DRUG CAN PENETRATE THROUGH SKIN VIA THREE PATHWAYS

a) Through hair follicles.
b) Through sebaceous glands.
c) Through sweat duct.

Transdermal drug delivery systems are employed in varied skin disorders, conjointly within the management of angina pectoris, pains, smoking stop & medical specialty disorders corresponding to Parkinson's un wellness (Arti Kesarwani, *et al.,* 2013; Sampath Sampath Kumar KP, *et al.,* 2010). The skin of an adult is approximately 1/3 perfused and covers an area of about 2 m^2 (V.K. Rai *et al.,* 2018).

Under the microscope, the skin tissue consists of many histological layers, including epidermis, dermis, and hypodermis.

The epidermis, dermis, and subcutaneous tissues make up the skin, the biggest organ inthe body, which also includes auxiliary organs such as hair follicles and sebaceous gland. In a healthy state, the skin acts as a natural fence to maintain a stable environment both within and outside the body. However, when the skin is diseased, the barrier function is cooperated, smallmolecules and microorganisms can easily pass through the stratum corneum, and vital nutrients, including water and electrolytes, are easily lost from the body, upsetting this balanceand leading to disease. The environment, stress, sleep disorders, and many other limitations arejust a few factors that might harm the skin barrier. As society continues to change and people's lifestyles and the environment change, skin disorders have become more common in recent years. With a prevalence rate of 25%, skin conditions are currently the fourth most predominant non-fatal disease around the globe. In severe situations, patients feel considerably sick, and even their jobs and personal lives are negatively impacted.

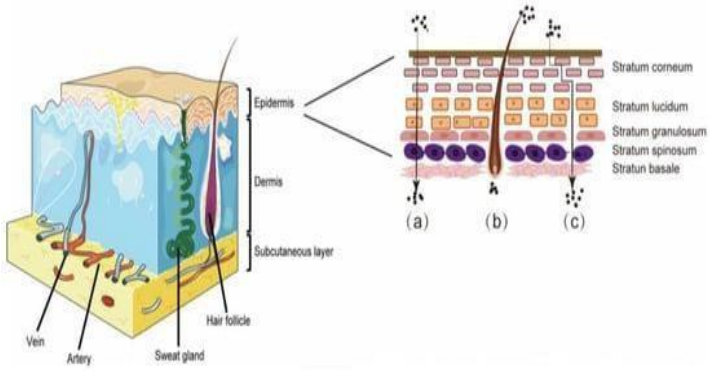

Fig. 1: Infectious pathogens are global disrupters. Development in biomedical science and technology has expanded the public health arsenal against infectious diseases.

ADVANTAGES AND DISADVANTAGES OF TDDS FOR CONTROLLING VIRAL INFECTIOUS DISEASES

ADVANTAGEOUS OF TDDS IN FIGHTING VIRAL INFECTION

There were many advantages and possible applications of TDDS for viral infectious diseases. TDDS is a more convenient and less invasive method for drug delivery, and a better choice for those afraid of hypodermal injections. They are particularly well suited for treating cutaneal viral infection because they can be applied directly and specifically to diseased skin, where they would decrease the systemic absorption and associated side effects. For example, buccal mucoadhesive or moisture-activated patches of acyclovir and acyclovir-loaded dissolving microneedle arrays have been used to treat herpes labialis while avoiding the side effects associated with systemic acyclovir treatment (Peira E, 2007; Sawyer MH, 1988; Spruance SL, Crumpacker CS, 1982)

In this article, summarize the current literature regarding TDDS application for fightingcommon cutaneous or systemic viral infectious diseases, including herpes simplex, varicella/herpes

zoster, warts, influenza, measles, and COVID-19. DDS signify an excellent alternative to oral delivery and hypodermic injections. To fight viral infections, TDDS, especially microneedles, provide a more convenient and less invasive way for disease treatment, prevention, and surveying. And, for cutaneous viral infection, TDDS provide localized treatment with high specificity and reduced systemic toxicity. In summary, TDDS, especially those employing microneedles, are well suited for reducing the illness and mortality associated with viral infectious diseases, and could be of great potential value to global health.

Many studies have been passed out on transdermal delivery methods using transdermal experiments, with corresponding advantages and disadvantages. In this review, also focus on the recent work and emerging applications of DDS in the prevention and treatment of common oral infectious diseases, including dental caries, periodontitis, peri-implantitis, and oral candidiasis, in order to find out the current challenges and opportunities for future research.

TDD methods aim to achieve controlled molecule permeation through various skin layers, holding immense potential in treating chronic diseases by ensuring prolonged therapeutic durations while keeping controlled drug levels (Tao Han, Diganta Bhusan Das, 2015; K.B. Ita, 2014). The prevailing transdermal systems in the market, notably patches founded on semi-permeable membranes, are widely used as Transdermal Drug Delivery Systems (TDDS) or 'Skin patches.' These systems are designed to effectively deliver drugs through the skin and into the bloodstream (Kharat Rekha Sudam, Bathe Ritesh Suresh, 2016; Zachary Brooks, *et al.,* 2022; Wokovich A, Prodduturi S, Doub W, *et al.,* 2006). TDDS possess advantages in managing skin diseases by avoiding first-pass metabolism and regulating drug input over extended periods (Nina Dragicevic, Howard Maibach, 2018). Transdermal patch of scopolamine is the first transdermal patch which is approved by FDA in 1981. TDDS have appeared as a viable substitute for oral medications and hypodermic injections (Yash Sunil Chavan *et al.,* 2022; Soni A, *et al.,* 2022).

ADVANTAGES OF TRANSDERMAL DRUG DELIVERY SYSTEM (TDDS) (DESHWAL AND VERMA, 2012):

The advantages of transdermal delivery over other traditional delivery modalities are as follows:

- Hepatic first pass metabolism, salivary metabolism and intestinal metabolism are bypassed thus increasing bioavailability and efficacy of drugs.
- Self-administration is possible.
- In case of an emergency, deduction of the patch by removal of the application from the surface of the skin at any point of time during therapy can instantly stop active ingredient input.
- Minimal inter and intra patient variation because the arrangement of skin structurally and biologically is the same in almost all the humans.
- Avoidance of gastrointestinal incompatibility.

- Avoidance of hazards and discomfort associated with parenteral therapy and improves patient compliance, as it is easy to apply.
- Steady and optimum blood concentration time profile achieved which reduce adverseeffects.
- Release of drug for prolonged time with single application which extend the duration of activity.
- Drugs entity with short biological half-lives and narrow therapeutic window are utilized.
- Avoiding the variation in plasma level of drug.
- Plasma concentration of strong drugs is maintained.
- Termination of therapy is easy at any point of time.
- Elimination of typical multiple dosing profile an enhancement of patient compliance.
- When oral route is unsuitable as with vomiting and diarrhoea then transdermal route isused as alternate for deliver the drug candidate.

DISADVANTAGE OF TRANSDERMAL DRUG DELIVERY SYSTEM (TDDS) (DESHWAL AND VERMA, 2012):

- Only potent drugs are suitable candidates for transdermal delivery
- Skin irritation may occur in some patient at the site of application
- The delivery system is not suitable for drugs needs high blood levels
- This system is uneconomic 5. Dose dumping may occur due to Binding of drug to skin
- It can be used only for chronic situations not for acute condition because chronic condition require drug therapy for a long period of time e.g., hypertension, angina and diabetes etc.
- Therapeutic performance of the system Affected by Cutaneous metabolism
- Ionic drugs are not suitable candidate for Transdermal therapy.

LIMITATION OF TDDS

- Ionic medicines can't be delivered using TDDS.
- High drug levels in the blood or plasma cannot be reached with TDDS.
- It cannot grow for medications with big molecular weights.
- Cardiac drug delivery is not possible with TDDS.
- If a medication or formulation irritates the skin, TDDS cannot occur

FACTORS AFFECTING TRANSDERMAL PATCHES

There are various factors which disturbs the action of transdermal patches. These are given below:

PHYSICOCHEMICAL PROPERTIES

- Partition coefficient
- Molecular size
- Solubility/melting point
- Ionization

PHYSIOLOGICAL & PATHOLOGICAL CONDITIONS OF SKIN

- Reservoir effect of horny layer

- Lipid film
- Skin hydration iv. Skin temperature
- Regional variation
- Pathological injuries to the skin
- Cutaneous self-metabolism
- Skin barrier properties in the neonate and young infant
- Skin barrier properties in aged skin
- Race
- Body site
- Penetration enhancers used (Jawale N. R., *et al.,* 2017).

COMPONENTS OF TRANSDERMAL DRUG DELIVERY SYSTEM

- Polymer matrix/ Drug reservoir
- Drug
- Permeation enhancers.
- Pressure sensitive adhesive (PSA).
- Backing laminate.
- Release liner.
- Rate controlling membrane: (Debjit Bhowmik, *et al.,* 2010; Muhammad Shahid Latif, *et al.,* 2022; Shubhrajit Mantry, *et al.,* 2023).
- Other excipients like plasticizers and solvents.

POLYMER MATRIX/ DRUG RESERVOIR

It is prepared by scattering the drug in liquid or solid state artificial chemical compoundbase. It should have biocompatibility and chemical compatibility with the drug and different parts of the system like penetration enhancers. In addition, they must give reliable and effectivedelivery of a drug throughout the product's meant time period and may be of safe status.

DRUG

The transdermal route is an extremely attractive option for the drugs with appropriate pharmacology and physical chemistry. The foremost condition of TDDS is that the drug possesses the right mix of physicochemical and biological properties for transdermal drug delivery. Drug is in direct contact with release liner.

PERMEATION ENHANCERS

Penetration enhancers are molecules, which reversibly change the barrier properties of the stratum corneum. They aid in the systemic delivery of drugs by allowing the drug to penetrate more readily to viable tissues. They can be merged in transdermal formulation to obtain systemic delivery of the drug or for delivery of drugs to the deeper layers of the skin or to achieve a given therapeutic effect with a reduced concentration of the active constituents.

PRESSURE SENSITIVE ADHESIVE

This is bind to the skin due to the intermolecular and intraatomic force and it attains good contact (Sharad Bajpai, *et al.,* 2022)

BACKING LAMINATES

The primary function of the backing laminate is to provide support. They should be able to prevent drug from leaving the dosage form through top. They must be impermeable to drugs and permeation enhancers.

RELEASE LINER

During storage release liner prevents the loss of the drug that has migrated into the adhesive layer and contamination. It is therefore regarded as a part of the primary packaging material rather than a part of dosage form for delivering the drug.

RATE CONTROLLING MEMBRANE

Rate controlling membranes in transdermal devices govern drug release from the dosage form. Membranes made from natural polymeric material such as chitosan show great promise for use as rate controlling membranes. It should be flexible enough not to split or crack on bending or stretching. Some of rate-controlling membranes are polyethylene sheets, ethylene vinyl acetate co-polymer, and cellulose acetate. Recently composite poly-2- hydroxyethyl methacrylate (PHEMA) membranes have been evaluated as rate controlling barriers for transdermal application.

OTHER EXCIPIENTS

Various solvents such as chloroform, methanol, acetone, isopropanol and dichloromethane are used to prepare drug reservoir. In addition, plasticizers such as dibutylpthalate, triethylcitrate, polyethyleneglycol and propylene glycol are added to provide plasticity to the transdermal patch

TYPES OF TRANSDERMAL DRUG DELIVERY SYSTEM SINGLE-LAYER DRUG-IN-ADHESIVE SYSTEM

In this type of patch, the adhesive layer of this system contains the drug. The adhesive layer not solely serves to stick the varied layers together, at the side of the entire system to the skin, however it's additionally chargeable for the cathartic the drug. The adhesive layer is surrounded by a temporary liner and a backing.

RESERVOIR SYSTEM

In this System the drug reservoir is unbroken in between backing layer and a rate dominant membrane. And drug releases through microporous rate-controlled membrane. Drug can be in the form of a solution, suspension, or gel or dispersed in a solid polymer matrix in the reservoir compartment.

MATRIX SYSTEM

This system is of Two type

Drug-in-Adhesive System For the formation of drug reservoir, the drug distributed in Associate in nursing adhesive compound then spreading the medicated polymer adhesive by solvent casting or by melting the adhesive (in the case of hot-melt adhesives) on to an resistantbacking layer.

a) **Drug-in-Adhesive System:** For the formation of drug reservoir, the drug dispersed in an adhesive polymer and then spreading the medicated polymer adhesive by solvent casting or bymelting the adhesive (in the case of hot-melt adhesives) on to an impervious backing layer.
b) **Matrix-Dispersion System:** In this system the drug is dispersed homogeneously in a hydrophilic or lipophilic polymer matrix. And this containing polymer along with drug is fixed onto an occlusive base plate in a compartment fabricated from a drug- impermeable backing layer. In this system the adhesive is spread along the circumference instead of applying on the face of drug reservoir to form a strip of adhesive rim (Prausnitz, M. R., & Langer, R, 2021).

