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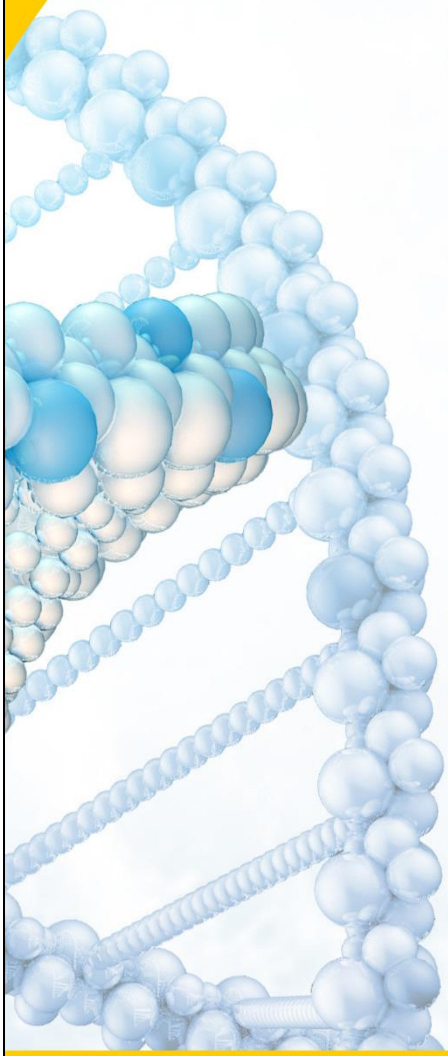
RECENT TRENDS OF INNOVATIONS IN CHEMICAL AND BIOLOGICAL SCIENCES VOLUME V



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RECENT TRENDS OF INNOVATIONS IN CHEMICAL AND BIOLOGICAL SCIENCES

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Title: **RECENT TRENDS OF INNOVATIONS IN CHEMICAL AND BIOLOGICAL SCIENCES (VOLUME-V)**

Editors: **Dr. Bassa Satyannarayana, Mr. Mukul Machhindra Barwant, Kamireddy Mahalaxmi**

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PREFACE

Chemical sciences and Biological science play an important role in the evolutionary concept of the living world. This book Recent Trends Innovation Chemical and Biological Science: An Approach towards Qualitative and Quantitative Studies and Applications is a considerable effort taken by different authors in the discipline to provide new methodologies of research, its applications, and practical inducements of chemical sciences and Biological Science. The various themes in the book such as application of biological organisms, ethnomedicinal used in different human disorder, biological activity of Indian medicinal plants, Ethnobotanical study, Ecofriendly energy, Transplastomic plants, Role of Sacred Groves in Biodiversity Conservation, Medicinal property rich plants comphora and Different traditional parts in India its application. It covers topic from environment science like effect of toxic chemical on environment. Also covered point from pharmacognosy like as the pharmacological property of Euphorbiaceae. It cover topic like phytochemistry biochemistry and active ingredients Indian medicinal plants.From chemical science subject like organic and inorganic and as well as applied chemistry included such as the Inorganic Metal Oxide-Polymer Nanocomposites For Near Infra-Red, Qsar: A Useful Tool Of Computational Chemistry For Designing New Drug And Predicting Their Biological Activities It also cover there under medicinal and computational chemistry This book acts as an intermediary manual between Chemical sciences with other disciplines paving a way for ideas to new research in the respective arena. The experiments described in the boom chapters are such as should be performed by everyone beginning the study of chemistry, and would also serve as an excellent introduction to a course of qualitative and quantitative analysis. All scientists, academicians, researchers, and students working in the fields of chemistry, biology, physics, materials science, and engineering, among other fields, will find this book quite valuable.

This book with valuable book chapters from eminent scientists, academicians, and researchers will surely be a part of almost information for the coming new research taken by the researchers in the field of chemical sciences and other disciplines in the future.

Dr. Bassa Satyannarayana

Mr. Mukul Machhindra Barawnt

Kamireddy Mahalaxmi

TABLE OF CONTENT

Chapter 1

ENVIRONMENTAL CHEMISTRY- AN OVERVIEW

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ABSTRACT

Environmental chemistry is a fast-developing science aimed at deciphering fundamental mechanisms ruling the behavior of pollutants in soil, air and aquatic ecosystems. Remediation of environmental media and to new, low energy, low emission, and sustainable processes can be made by applying the above knowledge to the current environmental issues. Chapters review analyses how the chemicals enter the environment, their effects, chemical fate, the response of living organisms in that particular environment in air, water, plant and soil. Several highlights include the overlooked impact of chemical pollutants from industries and other sources that affect the environment is discussed below.