MICRO-RESERVOIR SYSTEM

This system is a combination of reservoir and matrix- dispersion systems. The drug reservoir is designed by first suspending the drug in an aqueous solution of water-soluble polymer and then dissolving the solution homogeneously in a lipophilic polymer to form thousands of unreachable, microscopic spheres of drug reservoirs. This thermodynamically unstable dispersion is stabilized quickly by immediately crosslinking the polymer in situ byusing cross linking agents.

FACTORS AFFECTING DRUG PENETRATION

Two types of factors affect the drug penetration such as biological and physiochemical factors Factors are listed below (Finnin BC, Morgan TM, 1999 ; Zhou Y. 1997; Rajesh N,*et.al* 2010; Dey S,Malgope A. 2010; Minghetti P, *et al.*, 1999).

Biological factors

- Skin age
- Skin condition
- Species difference
- Blood supply
- Skin metabolism
- Regional skin site.

Physiochemical factors

- Temperature and pH
- Skin hydration
- Diffusion coefficient
- Drug content
- Molecular size and shape
- Partition coefficient

CONCLUSION

The TDDS attracts increasing attention because it addresses problems with oral pharmaceutical bioavailability, the inconvenience of using injectable drugs, pain, and unrestrained drug release. Additionally, the TDDS improves penetration efficiency while also increasing targeting, stability, and efficiency compared with conventional topical medicines. Because most related research is still in the preclinical stage, further clinical trials are needed to evaluate the effectiveness and safety of the TDDS. The TDDS has high potential and substantial commercial value for dermatological treatments. Transdermal drug delivery is notonly defined about patch and its application but it is a system containing other formulations like ointments, creams, gels which are complete for use as transdermal drug delivery with the help of penetration enhancers but the dose concept cannot be successfully controlled with thesesemisolid formulations as can be done in a patch.

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Chapter 12

THE EVOLUTION, APPLICATIONS, AND ENVIRONMENTAL IMPACT OF THERMOPLASTICS

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ABSTRACT

This chapter explores the history, production, and environmental implications of plastic materials, highlighting their integral role in modern industry since their invention in the 1850s. With global plastic production surpassing 400 million tons in 2020, the focus shifts to the environmental challenges posed by plastic waste, including pollution, harm to ecosystems, and potential health risks from additives. The need for effective waste management strategies, such as recycling and microbial degradation, is emphasized to address the growing concerns surrounding plastic accumulation and its detrimental effects on both the environment and public health.

KEYWORDS: Plastics, Environmental Impact, Microbial Degradation, Recycling, Synthetic Polymers.

INTRODUCTION

Plastics were invented in the 1850s in England and are now widely utilized in many parts of life. Plastic materials have steadily become an integral component of human industry and exist during the last half-century. Both the Latin term "plasticus" and the Greek word "plastikos", which imply "able to be molded, pertaining to molding," are the origins of the word plastic (Temporiti *et al.,* 2022; Fried 1995; Joel 1995). In accordance with ASTM D6098-16. The plastic is a large variety of unique materials that can be moulded into functional forms and patterns that are entirely or primarily organic in nature (ASTM D6098). Pressure and heat are used, either separately or together. Plastic materials have gradually displaced conventional materials such as metal, glass, and wood in a range of applications due to its very cheap manufacturing low-costs, durability, and great strength when compared to previous materials (Ahmed *et al.,* 2018). As a result, worldwide plastic output is expanding year after year. Global plastic manufacturing was over 400 million tons in 2020 alone (Feil and Pretz, 2020).

The vast majority of the billions of virgin plastic objects manufactured to date are disposable convenience items that are eventually abandoned in the natural environment (Nielsen *et al.,* 2020). Plastics basic production cost is substantially cheaper than its recycling cost. This has resulted in a significant accumulation of plastic garbage in the eco-friendly environment, which

has already had a harmful impact on life on land and at sea (Kaseem *et al.,* 2012). Because plastic rubbish defies natural breakdown, its disposal contributes to a rise in solid waste. Plastic waste leachate has an impact on the population and activity of soil microorganisms (Lahive *et al.,* 2019).

Synthetic polymers are the main topic of the current investigation. The seven most common forms of synthetic plastic are utilized globally. These include acrylic, polylactic acid (PLA), terephthalate (PET), polycarbonates, nylon, fibers, polyvinyl chloride (PVC), polystyrene (PS), polyethylene high-density polyethylene (HDPE), polypropylene (PP), and low-density polyethylene (LDPE). The amount of plastic produced globally increases annually. Global plastic output decreased from 359 million tonnes per year in 2018 to 368 million tonnes per year in 2019 (Plastic Europe 2020). With 31% of global plastic output in 2019, China is the world leader in this industry (Plastic Europe 2020). Although the amount of new plastic produced each year rises, precise standards of plastic waste management and recycling are still not being attained (Plastic Europe 2020). 2018 had a total production of 61.8 million tonnes of plastic in Europe. However, only 9.4 million tonnes of post-consumer plastic garbage were collected in Europe in 2018 (Plastic Europe 2020). In 2017, 8300 million tonnes of virgin plastic were reportedly produced worldwide. In 2015, there were 6300 million tonnes of plastic trash produced; only 9% of that was recycled, 12% was burned, and 79% was disposed of in landfills or the environment (Geyer *et al.,* 2017).

CLASSIFICATION OF PLASTICS

Chemically, there are many different categories of plastics that are categorized in accordance with their chemical makeup and characteristics. Plastics are formed via the polymerization of tiny particles.

A class of plastics known as thermoplastics may be recycled and can be remelted and processed back into a finished product. The molecular bonds of thermosets, also known as thermosetting, are securely bonded in cross links, making them a plastic group that cannot be remelted (Asiandu *et al.,* 2021; Chan & Ji 1999; Albeno*et al.,* 2009; Kaseem *et al.,* 2013).

Plastics are of two types, thermoplastics and thermosetting polymers, based on their thermal characteristics. Plastics are produced via the polymerization of tiny molecules.

THERMOPLASTICS

It is a sort of plastics that may be repeatedly molded, yet heating does not cause any chemical changes to occur in its makeup. Polyvinyl chloride (PVC), polytetrafluoroethylene (PTFE), polypropylene (PP), polyethylene (PE), and polystyrene (PS) are examples of thermoplastics. These polymers, which are typically referred to as ordinary plastics, have molecular weights that be different from 20K to 500K atomic mass units. Atoms and molecules are joined end to end in carbon chains to create macromolecules, which are organized linearly in the form of

chains. Opening of the double bond, which is necessary to create linear macromolecules, and the reaction is carried out by the use of free radicals.

THERMOSETTING PLASTICS

Thermosetting polymers are a new sort of plastics that cannot be melted and worked with once it has been cast into a specific shape. Not all thermosetting chemical reactions result in irreversible outcomes (Ghosh *et al.,* 2013). Stepping up when polymerization is carried out under ideal conditions, polyurethanes and phenol-formaldehyde are produced. Each step results in the production of H_2O and HCl as byproducts, which allows the intermolecular condensation of bifunctional molecules. The monomers in thermosetting plastic go through very small chemical changes when heated, resulting in an infusible mass (Singh and Sharma, 2008).

PROPERTIES OF PLASTIC MATERIALS

Presently, thermosoftening polymers, also known as thermoplastic materials, that may also perform continuous conversion from solids into viscous state under the rising temperature, are used to produce 80% of commercial plastic products. More than 4000 different brands of building thermoplastic materials are produced using 10 to 15 fundamental types of industrial polymers (Melnikova, 2013). Materials based on polyolefin's (polyethylene and polypropylene), polystyrene, and polyvinyl chlorides make up over 90% of all plastic produced; they can resist continual pressure of up to 10-15 MPa and temperature levels of up to 80± 20°C. In terms of manufacturing volume, materials made from PET, polyamides, polycarbonates, and polyformaldehydes account for around 9%. These can sustain temperatures ranging from to 150°C and compressive forces of up to 140± 20 MPa because to their greater thermo - mechanical strength.

Ethylene monomers are the building blocks of polyethylene (PE). Low-density polyethylene (LDPE), high-density polyethylene (HDPE), and extreme high weight polyethylene are a few PE variants that are made utilising various methods (UHMWPE). Strongly branched chains, a degree of polymerization of 50000, a density of 910–935 kg/m3, and a crystallinity of 50–60% are the characteristics of LDPE. A dense polymer material made of linear molecules, HDPE has a density between 930 and 970 kg/m3 and crystallinitybetween 70 and 85 percent (Galygin*et al.,* 2012). The branching of their macromolecules is primarily responsible for the differences in the characteristics of LDPE and HDPE: the more branching sites in the chain, the more elastic and less crystallinity the polymer. Almost every industry, agricultural, and home markets utilise LDPE and HDPE extensively, mostly for product packaging.

Since UHMWPE makes up a relatively small portion of total manufacturing, it should be recognized as a very potential tool with such a broadening range of uses. Utilizing metalloorganic processing, UHMWPE is produced; its molecular weight varies from 1.5 to 8 MDa. It's used to produce high-strength technological items, including armour, and has a high

degree of strength and resistance to cold. UHMWPE is a substance utilized in endoprosthetics since it is biologically inactive. It is used to produce ice because of its incredibly low friction coefficient (Table 1)(Zakharov *et al.,* 2009; Kudryashova, 2020).

Table 1: MFI of different PE and Density (Khanam& Mariam, 2015).

Type of polyethylene (PE)	Density (gram per cm^3)	Melt flow index (gram per 10 min)
HDPE (High density polyethylene)	0.941 to 0.965	0.2 to 3.0
MDPE (Medium- density polyethylene)	0.926 to 0.940	1.0-2.0
LDPE (Low-density polyethylene)	0.915 to 0.925	0.3 to 2.6
LLDPE (Linear low-density polyethylene)	0.915 to 0.925	0.1 to 10.0
VLDPE (Very low-density polyethylene)	0.870 to 0.914	0.026 to 0.1

Low-density polyethylene is flexible and has lower tensile and compressive strengths than HDPE because of the uneven packing of the polymer chains. LDPE is frequently used in food packaging items, rigid containers, and plastic film applications such as plastic bags and film wraps (Klyosov, 2007; Pascu, 2005). MDPE (Medium-density polyethylene) combines the characteristics of HDPE and LDPE. In comparison to HDPE, medium-density polyethylene is less stiff and harder but has superior impact and drop resistance, less notch sensitivity, and better fracture resistance. It is never as smooth as LDPE and is softer than HDPE. The demand for various types of plastics worldwide in 2006 is shown in the below (Fig. 1) (Statistics by Plastics Europe 2008).

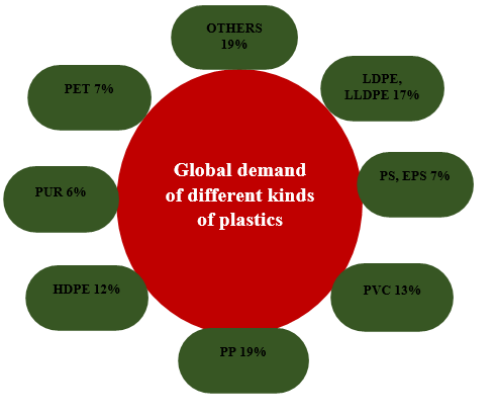

Fig. 1: Demand for various types of plastics by type of resin worldwide

APPLICATIONS OF HDPE

High Density Polyethylene (HDPE) is the perfect material for a variety of applications across sectors because to its excellent mix of features. High density polyethylene is used primarily for the following purposes.

Applications of Packaging– Crates, trays, bottles for milk and fruit juices, food packaging caps, jerry cans, drums, industrial bulk containers, etc. are all packaging applications that use high

density polyethylene. HDPE gives the finished product a respectable impact strength in these applications.

Consumer Goods –HDPE is a popular material for many domestic and consumer goods, including toys, ice boxes, household goods, and garbage cans, due to its low cost and simplicity of processing.

Textile and Fibers -Due to its high tensile strength, HDPE is frequently used for agricultural purposes, including in ropes, fishing and sport nets, nets, industrial and ornamental fabrics, and ropes.

Applications of LDPE

LDPE (Low-density polyethylene), has a low crystallinity (50–60%) and is a semi-rigid polymer. It has a higher level of short and long side-chain branching than HDPE. Between 4,000 and 40,000 carbon atoms make up the LDPE, which has several short branches. It is made at high pressures (1000–3000 bar; 80–300 °C) using a method called free radical polymerization. Low-density polyethylene is produced using either the stirred autoclave or tubular techniques. Due to its faster rates of ethylene conversion than the autoclave, the tubular reactor has been gaining popularity.

Applications of LLDPE

Using Ziegler-Natta or metallocene catalysts, linear low density polyethylene (LLDPE) is created by polymerizing ethylene (or ethane monomer) with 1-butene and lower amounts of 1-hexene and 1-octene. In terms of structure, it resembles LDPE. LLDPE is made up of a linear backbone and short, uniform branches (unlike longer branches of LDPE). Upon extension, these short branches are able to rub up against one another without changing into LDPE. Due to the qualities listed below, linear low-density polyethylene (LLDPE) has replaced low density polyethylene rather well in the current environment.

POLYETHYLENE HAZARDOUS TO THE ENVIRONMENT AND TO LIVING THINGS.

No matter where the polyethylene waste comes from, its accumulation in the ecosystem will undoubtedly cause serious problems. Approximately 79% of waste made of polyethylene is dumped in landfills (Ritchie and Roser, 2018; Canopoli *et al.,* 2018). Eventually, this garbage will oxidise naturally in the presence of sunlight. The sun's heat and UV rays will cause some of the C-H bonds in the polymer's structure to break, releasing the additives and plasticizers into the environment and creating greenhouse gases. Global warming and ozone depletion are gravely threatened by this (Iskander *et al.,* 2016).

Although it was initially believed that plastic was harmless and inert, years of environmental plastic waste have led to a number of linked problems. The environmental cost posed by plastic garbage pollution is now generally understood, especially in the aquatic environment where plastics suffer longer biophysical degradation, have negative effects on species, and have

limited disposal options (Rochman *et al.*,2013; GESAMP *et al.*, 2016, Derraik *et al.*, 2002; Thompson *et al.*, 2004; Kaiser 2010; Wilcox 2015; and Jambeck *et al.*,2015).

PLASTIC WASTE EFFECTS ON PUBLIC HEALTH

Despite the fact that plastic polymers are generally acknowledged to be slow-acting and to provide little risk to human health, some additives and maybe lingering monomers from these polymers are regarded to be the root of the supposed health risks (Araiyo *et al.*,2002). The majority of additives used in plastics have the potential to harm the endocrine system and cause cancer (Wikipedia). Humans are most exposed to these substances by ingestion, skin contact, and inhalation, which are the three main routes of exposure. Dermatitis has been linked to skin contact with some of the compounds included in plastics. Because they can bioaccumulate in the food chain after being digested by a range of freshwater and marine organisms, microplastics are substantial pollutants that are dangerous to the public's health (Gallowy, 2015). Human health risks can result from eating animals that have been exposed to microplastics and plastic additives. Biomonitoring studies on human tissues have shown that plastic materials persist in the population of humans through the assessment of environmental pollutants (Brydson, 1999).

CONTROLLING PLASTIC WASTE

LANDFILLING

About 10% of household trash is made up of plastic, most of which is dumped in landfills. Despite the fact that land filling is the most popular conventional waste management method in many countries, there is an increasing issue with the paucity of land that can be utilized for them. For instance, land filling has long been a preferred method in the UK since it is simple, economical, and doesn't usually required for treatment, cleaning, or separation. Despite the fact that in 1999, 65% (8.4 million tonnes per year) of the entire domestic rubbish that could be recovered in plastics was shipped there, plastic trash land filling is currently the least desired waste management option in the UK (APME). Concern over the effects of landfills on the environment and human health is growing due to the types, quantities, and potential for leaking of toxic substances at garbage sites (Miller, 2005). Reducing the amount of waste placed in landfills is a top aim for the UK government (see, for instance, European Commission 1999/31/EC's Landfill Directive). However, estimates indicate that 60% of municipal garbage in England is still placed in landfills, compared to 20% and 37% in Germany and France, respectively, making it difficult to reach this target (EEA, 2007). However, there is a potential that decomposing plastic wastes and additives, which can linger in the environment for a long time, could contaminate the soil and groundwater. If landfills are managed effectively, environmental pollution and public health risks may be reduced (Oehlmann *et al.*, 2009; Teuten *et al.*,2009).

DESTRUCTION OF PLASTIC

An option to land filling plastic waste is to burn it, but there are growing concerns that doing so could release hazardous chemicals into the atmosphere. For instance, the combustion of plastic trash produces halogenated compounds and polyvinyl chloride whereas the incineration of plastics releases furans, dioxins, and polychlorinated biphenyls (PCBs) into the environment (Gilpen *et al.,* 2003). The disadvantage of burning plastics is that the harmful gases released into the atmosphere pollute the air. Plastics are damaging to both people and the environment when they are burned because they permanently damage the combustion heater and flue systems. In LDPE, Low molecular weight compounds have the potential to pollute the air by directly vaporizing into it. Some low molecular weight chemicals may also make combustible mixes, while others may oxidise into solid form, depending on the material.

During incineration, plastics normally coke, and the degree of coking depends on the burning conditions (Nagy, 2016). Hazardous gases are generated when plastic and plastic composite materials are burned. Soot, ashes, and other particles are produced when plastics are burned. These substances may eventually settle on vegetation and soil and enter aquatic habitats. Some of these dangerous compounds may dissolve into the soil, contaminate the groundwater, or be absorbed by the vegetation that grows there, entering the food chain, as a result of rainfall. Some of the ingredients used to burn plastic can chemically react with water, modifying the pH of the resulting substances, which can affect how aquatic ecosystems function.

PLASTIC TRASH CONTAMINATION OF THE ENVIRONMENT

The distribution of plastic waste is correlated with human population density. The rising human population has raised demand for plastics and plastic products. The degradation of the environment's natural beauty (Andrady, 2003), the entanglement and death of aquatic organisms (Hofmeyer*et al.,* 2006; Lithner *et al.,* 2009), the clogging of sewage systems in towns and cities, particularly in developing countries (Adane, 2011), and the breeding of mosquitoes and other disease-carrying vectors are just a few examples of how environmental pollution can be seen (Ellis, 2005; Nejru, 2004; Alabi *et al.,*2012).

Microbiological degradation and deterioration of polyethylene is a better solution to prevent the issues related to polyethylene.

On the deterioration and degradation of polyethylene, several scientists have worked. There hasn't been much research on the use of enzymes and biosurfactants in the microbiological deterioration and breakdown of synthetic polymers. Because of this, we have attempted to partial degradation of polyethylene in our study utilizing screened microorganisms, microbial enzymes and biosurfactants that were isolated from dumpsite soil.

CONCLUSION

The pervasive use of plastics has led to significant environmental and health challenges, including pollution and the persistence of harmful additives in human populations. Despite the

economic advantages of plastic production, the inadequate management of plastic waste contributes to ecological degradation and public health risks. Transitioning to sustainable waste management practices, such as recycling and microbial degradation, is essential to mitigate these impacts and protect both the environment and human health.

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Chapter 13

SEASONAL COMPOSITION OF ALGAE IN A EUTROPHIC WATER BODY

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ABSTRACT

The occurrence of algal bloom in eutrophic, freshwater is significant from several viewpoints related to sustainable development. In addition to identifying the algal species that rapidly proliferate in response to eutrophication, studying phytoplankton in eutrophic waters helps to assess the environmental inventory of these fast-growing algae species and their impact on water quality indicators. Understanding the precise environmental conditions that fast-growing algae is crucial for managing toxic algal blooms and using non-toxic species for phycoremediation or as valuable resources for fuel, food, or animal feed. The measurement of the seasonal dynamics of the phytoplankton population was conducted in this particular environment. A total of 150 algal species, categorised into 8 phyla, 11 classes, and 26 orders, were detected in the waters. The study evaluated the ecology and diversity of algal communities about 1-year seasonal variations. This allowed for the evaluation of the ecological range of some dominating species that are often found in eutrophic environments.

KEYWORDS: Algal bloom, Eutrophication, Phycoremediation.

INTRODUCTION

Algal blooms are frequently observed in eutrophic freshwaters in rural, agricultural, and urban areas throughout many locations globally. Typically, eutrophic waters are regarded as significant water sources that require appropriate recycling to fulfill future drinking water needs.[1] The composition of phytoplankton in aquatic bodies is mostly regulated by environmental conditions, including pH, temperature, light, and nutrient levels. The composition, distribution, and abundance of distinct phytoplankton species in water bodies are primarily influenced by the physical and chemical water quality criteria.[2] Typically, natural waters have very little quantities of nutrients like nitrogen and phosphorus, which prevent excessive development of all types of plants. Eutrophication of water bodies is caused by the excessive addition of nutrients, such as nitrogen or phosphorus.[3]

Eutrophication in freshwater ecosystems typically stimulates rapid proliferation of specific species, leading to their great abundance or dominance. Water blooming refers to the phenomenon of water acquiring a distinct coloration as a result of an excessive presence of algae. Algal blooms in bodies of water result in increased yearly primary output and the buildup of algal biomass in eutrophic water systems.[4] The fast-growing species are often those that exhibit a rapid rise in population density in eutrophic environments in response to nutrient inflow, particularly nitrogen or phosphorus. The occurrence and spatial spread of algal bloom are progressively rising year. Algal bloom is frequently regarded as the primary cause of water quality degradation, unpleasant aromas and flavours, fish mortality, changes in the food chain, and toxicity, all of which have negative impacts on human health.[5] Nevertheless, the issue of excessive growth of algae in nutrient-rich waterways can also be viewed as a chance to investigate rapidly proliferating algal species that are not harmful to the environment, with the aim of creating sustainable industrial prospects. Several fast-growing algae species have the potential to be exploited as sources of food, feed, fuel, and nutraceuticals. [6] Additionally, they can be employed for water cleaning through a process called phycoremediation. The employment of rapidly growing algal species to clean up eutrophic or polluted streams has the potential to produce a significant amount of biomass that can be beneficial for many human advancements.[7] Hence, the investigation of non-toxic, rapidly growing algae species in nutrient-rich waters can aid in the creation of an innovative 'ecotechnology' that promotes efficient freshwater management and the production of valuable biomass. This, in turn, supports sustainable development.[8]

Typically, changes in the physical and chemical characteristics of water quality over different seasons lead to commensurate changes in the population dynamics of certain types of algae in bodies of water. [9] Algal species vary in their ability to utilise a particular combination of water quality characteristics. Hence, it is crucial to conduct a comprehensive evaluation of various water quality indices, as well as the variety of phytoplankton and the population dynamics of individual species, in different types of eutrophic freshwater bodies that are exposed to various human influences. [10] These research allow for the assessment of the most prevalent and rapidly expanding algae species in nutrient-rich waterways. It becomes crucial in harnessing the industrial capabilities of these species. Identifying the industrial capabilities of rapidly developing species has become an important topic that is very relevant to sustainable development.[11]

The evaluation of seasonal dynamics of phytoplankton populations in freshwater systems, a well-studied issue in aquatic ecology, has several industrial applications. Several researchers have previously identified distinct environmental elements that contribute to the seasonal changes in different groupings of algae populations in bodies of water.[12] Typically, conducting a thorough evaluation of the types and changes in phytoplankton populations,

using diversity indices and monitoring water quality parameters, provides valuable insights into the ecology of aquatic ecosystems. [13] This information is particularly helpful in determining the factors that influence the occurrence of algal blooms.[14] The primary goals of this study were to investigate the variety of algal species in various types of nutrient-rich waters, dominant fast-growing species in the nutrient-rich freshwater environments, seasonal variations in algal communities, assess the presence of any toxic algal species in the nutrient-rich waters.[15]

MATERIALS AND METHODS

STUDY AREA

Nallacheruvu Located in Boduppal Hyderabad city, Nallacheruvu, also known as Pedda Cheruvu is a small lake in Medchal Malkajgiri District in the Indian state of Telangana and on the western middle of the city of Hyderabad.(fig.1)Toxic foam from chemical effluents released into the Nalla Cheruvu (lake) in Uppal is spilling over on to the roads. The lake that spreads across 35 acres has an excess water outlet. This canal is now a frothing drain rich with chemical toxins. The drain leads to the Musi river, barely 1 kilometer ahead.

Fig. 1: Indicating Eutrophic Lake

SAMPLING AND ANALYSIS

Out of the two litres of water sample collected from three stations of water body 1 year study at the morning time 7 am – 8 am time period season wise and sent to the laboratory, precisely one liter was subjected to centrifugation at a force of 2930×g for a duration of 5 minutes in order to quickly separate the algae from the water. The algal sample was diluted to a volume of 50 mL and thereafter used for subsequent investigations. The quantitative determination of the number of algal species followed the procedure of the Lackey's drop count technique [16]. The enumeration of algal species was conducted in triplicate at a magnification of 40x using a high-magnification digital compound microscope (Motic BA 310, Hong Kong). The average of the triplicate counts was utilized as the representative value for each body of water. During each instance of triplicate counting, a minimum of three fields were seen and the following equation was utilized to evaluate the algal density [17].

The density of phytoplankton was ultimately quantified as the number of organisms per litre. The microalgal species were identified using a high-magnification compound microscope, namely the Motic BA 310 from Hong Kong and the Olympus BX 53 from Japan. The microphotographs were captured using a Q imaging digital camera, namely the Micropublisher 5.0 RTV model, which was attached to an Olympus BX 53 high-magnification microscope. Morphological measurements were acquired from microphotographs utilising Q-Capture Pro 7 image analysis. Software (USA). The algae were recognised using algal keys [18][19] and digital picture libraries of desmids.

RESULTS &DISCUSSION

Details of algal flora

A total of 150 microalgal species, classified into 8 phyla, 11 classes, and 26 orders, were discovered. The phylum Chlorophyta was the most abundant group, consisting of 128 species. It was followed by Charophyta with 90 species, Cyanophyta with 30 species, Bacillariophyta with 20 species, Euglenophyta with 10 species . *Cosmarium*, a microalga genus, has the most species diversity with 29 species, followed by *Scenedesmus* with 22 species. The lake is spread with water hyacinth. The relative abundance of microalgae regardless of the seasons. The microalgal species with the highest relative abundance was the green alga*Ankisrtodesmus falcatus, Ankistrodesmus spiralis, Chlorococcum humicola Coelastrum microporum*, *Coelastrum reticulatum*, *Cosmarium contractum, Cosmarium retusiforme, Crucigeniella irregularis, Gleocystis gigas, Kirchneriella lunaris, Kirchneriella obesa, Melosira granulata, Microcystis aeruginosa, Monoraphidium arcuatum, Monoraphidium contortum, Monoraphidium griffithii, Oocystis lacustris, Pediastrum duplex, Pediastrum tetras Radiococcus nimbatus, Scenedesmus dimorphus,Scenedesmus perforates, Scenedesmus quadricauda, Selenastrum bibarianum*, *Selenastrum gracile, Tetraedron gracile, Tetraedron trigonum*. It was followed by *Ankistrodesmus falcatus* the diatom *Melosira granulata* and

the green algae *Coelastrum microporum*, *Scenedesmus perforatus*, and *Scenedesmus dimorphus*. The algae species depicted in Table-1, Figure 2, 3, 4.

Table 1: Some of the Dominated Species found in Eutrophic Pond

Cyanophyceae-*Oscillatoria limosa, Oscillatoria curviceps, Oscillatoria animalis, Oscillatoria chalybea, Oscillatoria ornata, Merismopedia punctata, Microcystis aeruginosa, Arthrospira platensis and Chroococcus minutus*
Chlorophyceae-*Eudorina elegans, Chlamydomonas angulosa, Pandorina morum, Chlorella vulgaries, Coelastrum microporum, Scenedesmus acutiformis, Scenedesmus armatus, Scenedesmus quadricauda, Ankistrodesmus falcatus and Actinastrum hantzschii.*
Euglenophyceae-*Euglena polymorpha, Euglena acus, Euglena proxima, Euglena oxyuris, Phacus acuminatus, Phacus curvicauda and Phacus longicauda*
Bacillariophyceae-*Nitzschia palea, Navicula pupula, Navicula mutica, Navicula, rhynchocephala, Gomphonema parvulum and Cyclotella meneghiniana*.

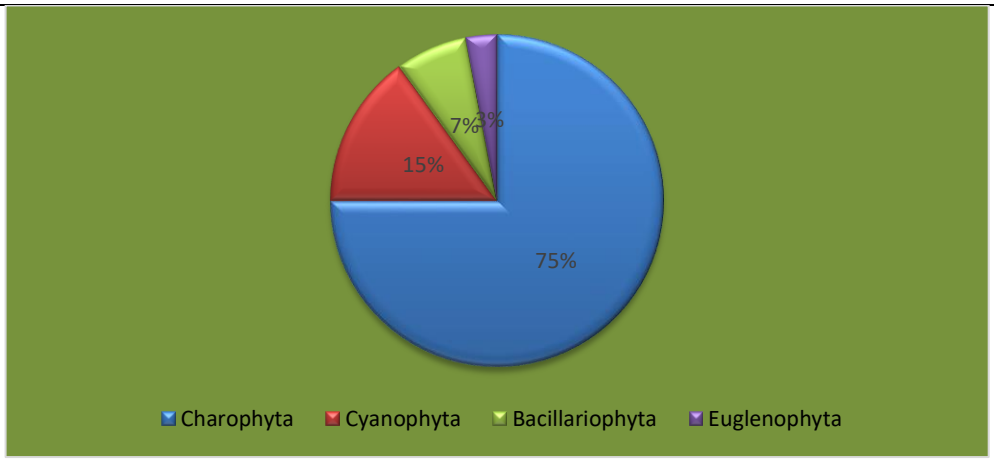

Fig. 2: Algal Composition

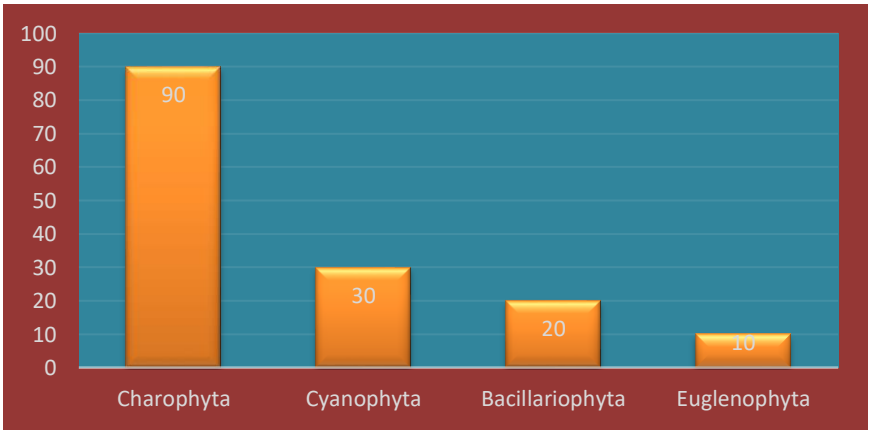

Fig. 3: Occurrence of Algae

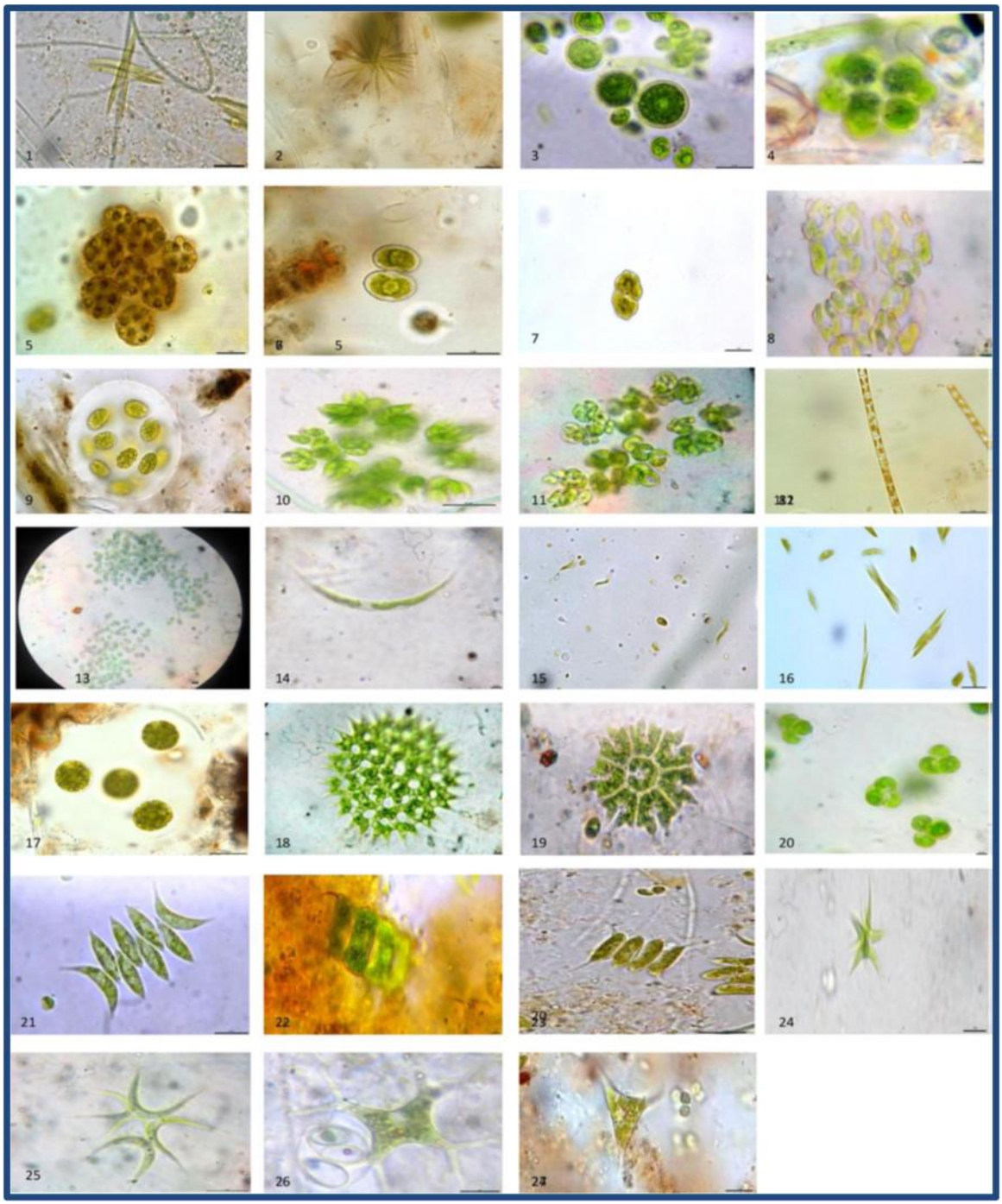

Fig. 4: Common algae found in eutrophic water body

1. *Ankisrtodesmus falcatus*, 2. *Ankistrodesmus spiralis*, 3.*Chlorococcum humicola*, 4.*Coelastrum microporum*, 5.*Coelastrum reticulatum*, 6.*Cosmarium contractum*, 7.*Cosmarium retusiforme*, 8.*Crucigeniella irregularis*, 9.*Gleocystis gigas*, 10.*Kirchneriella lunaris*, 11.*Kirchneriella obese*, 12.*Melosira granulata*, 13.*Microcystis aeruginosa*, 14.*Monoraphidium arcuatum*, 15.*Monoraphidium contortum*, 16.*Monoraphidium griffithii*, 17.*Oocystislacustris*, 18.*Pediastrum duplex*, 19.*Pediastrum tetras*, 20.*Radiococcus nimbatus*, 21.*Scenedesmus dimorphus*, 22.*Scenedesmus perforatus*, 23.*Scenedesmus quadricauda*, 24.*Selenastrum bibarianum*, 25.*Selenastrumgracile*, 26.*Tetraedron gracile*, 27.*Tetraedron trigonum*

The principal component analysis identified five groupings of components that contribute to the occurrence of algal blooms by extracting all water quality metrics. In summary, the investigation has uncovered valuable new data on several previously unstudied rapidly growing non-toxic algal species, including *Ankistrodesmus falcatus, Radiococcus nimbatus, Coelastrum microporum*, and Scenedesmus dimorphus. These species have industrial applications and can play a role in ecotechnological advancements that are crucial for achieving sustainable development. Summertime in eutrophic freshwater bodies of water is often associated with greater mineral content than monsoon time; this is likely due to an uptick in phytoplankton density and dominance values for certain species. When it comes to aquatic bodies, eutrophic circumstances tend to bring about greater variety than oligotrophic ones. Phytoplankton compositions, including diatoms, are used as bioindicators for water quality on a global scale.[21]

CONCLUSION

The many types of algae seen in eutrophic freshwaters. The study also clarified the population dynamics and ecological range of the rapidly expanding dominating algae in the eutrophicated waters of the studied lake. Overall, the research emerged as a paradigm for the identification of rapidly proliferating algae species and the comprehensive assessment of their presence in nutrient-rich environments. The information produced is crucial for the advancement of enterprises that rely on algae for food, fuel, nutraceutical, and bioremediation applications. These sectors play a key role in promoting sustainable development worldwide[22]. The study area had an ample amount of the green microalgae *Kirchneriella lunaris, Ankistrodesmus falcatus, Radiococcus nimbatus, Scenedesmus dimorphus, Coelastrum microporum,* and the diatom species *Melosira granulata* in its eutrophic waters. Upon deeper examination of the algal populations, it was seen that some species exhibited higher abundance and were densely concentrated throughout the summer, but the total diversity of the phytoplankton community increased during the monsoon season. The present characterization of the ecological amplitudes of the five dominant species provides important ecological information for future applications, especially when selecting species for bioremediation or industrial cultural purposes.[23] This information is particularly valuable in relation to diverse water quality parameters.

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Compliance with ethical standards

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Chapter
14

RURAL DEVELOPMENT PROGRAMMES IN INDIA: BEFORE AND AFTER INDEPENDENCE

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ABSTRACT

Rural development has been central to India's government policies before and after independence, aimed at improving living standards in rural areas. This chapter explores the evolution of rural development programs in India, analyzing key initiatives and their impacts during the British colonial period and post-independence, highlighting their role in enhancing rural livelihoods.

KEYWORDS: Rural Development, India, Government Policies, British Colonial Period, Post-Independence, Rural Livelihoods, Development Programs.

INTRODUCTION

Rural development in India has been an important point of government policies, both before and after independence. The objective has always been to uplift the living standards of the rural population, which constitutes a significant part of every country. This article explores the evolution of rural development programmes in India, examining the initiatives and their impacts during the British colonial period and in the post-independence time.

Rural Development Programme before Independence

COLONIAL POLICIES AND THEIR IMPACT

The British colonial administration primarily focused on extracting resources from rural India, which led to significant economic and social disruption. Agricultural productivity was emphasized to support the colonial economy, often at the expense of rural development.

The introduction of cash crops, such as indigo and cotton, for export markets spoiled the traditional farming system, leading to economic difficulties for farmers.

COMMUNITY DEVELOPMENT INITIATIVES

Some early steps for rural development were initiated by Indian social reformers and organizations. Broad steps included the foundation of cooperative societies and self-help groups focusing in improving agricultural practices and socio-economic status.

Mahatma Gandhi's stress on self-stand and village industries gave a groundwork for future rural development plannings. His advisory for "Gram Swaraj" (village self-made) emphasized local empowerment and sustainable social living.

RURAL DEVELOPMENT AFTER INDEPENDENCE

Early Post-Independence Initiatives:

Community Development Programme (1952): One of the first major rural development programe which aimed to flourish overall development in rural areas through community participation. The programme focused on agricultural practices, health, education, and basic infrastructure.

National Extension Service (1953): This was introduced to complement the Community Development Programme by providing technical knowledge to support rural communities.

Green Revolution (1960s-1970s):

A significant achievement in India's agricultural history, the Green Revolution aimed at transforming agriculture through the introduction of high-yielding varieties of seeds, chemical fertilizers, and advanced irrigation techniques. M.S Swaminathan is the father of Indian Green Revolution.

The Green Revolution led to substantial increases in agricultural productivity and food security but also resulted in regional disparities and environmental concerns.

Integrated Rural Development Programme (IRDP) (1978):

IRDP was launched to alleviate rural poverty by providing income-generating assets and credit facilities to the rural poor. The programme aimed to target the most vulnerable sections of society, including small farmers, landless laborers, and artisans.

National Rural Employment Programmes:

Jawahar Rozgar Yojana (JRY) (1989): This wage employment programme aimed at generating employment opportunities in rural areas through the creation of rural infrastructure.

Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) (2005): One of the most ambitious rural employment schemes globally, MGNREGA guarantees 100 days of wage employment to rural households, focusing on unskilled labor-intensive work. The programme aims to enhance livelihood security and create durable assets in rural areas.

Rural Development through Self-Help Groups (SHGs):

The promotion of SHGs has been a dynamic role in rural development strategies. These groups, primarily composed of women, are designed to provide microfinance and promote entrepreneurship, thereby enhancing socio-economic status.

Pradhan Mantri Gram Sadak Yojana (PMGSY) (2000):

PMGSY focuses on improving rural connectivity by constructing all-weather roads. Better connectivity facilitates access to markets, healthcare, and education, thereby boosting rural development.

Digital Initiatives for Rural Development:

Recent years have seen a push towards digital inclusion in rural areas. Programmes like Digital India aim to bridge the digital divide by providing internet access, digital literacy, and e-governance services to rural populations.

COMPARATIVE ANALYSIS: BEFORE AND AFTER INDEPENDENCE

Focus and Approach:

Pre-independence initiatives were irregular and largely driven by social reformers and local efforts. The focus was on immediate relief and localized development.

Post-independence, rural development became a central government priority, with structured programmes targeting comprehensive socio-economic growth.

Scale and Reach:

Before independence, rural development efforts were limited in scale and reach, often failing to address the widespread needs of the rural populace.

After independence, national-level programmes focused at holistic development were implemented, significantly expanding the scope and impact of rural development efforts.

Community Involvement:

Both pre- and post-independence efforts emphasized community involvement. However, post-independence programmes institutionalized community participation through structured frameworks like Panchayati Raj Institutions and Self Help Groups.

Economic Impact:

The economic impact of pre-independence efforts was minimal due to limited resources and colonial exploitation.

Post-independence programmes have had a substantial economic impact, improving agricultural productivity, generating employment, and enhancing rural infrastructure.

CHALLENGES AND FUTURE DIRECTIONS

Despite significant progress, rural development in India faces numerous challenges:

Persistent Poverty: A substantial portion of the rural population still lives in poverty, requiring targeted poverty alleviation strategies.

Regional Differences: There are stark disparities in development across different regions, necessitating region-specific interventions.

Environmental Sustainability: The emphasis on productivity has sometimes led to environmental degradation. Future strategies must balance development with sustainability.

CONCLUSION

Rural development in India has evolved significantly from the colonial period to the present day. While pre-independence efforts were foundational, post-independence initiatives have been transformative, addressing the diverse needs of the rural population. Continued focus on inclusive, sustainable, and technology-driven development is essential to achieve holistic rural growth and improve the quality of life for millions of rural Indians.

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Chapter 15

GLOBAL AGRICULTURAL TRADE AND ECONOMICS

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ABSTRACT

Global agricultural trade is crucial for food security, economic growth, and environmental sustainability. It encompasses the exchange of agricultural products across nations and is influenced by trade policies, practices, and marketing strategies. This chapter examines the economics of agricultural trade and its impact on production, distribution, and international consumption.

KEYWORDS: Agricultural Trade, Global Food Security, Economic Growth, Trade Policies, International Market, Environmental Sustainability, Marketing Strategies.

INTRODUCTION

Global agricultural trade plays a very important role in the global food security, economic growth, and environmental sustainability. Agricultural trade involves the mutual exchange agricultural products, such as grains, vegetables, fruits, meat, and dairy products between different countries. The economics of agricultural trade comprises the trade policies, practices, and marketing skills that effect the production, negotiation, distribution, and consumption of these goods in the international market.

SIGNIFICANCE OF GLOBAL AGRICULTURAL TRADE

Food Security: Global Agricultural trade ensures that countries with surplus production can supply those with the countries who are lacking food gains, thereby balancing global food availability is a key point. For instance, nations experiencing droughts or poor harvests can rely on imports to meet their food needs.

Economic Development: Exporting agricultural products can significantly boost the economies of developing countries. It provides farmers with access to larger markets, increasing their income and improving livelihoods.

Diversity of Diets: Trade allows consumers to access a variety of foods that may not be produced locally. This enhances dietary diversity and nutrition, contributing to overall health and well-being.

Technological Transfer: Exposure to international markets encourages the adoption of modern farming techniques and technologies, improving productivity and sustainability in agriculture.

KEY PLAYERS IN GLOBAL AGRICULTURAL TRADE

Exporters: Major agricultural exporters include the United States, Brazil, China, India, and the European Union. These countries have the resources, climate, and technology to produce large quantities of agricultural goods.

Importers: Significant importers include China, Japan, the European Union, and the Middle East. These regions may lack sufficient agricultural capacity due to limited arable land, water resources, or suitable climate conditions.

TRADE POLICIES AND AGREEMENTS

Tariffs and Subsidies: Governments often use tariffs and subsidies to protect their domestic agricultural sectors. Tariffs make imported goods more expensive, encouraging consumers to buy local products. Subsidies support farmers financially, allowing them to compete in the global market.

Trade Agreements: Multilateral and bilateral trade agreements, such as the World Trade Organization (WTO) agreements, the North American Free Trade Agreement (NAFTA), and the European Union's Common Agricultural Policy (CAP), regulate international agricultural trade. These agreements aim to reduce trade barriers, promote fair competition, and ensure the stability of food supplies.

Non-Tariff Barriers: Countries also impose non-tariff barriers, such as sanitary and phytosanitary (SPS) measures, to protect human, animal, and plant health. While these measures are essential, they can sometimes be used to restrict trade unfairly.

MARKET DYNAMICS

Supply and Demand: Global agricultural markets are influenced by supply and demand dynamics. Factors such as weather conditions, pest infestations, and technological advancements can affect supply, while population growth, income levels, and consumer preferences drive demand.

Price unstability: Agricultural prices are inherently volatile due to their dependence on natural factors. This volatility can be exacerbated by trade policies, currency fluctuations, and geopolitical events, impacting both producers and consumers.

Access to market: Access to markets is critical for agricultural trade. Infrastructure, such as ports, roads, and storage facilities, plays a vital role in ensuring that goods can be efficiently transported and traded.

CHALLENGES IN GLOBAL AGRICULTURAL TRADE

Obstructions in Trade: Protectionist policies, such as high tariffs and subsidies, can distort markets and limit the benefits of trade. They can lead to trade disputes and retaliatory measures, disrupting global supply chains.

Effect on Environment: Intensive agricultural production for trade can lead to environmental degradation, including deforestation, soil erosion, and water pollution. Sustainable practices are essential to mitigate these impacts.

Discrimination: There is often an imbalance in trade benefits, with developed countries gaining more than developing ones. Ensuring fair trade practices and supporting smallholder farmers in developing countries is crucial for inclusive growth.

Quality and Quantity: Differences in food safety and quality standards can create trade barriers. Harmonizing these standards while ensuring consumer safety is a complex but necessary task.

FUTURE PROSPECTS

Sustainable Trade: There is a growing emphasis on sustainability in agricultural trade. Practices such as organic farming, fair trade certification, and carbon footprint reduction are gaining traction.

Digitalization: Technology is transforming agricultural trade. Digital platforms, blockchain, and precision agriculture are enhancing transparency, efficiency, and traceability in supply chains.

Climate Change Adaptation: As climate change affects agricultural productivity, trade will play a vital role in redistributing food resources. Innovations in crop resilience and adaptive strategies will be essential.

Emerging Markets: Developing countries are becoming significant players in global agricultural trade. As their economies grow, they will contribute more to both the supply and demand of agricultural products.

CONCLUSION

Global agricultural trade is a complex and dynamic field that impacts food security, economic development, and environmental sustainability. Understanding the economics behind it is essential for policymakers, businesses, and stakeholders to navigate the challenges and opportunities it presents. By promoting fair, efficient, and sustainable trade practices, we can ensure a stable and prosperous global agricultural market.

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Chapter 16

GREEN COSMETICS: EVOLUTION OF SUSTAINABLE BEAUTY

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ABSTRACT

To maintain wealth in a world where everyone has the potential to thrive, it is essential to foster sustainable growth. This involves not only pursuing economic development but also ensuring that is environmentally responsible and social inclusive. By prioritizing long-term sustainability, we can create a balanced approach that benefits all and secures prosperity for future generations. To achieve this goal, it is beneficial to convert food wastes into valuable resources by extracting and utilizing its components to create new sustainable products. Such products not only offer effectiveness and cost efficiency also contribute to environmental sustainability. By recycling food waste we can reduce landfill waste, minimize resource consumption, and support a circular economy. This approach not only addresses environmental concerns but also promotes economic growth and innovations in creating ecofriendly solutions.

KEYWORDS: Sustainability, Agro Wastes, Cosmetics, Plant –By- Products.

INTRODUCTION

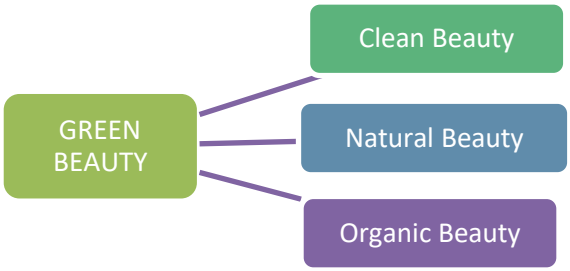
Cosmetics derive their name from the Greek phrase "Kosmeticos," which means that to adorn. Any substance used to decorate or improve one's look is considered a beauty. Over the past three-four a long time, using cosmetic has visible a great rise. This merchandise is designed solely for outside software and are typically used at the pores and skin, hair, and nails. Their cause consists of overlaying, coloring, softening, cleaning, nourishing, and protective the frame's exterior.

Fruits and vegetables are crucial components of our diet, and their significant nutritional benefits have been extensively researched for decades. Beyond primary metabolites, which include essential nutrients like vitamins and minerals, plant also produces a diverse range of secondary metabolites. These compounds, such as flavonoids, carotenoids, and phenolic, offer additional health benefits and contribute to the plants defense mechanisms. Understanding and utilizing these secondary metabolites can enhance the nutritional value of our diet and support

innovative approaches in sustainable food systems and health now a day's most agricultural waste is processed using basic waste management and valorization strategies as animal feed, production of composts, and fertilizer, as well as an aerobically digestion to biogas. Since this type of processing is associated with high costs of drying, storage and transportation. As a result, there is an increasing need for more efficient and environmentally sustainable approaches to utilizing and recycling this waste. Implementing advanced technologies such as integrated waste-to-resource systems, precision composting techniques, and bioengineering can optimize waste processing, reduce costs, and enhances resource recovery. Additionally, developing innovative practices that convert agricultural waste into high-value products, such as biodegradable materials or bioactive compounds, can contribute to more sustainable agricultural systems, support circular economics, and mitigate environmental impacts.
(FWIP, 2020) (Dini.I, Laneri. S.)

Agricultural processing industries produce 10-60% of their raw materials as solid waste. In some cases, the by-products derived from this waste can be even more valuable than the primary products. Leveraging these waste materials can lead to the development of high value products, such as specialized bioactive compounds or sustainable materials, which not only enhance economic returns but also contribute to environmental sustainability by reducing waste and promoting resource efficiency. Exploring these opportunities can drive innovation and create va more circular economy in agricultural processing. (Santos. F, Bruno, 2015)

GREEN COSMETICS



In the cosmetic industry, green and sustainable cosmetics are defined as products formulated with natural ingredients derived from renewable raw materials. These eco-friendly cosmetics improve product quality, bolster brand reputation, and strengthen corporate responsibility. By prioritizing environmental sustainability, green cosmetics help reduce ecological impact, appeal to increasingly eco-conscious consumers, and promote ethical practices within the industry. Embracing these principles can also drive innovation and set new standards for responsible beauty products (Leja, Ross –Fitcher, 2018).

CITRUS FRUIT PROCESSING BY-PRODUCTS

Citrus plants (own family: Rutaceae), commonly known as agrumes, constitute one of the international's predominant fruit crops. Fresh citrus end result are wealthy assets of nutritional

fibers, which can be linked to the prevention of gastrointestinal diseases and the reduction of circulating cholesterol levels. They also are plentiful in vitamins C and B, and comprise vital compounds which include carotenoids, flavonoids, and limonoids. These organic parts are essential for human fitness development, generally because of their antioxidant homes.

Citrus processing generates a giant quantity of agricultural waste, predominantly within the shape of press cakes. The disposal of these press cakes is luxurious due to the charges related to dealing with and transportation. Addressing this trouble calls for modern solutions that not simplest lessen disposal prices but additionally improve useful resource performance and sell environmental sustainability. By integrating waste-to-value technology, it's miles feasible to transform waste into worthwhile, sustainable merchandise, thereby contributing to a round economic system. This technique now not handiest reduces the environmental impact of citrus processing however also aligns with broader desires of waste discount and aid optimization.

Melanin manufacturing within the pores and skin is determined by means of the pastime of a key enzyme, tyrosinase, and its transcription element MITF. Thus, downregulating tyrosinase interest or expression can bring about reduced melanin content material inside the skin. Citrus press desserts and citrus fruit peels were extracted the use of ethanol, and remedy with these extracts significantly decreased cellular melanin content material through inhibiting tyrosinase pastime (Singh M., Agrawal S.).

VALORIZATION OF BY-PRODUCTS DERIVED FROM PINEAPPLE AND GRAPEVINE

Pineapple (Ananascomosus) is the maximum processed tropical fruit, generating a great quantity of by using-products, accounting for 25-35% of the fruit, more often than not in the shape of rind and center. These with the aid of-products are wealthy in compounds with antioxidant hobby, which makes them incredibly treasured for capacity use within the cosmetic enterprise.

UV radiation at a wavelength of one hundred ninety-280 nm is one of the primary sustainable sanitation techniques for fruits. This environmentally friendly and comparatively inexpensive approach has been shown to increase the L-ascorbic acid content in the rind of pineapple, with stages higher than the ones located within the whole fruit.

Grapevine is another species with excessive dietary cost, wealthy in beneficial compounds together with vitamins, tannins, polyphenols, and carotenoids. Approximately 15% of beaten grapes emerge as grape marc or pomace, the solid derivative left over from winemaking, which consists of pulp, skins, and seeds. The proteasome is a proteolytic machine concerned in casting off bizarre and broken proteins, and its activity can be inhibited in careworn cells through incredibly oxidized and aggregated proteins in the cytoplasm. An aggregate of liposoluble marc extract (LME) and liposoluble mobile extract (LCE) has been proven to significantly decorate the detoxifying capacity of cells, growing proteasome pastime through 44% in fibroblasts and 61% in keratinocytes.

COFFEE PROCESSING BY-PRODUCTS

The espresso processing enterprise is every other supply of big amounts of disposable via-products. Coffee plants (Coffeaarabica and Coffearobusta) are cultivated in many countries, and the guide series and choice of coffee berries can result in portions of unused inexperienced beans which can be routinely broken or insufficiently ripe for further processing.

To create a valuable ingredient rich in bioactive antioxidant compounds, unroasted coffee beans can go through decaffeination using pure water and carbon dioxide (CO2), observed by using ethanol extraction. The resulting jelly-like extract can beautify natural pores and skin cell renewal, sell a good skin tone, assist prevent water loss, lighten the skin via inhibiting melanin synthesis, and boost up the restore of damaged pores and skin by way of decreasing irritation.

Table 1: Some of the examples for ingredients that can be used in the formulation of Green Cosmetics

Foods	Bioactive Molecules	Bioactivity	Cosmetic Relevance
Green tea	Catechin derivatives	Freeradical scavengers	Moisturizing effect Treat acne
Pomegranate	Ellagicacid, punicalagin, punicic acid	Antioxidant, anti-fungal, anti-inflammatory	Decreases wrinkles
Coconut	Fatty acids	Antioxidant Anti-inflammatory	Inhibits UV light mediated skin aging, Moisturizes skin, Removes black spots
Papaya	Flavonoids Phenolic acids Cysteine endopeptidases	Anti-inflammatory	Reduces Skinerythrma, proteolytic wound debriment
Lemon	Flavanones Limonene	Antioxidant	Antiaging Reduce acne and hair disorders
Glycyrrhiza glabra	Flavonoids	Antioxidant Anti-inflammatory	Prevent pigmentation Deodorant properties Improves hair growth

(SumitK, Vivek S, Sujata.S, Ashish B)

FUTURE SCOPE OF GREEN COSMETICS

According to industry experts, the cosmetics market in the nation is projected to grow by 25%. This robust expansion is attributed to the increasing consumer preference for cosmetics made from natural ingredients. Additionally, the trend towards organic and eco-friendly products, driven by heightened environmental awareness and demand for sustainable practices, is

expected to further fuel this growth. As more consumers seek products that align with their values and offer perceived health benefits, the market is likely to continue its upward trajectory (Anastas, Warner).

The demand for sustainability in the beauty sector is gaining significant momentum, profoundly reshaping the industry. Consumers are increasingly willing to invest in sustainable beauty brands, viewing it as a personal responsibility to support environmentally conscious practices. This shift reflects a growing awareness of the environmental impact of beauty products and desire for ethical consumption. Companies are also leveraging sustainability as a key differentiator in a competitive market, fostering loyalty among consumers who prioritize ethical and green practices. Additionally, the rise of digital platforms and social media has amplified the visibility of sustainable beauty brands, enabling them to reach a broader audience and influence market trends. This convergence of consumer values and industry practices is likely to drive further growth and evolution in the beauty sector.

Many Indian local brands have gained attention for their exceptional natural recipes, passed down through generations and adapted to today's skincare solutions. These brands have successfully blended traditional wisdom with modern science to create effective and authentic skin care products that resonate with consumers. From herbal formulations using Ayurvedic ingredients to eco-friendly and sustainable practices, these brands emphasize purity and quality. Their commitment to using natural, locally sourced ingredients not only supports local farmers but also ensures that the products are free from harmful chemicals. As a result, some of the Indian skincare brands are carving a niche in the global market, appealing to those who seek holistic and natural beauty solutions.

CHALLENGES TO DEVELOP SUSTAINABLE BEAUTY BRANDS:

1. Material deficiencies
2. Vendor misinformation
3. Lack of regulation

CONCLUSION

Every sector of human activity will have to become sustainable. Agriculture, because it uses enormous land and water resources and contributes sustainability to pollution, has the most serious sustainability issues and needs to change the practices. Supporting small scale farmers and local food systems can further enhance sustainability by reducing the carbon footprint associated with transportation and promoting community resilience. Governments and organizations must invest in research and development to innovate and spread sustainable farming techniques. By transitioning to more sustainable agricultural practices, we can ensure food security, protect the environment, and create a more resilient agricultural system for future generations.

The cosmetic industry can certainly represent a remunerable solution on how recycling disposable by- products. Moreover, the cosmetic market is always growing, despite the economic crisis. Over 5 billion cosmetics are sold every year. Undoubtedly, extracts obtained from the by-products represent a valid "green" alternative to the regular plant derived extracts, commonly used in cosmetics. Besides their proven beneficial effects on human skin, the agro-food by-products have the advantages of being bio-sustainable and inexpensive (Anurupa Singh, Rachita Kapoor, Richa Mishra).

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Chapter
17

FOOD SECURITY AND EXTENSION EDUCATION: ECONOMIC STRATEGIES FOR SUSTAINABLE LIVELIHOODS

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ABSTRACT

Food security is a critical issue in developing nations where agriculture serves as the primary livelihood. This chapter explores the role of extension education in improving agricultural productivity and promoting sustainable livelihoods. The article highlights the impact of initiatives like Krishi Vigyan Kendra (KVK) and discusses economic strategies essential for achieving long-term food security.

KEYWORDS: Food Security, Agriculture, Extension Education, Sustainable Livelihoods, Krishi Vigyan Kendra, Economic Strategies, Developing Nations.

INTRODUCTION

Developing and underprivileged nations are significantly impacted by food security challenges. Agriculture is the primary source of livelihood for many people in these regions, often labeled as the third world by more developed countries. While global efforts aim to make food more accessible and affordable to all societal segments, the reality often falls short of these aspirations. Food security involves more than just the availability of food; it also requires ensuring that food is accessible, affordable, and nutritious for everyone. Extension education plays a vital role in enhancing agricultural productivity, boosting food security, and promoting sustainable livelihoods by equipping farmers with the knowledge and skills needed to adopt modern and sustainable farming practices. In India, for example, initiatives like Krishi Vigyan Kendra (KVK) work towards modernizing farming methods while ensuring sustainability to maximize agricultural output.

This article explores the relationship between food security, extension education, and economic strategies designed to foster sustainable livelihoods. It outlines the challenges faced by farmers, the role of extension services in addressing these challenges, and the economic strategies necessary for long-term food security.

THE IMPORTANCE OF FOOD SECURITY

Food security, as defined by the Food and Agriculture Organization (FAO), is the condition where all people have consistent access to sufficient, safe, and nutritious food to maintain a healthy and active life. This concept is built on four key pillars: availability, access, utilization, and stability.

1. Availability refers to a reliable supply of food, whether from domestic production, imports, or food aid.
2. Access is the ability of individuals to obtain food, whether through purchasing, bartering, or other means.
3. Utilization focuses on the proper use of food, requiring a balanced diet that provides sufficient energy and essential nutrients.
4. Stability ensures that food access remains consistent over time, minimizing the risk of food crises.

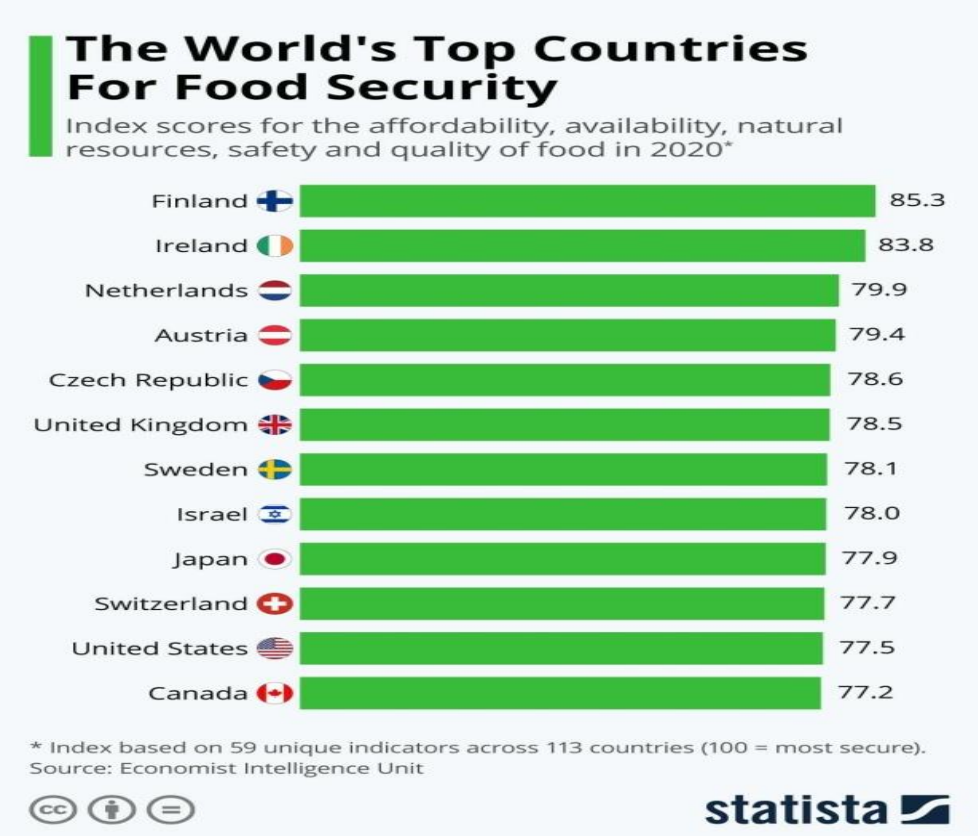

Fig. 1: Food Security. Source: https://www.weforum.org/agenda/2021/03/countries-food-security-index-ranked-chart/

Achieving food security is crucial for reducing poverty, fostering economic development, and maintaining social stability. However, numerous challenges, including climate change, population growth, and economic instability, continue to threaten global food security.

CHALLENGES IN ACHIEVING FOOD SECURITY

Several obstacles impede the realization of food security, particularly in rural and agrarian communities:

Low Agricultural Productivity: Many smallholder farmers face low productivity due to limited access to modern farming techniques, quality inputs, and infrastructure. This often results in inadequate food production, exacerbating food insecurity.

Climate Change: The agricultural sector is highly vulnerable to climate change, which affects crop yields, water availability, and the spread of pests and diseases. Unpredictable weather patterns and extreme events like droughts and floods further disrupt food production and supply chains.

Economic Constraints: Limited access to credit, markets, and financial services prevents farmers from investing in technologies and practices that could enhance productivity. Economic challenges also reduce their capacity to cope with shocks such as price volatility or crop failures.

Knowledge Gaps: A lack of knowledge and skills in modern agricultural practices often leads to inefficiencies and reduced productivity among farmers. Traditional farming methods alone may not suffice to meet the growing food demand.

Social and Gender Inequities: Women, who play a crucial role in food production, often encounter barriers to accessing resources, education, and decision-making processes. These social inequities further contribute to food insecurity, particularly in vulnerable communities.

Fig. 2: Gender Inequality. Source: https://earth.org/global-food-security/

THE ROLE OF EXTENSION EDUCATION IN FOOD SECURITY

Extension education is a critical tool for addressing the challenges faced by farmers and improving food security. It involves sharing knowledge, skills, and technologies with farmers and rural communities to enhance their agricultural practices and livelihoods. Extension services are delivered through various channels, including government agencies, non-governmental organizations (NGOs), the private sector, and digital platforms.

Enhancing Agricultural Productivity: Through extension education, farmers gain access to modern agricultural practices such as improved seed varieties, efficient irrigation techniques,

and sustainable land management. These practices help increase crop yields, reduce post-harvest losses, and boost overall farm productivity.

Building Climate Resilience: Extension services are essential in promoting climate-smart agriculture, which includes practices that mitigate the impacts of climate change and adapt to its effects. Techniques like agroforestry, conservation agriculture, and integrated pest management help farmers reduce their vulnerability to climate-related risks and stabilize food production.

Improving Market Access: Extension education assists farmers in better accessing markets by providing information on market trends, quality standards, and value addition. It also supports the formation of farmer cooperatives and producer organizations, which can improve farmers' bargaining power and help them secure better prices for their products.

Promoting Sustainable Livelihoods: Extension services encourage income diversification by supporting activities such as livestock rearing, agro-processing, and agribusiness. Diversifying income sources reduces reliance on a single source and enhances economic resilience, contributing to food security.

Gender-Sensitive Approaches: Incorporating gender-sensitive approaches in extension education ensures that women farmers have equal access to resources, knowledge, and decision-making opportunities. Empowering women in agriculture can lead to better food security outcomes, as women are more likely to invest in their families' nutrition and well-being.

ECONOMIC STRATEGIES FOR SUSTAINABLE LIVELIHOODS

To achieve sustainable livelihoods and food security, it is vital to implement economic strategies tailored to the needs and capacities of rural communities. These strategies should focus on increasing agricultural productivity, improving market access, and building economic resilience.

Investing in Agricultural Infrastructure: Governments and development partners should prioritize investments in infrastructure such as roads, irrigation systems, storage facilities, and market centers. Improved infrastructure can reduce post-harvest losses, lower transportation costs, and facilitate better market access.

Expanding Access to Credit and Financial Services: Providing farmers with greater access to credit and financial services allows them to invest in technologies that enhance productivity, purchase necessary inputs, and manage economic shocks. Microfinance institutions, cooperatives, and digital financial services can be crucial in delivering these financial resources.

Developing Value Chains: Strengthening agricultural value chains by improving processing, packaging, and marketing can increase the value of agricultural products and boost farmers' incomes. Extension services can contribute to value chain development by offering training on quality standards, business management, and market linkages.

Promoting Public-Private Partnerships (PPPs): Collaborations between the public and private sectors can improve the delivery of extension services and support the development of agricultural markets. PPPs can leverage the strengths of both sectors to provide farmers with better access to inputs, technology, and markets.

Encouraging Agro-Entrepreneurship: Fostering agro-entrepreneurship among rural youth can create employment opportunities and drive innovation in agriculture. Extension services can support this by providing training on business development, marketing, and financial management.

CONCLUSION

Addressing food security is a complex challenge that requires a comprehensive approach to ensure sustainable livelihoods for rural communities. Extension education plays a pivotal role in enhancing agricultural productivity, building climate resilience, and improving market access—all of which contribute to food security. By implementing focused economic strategies, such as investing in infrastructure, expanding access to credit, and promoting value chain development, stakeholders can create an environment conducive to sustainable agriculture and food security.

Achieving these goals requires strengthening extension services, promoting gender equity, and fostering collaboration among governments, development partners, and the private sector. With these efforts, rural communities can be empowered with the knowledge, resources, and opportunities they need to secure food security and sustainable livelihoods.

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Chapter 18

FISH BREEDING IN INDIA

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ABSTRACT

Fish breeding in India plays a significant role in the nation's economy, food security, and employment generation. This chapter provides an overview of fish breeding practices, highlighting the historical evolution, major species involved, and the socio-economic importance of this industry. With a variety of species like Indian Major Carps, Exotic Carps, Catfish, Tilapia, and Trout being bred in different regions, India capitalizes on its diverse climatic conditions to support aquaculture. The chapter details the breeding techniques employed, including natural, induced breeding, and hybridization, emphasizing their adoption rates and effectiveness. It also covers hatchery management essentials such as water quality, broodstock nutrition, disease control, and larval rearing, which are critical to successful fish breeding operations. The socio-economic impact of fish breeding is explored, illustrating its contribution to rural livelihoods, employment generation, and export earnings. Additionally, the chapter addresses challenges like environmental degradation, climate change, disease outbreaks, and resource constraints that hinder the sector's growth. The future of fish breeding in India relies on continued research and sustainable practices to ensure long-term success and economic viability.

KEYWORDS: Fish Breeding, Aquaculture, India, Indian Major Carps, Exotic Carps, Catfish, Tilapia, Trout, Induced Breeding.

INTRODUCTION

FISH BREEDING IN INDIA

Fish breeding in India is a critical sector that contributes significantly to the country's economy, food security, and employment. As a country with extensive inland and coastal water resources, India has a rich tradition of aquaculture and fisheries. Fish breeding involves the controlled reproduction of fish species to enhance production, improve genetic quality, and ensure sustainable fish populations. This chapter delves into the methodologies, practices, and advancements in fish breeding in India, highlighting the diverse species, breeding techniques, and the socio-economic impact of the industry.

HISTORICAL CONTEXT

India's fish breeding practices date back centuries, with traditional methods being employed by local communities. Ancient texts and folklore often reference fish culture, indicating the historical significance of this practice. In modern times, fish breeding has evolved with scientific advancements and technological interventions, leading to the establishment of hatcheries and research institutes dedicated to aquaculture.

MAJOR FISH SPECIES FOR BREEDING

India's diverse climatic conditions and water bodies support a wide range of fish species suitable for breeding. Some of the major species include:

Indian Major Carps: Rohu (Labeo rohita), Catla (Catla catla), and Mrigal (Cirrhinus mrigala) are the cornerstone of freshwater fish breeding in India. Rohu is known for its fast growth rate and high nutritional value, making it a favorite among fish farmers. Catla, distinguished by its large head and rapid growth in large water bodies, is highly valued for its meat quality. Mrigal, although slower in growth compared to Rohu and Catla, is appreciated for its adaptability to diverse aquatic environments and its role in polyculture systems.

Exotic Carps: Species like Grass Carp (Ctenopharyngodon idella) and Common Carp (Cyprinus carpio) are also bred extensively. Grass Carp is particularly noted for its ability to control aquatic weed growth, thus enhancing the environment for other fish species. Common Carp, introduced in India several decades ago, has become a significant part of the aquaculture sector due to its high tolerance to varied environmental conditions and its efficiency in converting feed into body mass.

Catfish: Species such as Pangasius (Pangasianodon hypophthalmus) and Magur (Clarias batrachus) are popular for their high market demand. Pangasius is known for its rapid growth and ability to thrive in high-density farming systems, making it a cost-effective species for commercial farming. Magur, an air-breathing catfish, is favored for its resilience in low-oxygen waters and its high nutritional value, often used in traditional medicinal recipes.

Tilapia: Known for their fast growth and adaptability, Tilapia (Oreochromis niloticus) are increasingly being bred in India. Tilapia are often referred to as the "aquatic chicken" due to their high growth rates, ability to reproduce quickly, and resilience in various water conditions. Their mild-tasting flesh makes them popular among consumers, and their farming is often promoted as a means to improve food security and livelihoods in rural areas.

Trout: Cold-water species like Rainbow Trout (Oncorhynchus mykiss) are bred in the hilly regions of India. Rainbow Trout is prized for its delicate flavor and is often raised in the cold, clear waters of the Himalayan and other mountainous regions. The farming of this species requires specific conditions, including low water temperatures and high oxygen levels, which are typically found in these elevated regions. The success of Rainbow Trout farming has opened new avenues for aquaculture in non-traditional areas.

BREEDING TECHNIQUES

Fish breeding techniques in India can be broadly categorized into natural breeding, induced breeding, and hybridization.

NATURAL BREEDING

Natural breeding involves the use of natural water bodies where fish are allowed to spawn naturally. This method is often employed in well-managed ponds and reservoirs with controlled environments. While cost-effective, natural breeding requires optimal conditions and careful monitoring to ensure successful reproduction.

INDUCED BREEDING

Induced breeding is a more scientific approach where breeders use hormones to stimulate fish to spawn. This technique ensures higher yields and better control over breeding cycles. The process typically involves:

Selection of Broodstock: Healthy and mature fish are selected as broodstock.

Hormonal Injection: Hormones such as Ovaprim, HCG, and pituitary extracts are injected to induce spawning.

Spawning and Fertilization: Fish spawn in controlled environments, and eggs are fertilized either naturally or artificially.

Incubation and Hatching: Fertilized eggs are incubated in hatcheries until they hatch into larvae.

HYBRIDIZATION

Hybridization involves crossing different species or strains to produce offspring with desirable traits such as faster growth, disease resistance, and better adaptability. Hybrid fish often show heterosis or hybrid vigor, making them suitable for commercial aquaculture.

Table 1: Analytical Chart: Breeding Techniques Adoption

Fish Breeding Technique	Adoption Rate (%)
Natural Breeding	30
Induced Breeding	55
Hybridization	15

This chart presents the adoption rates of various fish breeding techniques in India. Induced breeding shows the highest adoption rate due to its effectiveness and controlled outcomes, followed by natural breeding and hybridization. The data indicates the preference for scientifically advanced methods among Indian fish breeders.

HATCHERY MANAGEMENT

Successful fish breeding requires efficient hatchery management. Key aspects include:

Water Quality Management: Ensuring optimal water parameters such as temperature, pH, dissolved oxygen, and ammonia levels.

Broodstock Nutrition: Providing balanced diets to broodstock to enhance reproductive performance.

Disease Management: Regular health checks and preventive measures to control diseases.

Larval Rearing: Providing appropriate feed and environment for the larvae to ensure high survival rates.

SOCIO-ECONOMIC IMPACT

Fish breeding plays a vital role in rural development and poverty alleviation in India. It provides livelihoods to millions of people involved in aquaculture, processing, and marketing. The sector also contributes to nutritional security by providing a rich source of protein to the population.

Table 2: Socio Economic Impact

Impact Area	Description	Statistical Data
Employment Generation	Number of jobs created in rural and coastal areas due to fish breeding and associated activities	Approximately 14 million jobs
Income Augmentation	Increase in income levels of small-scale fish farmers and fishery workers	Average increase in income by 20%
Export Earnings	Foreign exchange earnings from the export of fish and fish products	Export earnings of $7.08 billion (FY 2020-2021)

This table illustrates the socio-economic impact of fish breeding in India. It highlights the contributions to employment, income augmentation, and export earnings. The data emphasizes the importance of the fish breeding sector in improving the livelihoods of rural communities and boosting the national economy.

CHALLENGES AND FUTURE PROSPECTS

Despite its growth, the fish breeding industry in India faces several challenges:

Environmental Degradation: Pollution and habitat destruction affect breeding grounds.

Climate Change: Changes in temperature and rainfall patterns impact fish breeding cycles.

Disease Outbreaks: Viral, bacterial, and parasitic infections pose significant threats to fish populations.

Resource Constraints: Limited availability of quality broodstock and hatchery facilities.

To address these challenges, ongoing research and development are crucial. Innovations in breeding techniques, genetic improvements, and sustainable practices are essential for the future growth of the industry.

CONCLUSION

Fish breeding in India is a dynamic and evolving field with immense potential. By leveraging scientific advancements and sustainable practices, the industry can continue to thrive, contributing to the country's economic growth and food security. Collaborative efforts between

government, research institutions, and the private sector are key to overcoming challenges and ensuring the long-term success of fish breeding in India.

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Chapter 19

EFFECT OF PH ON BINDING POWER OF HEMOGLOBIN: AN OVERVIEW OF BOHR EFFECT

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ABSTRACT

Hemoglobin is an iron contain complex protein. In deoxyhemoglobin iron atom is present in high spin Fe (II) oxidation state and lies about $0.5A^0$ above the plane contain porphyrin ring and form dome shaped structure. It is paramagnetic due to the presence of unpaired electron in Fe (II). When an oxygen molecule binds to the iron atom from its sixth coordination site. It oxidizes to low spin Fe (III) state. Such oxidized consist of smaller radius in comparison Fe (II). This low spin oxidation state forms the trigger of cooperativity phenomenon. The binding power of hemoglobin is P^H dependent and decreases with decrease in pH.

KEYWORDS: Hemoglobin, Cooperativity, Oxygen Transport, Bohr Effect.

INTRODUCTION

Hemoglobin is a complex protein having molecular weight is of about 64500. It plays a significant role in the oxygen transport from the lungs to the tissues and the return transport of carbon dioxide from the tissues to the lungs. It is an iron-containing bio-molecule that is essential for the survival of aerobic organisms. Hemoglobin is a tetrameric protein[1], composed of four polypeptide chains in which two chains are alpha (α) and other two are beta (β) chains. Each chain is associated with a heme group, which is responsible for binding oxygen. The heme group consists of a porphyrin ring with a central iron (Fe^{2+}) atom as shown in fig (1). The ability of hemoglobin to bind and release oxygen is central to its function. This process is governed by the partial pressure of oxygen (P^{O_2}) and the cooperative binding mechanism. The quaternary structure[2] of hemoglobin allows it to undergo conformational changes that are essential for its function. The two major conformations are the T (tense) state, which has a lower affinity for oxygen, and the R (relaxed) state, which has a higher affinity for oxygen. The transition between these states is critical for hemoglobin's ability to pick up oxygen in the lungs and release it in the tissues.

The binding of oxygen to one heme group as shown in fig (2), increases the affinity of the remaining heme groups for oxygen. The process is known as cooperative binding and is described by a sigmoid oxygen dissociation curve[3]. In addition to transporting oxygen, hemoglobin plays a vital role in transporting carbon dioxide, a waste product of cellular

respiration, from the tissues to the lungs. The Bohr Effect[4] describes how pH and carbon dioxide concentration influence hemoglobin's affinity for oxygen. Approximately 10% of carbon dioxide binds directly to hemoglobin, forming carbaminohemoglobin[5]. The remaining carbon dioxide is transported as bicarbonate ions (HCO_3^-) in the blood.

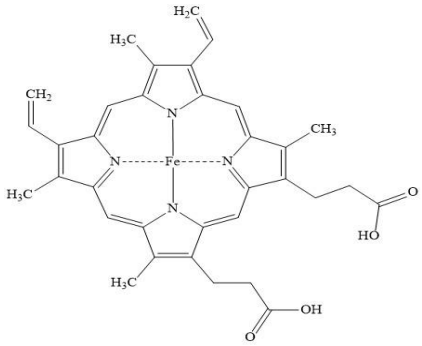

Fig. 1: Structure of hemoglobin

The enzyme carbonic anhydrase[6] catalyzes the reversible reaction between carbon dioxide and water to form carbonic acid (H_2CO_3), which dissociates into hydrogen ions (H^+) and bicarbonate ions. Hemoglobin buffers the hydrogen ions, which helps maintain blood pH within a narrow range. Hemoglobin also interacts with nitric oxide (NO), a signaling molecule involved in vascular regulation. NO binds to the heme iron in hemoglobin, forming a nitrosyl-hemoglobin[7-8] complex. This interaction plays a role in the regulation of blood pressure by modulating vasodilatation. However, the exact mechanisms by which hemoglobin modulates NO bioavailability and its physiological significance are still areas of active research. Some researchers also work on

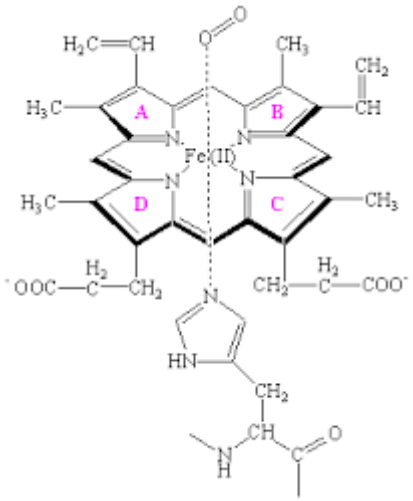

Fig. 2: Structure of oxyhemoglobin

Hemoglobin genetic disorder disease such as: Sickle cell anemia[9], which is one of the most well-known hemoglobinopathies, caused by a single point mutation in the β-globin gene. This mutation leads to the substitution of valine for glutamic acid at position 6 of the β-globin chain, resulting in the formation of hemoglobin S (HbS). Under low oxygen conditions, HbS polymerizes, causing red blood cells to assume a sickle shape, leading to various clinical

complications. Thalassemias[10] are another group of hemoglobinopathies characterized by the reduced synthesis of one of the globin chains, leading to an imbalance in the globin chain production. This imbalance results in ineffective erythropoiesis and hemolysis, causing anemia.

MECHANISM OF THE BOHR EFFECT

Hemoglobin, the oxygen-carrying protein in red blood cells, plays a significant role in transporting oxygen from the lungs to tissues and returning carbon dioxide from tissues to the lungs. The ability of hemoglobin to bind and release oxygen is not constant; it is influenced by several factors, including pH, carbon dioxide levels, and the concentration of 2, 3-bisphosphoglycerate (2, 3-BPG). Among these, pH plays a significant role in modulating hemoglobin's oxygen-binding affinity, a phenomenon known as the Bohr Effect. It is a physiological phenomenon where increase in acidity (a decrease in pH) leads to a decrease in hemoglobin's oxygen-binding affinity. Conversely, decrease in acidity (an increase in pH) results in an increased oxygen-binding affinity. This effect is crucial for the efficient delivery of oxygen to tissues that are metabolically active and producing carbon dioxide, which lowers pH. Hemoglobin, is a tetrameric protein composed of two alpha (α) and two beta (β) subunits. Each subunit contains a heme group, which binds one molecule of oxygen. The binding and release of oxygen involve conformational changes between the "tense" (T) state and the "relaxed" (R) state of hemoglobin. In the T state, hemoglobin has a lower affinity for oxygen. When pH decreases, there is an increase in hydrogen ion concentration, leading to the Protonation of specific amino acid residues in hemoglobin. Key residues involved in this process include histidine residues in the β-subunits. Protonation stabilizes the T state of hemoglobin, reducing its affinity for oxygen and promoting oxygen release. Carbon dioxide (CO_2) produced by metabolically active tissues also contributes to the Bohr Effect. CO_2 can react with water to form carbonic acid (H_2CO_3), which dissociates into bicarbonate (HCO_3^-) and hydrogen ions (H^+).

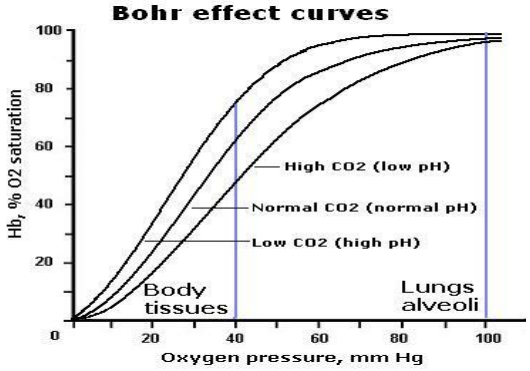

Fig. 3: Bohr Effect curves

This reaction further lowers the pH in tissues, enhancing the Bohr Effect and facilitating oxygen release. Additionally, CO_2 can directly bind to the N-terminal amino groups of hemoglobin, forming carbaminohemoglobin, which also stabilizes the T state. The Bohr Effect is vital for ensuring that hemoglobin efficiently delivers oxygen to tissues with high metabolic rates. In actively respiring tissues, the production of CO_2 and the resultant decrease in pH shift the

oxygen dissociation curve of hemoglobin to the right as shown in Fig (3), meaning more oxygen is released at a given partial pressure of oxygen (pO_2). This rightward shift is essential for meeting the oxygen demands of tissues during periods of intense activity.

CONCLUSION

Understanding the chemistry of hemoglobin not only provides insights into its physiological roles but also underpins the study of various blood disorders and therapeutic interventions. The ability of hemoglobin to bind and release oxygen is not constant; it is influenced by several factors, including pH, carbon dioxide levels, and the concentration of 2, 3-bisphosphoglycerate (2, 3-BPG). Among these, pH plays a significant role in modulating hemoglobin's oxygen-binding affinity, a phenomenon known as the Bohr Effect.

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