KEYWORDS: Aquatic ecosystem, Sustainable, Chemical pollutants, Environment

INTRODUCTION

Environmental chemistry is known as study of the sources, reactions, transport, effects and the fate of chemical species in the air, soil, and water environments and the effect of human activity and biological activity on the environment. It is a branch of science that deals with atmospheric aquatic and soil chemistry. It involves with the understanding of the influence of chemicals on environment, mostly about the chemical concentrations, composition and its effect on the environment. Environmental chemists draw a range of concepts from chemistry to study the effect of a chemical species in the environment.

AQUATIC ENVIRONMENT AND CHEMISTRY

The water bodies are very vast and are very deep that the chemicals from various sectors and actives let into the ocean bodies are negligible. Integrating environmental chemistry with ecotoxicology, we use advanced analytical approaches in laboratories and field experiments to generate novel insights and understanding necessary for preserving and restoring aquatic ecosystem. Experimental responses determined from the gene level to the population level and results show a major relevance in water quality and its management.

Figure 1: aquatic environment

SEEPING OF CHEMICALS INTO WATER ENVIRONMENT

Around 70 percent of the environment is composed of marine system. Recent studies show that the marine system is highly polluted by various human made pollutants. Rivers act as a bridge between the pollutants and the marine body. Various wastes and chemicals in different forms are being carried out by rivers from land to ocean. The main reason being run off, the industrial and agricultural run offs which has a high content of nitrogen and phosphorus, affect the ecosystem of the ocean. The high concentration of these chemicals influences the organismal growth of the marine system. They give rise to a condition called algal bloom where growth of large number of unicellular algae is observed. These algal blooms create a dead zone by consuming the oxygen in that area and make it unsuitable for the marine organisms to live in that particular area. This causes severe change in the balance of the marine ecosystem.

EFFECT OF CHEMICALS IN AQUATIC ENVIRONMENT

Most of the marine ecosystem is already considered to be endangered. When the pollutants destroy any one of the organisms in the marine system it ends up altering the overall food chain of the system which in turn begins to destroy other lives in the marine system. Because of which the overall balance of the marine ecosystem is completely distressed.

Most of the chemicals in the aquatic environment very much end up in the system of an organism which leads to the death of the organism and we can also notice the evolution of an organism due to the presence of these chemicals. These chemicals also get settled in the water beds which are a breeding place for most of the organisms. It also disturbs the natural habitat of the aquatic animals. Few organisms adapt themselves to live with the chemicals present in their environment but most of the organisms die due to the presence of the toxic chemicals. Apart for animals' plants also suffer due to these chemicals. They undergo modifications physically as well as genetically and continue to successfully retain in the environment showing survival of the fittest. The chemicals ingested in the ocean are consumed by marine organisms which then affect human bodies when they are consumed by humans.

KILLIFISH (A CHEMICALLY EVOLVED SPECIES)

Killifish is a small fresh water fish. They are found in some of the most polluted water bodies of United States. According to a study led by the University of California, these fishes have evolved by genetic mutation which has resulted in them being tolerant to the usual lethal doses of pollutants.

Since their population is very high, they are highly capable of undergoing various genetic mutations which is not possible for species with lesser population.

Figure 2: Killifish

THE ATMOSPHERE

We live and breathe in the atmosphere, a sea of gas consisting primarily of elemental oxygen (O_2) and nitrogen (N_2), with significant amount of water vapour, carbon dioxide (CO_2) the noble gas argon and trace quantities of other gases. Unlike ocean with its well-defined volume and surface, the atmosphere extends for many kilometres from Earth's surface, becoming less dense with increasing altitude. The air becomes thinner and thinner with increasing altitude and there is no definite altitude that differentiates where the atmosphere ends and outer space begins.

Atmospheric air consists of 78.1% nitrogen, 21.0% oxygen, 0.9% argon, and 0.03% carbon dioxide. 1-3% of air is made of water vapour. Various gases in air are present at trace levels of around 0.002% such as neon, helium, methane, krypton, nitrous oxide, hydrogen, xenon, sulphur dioxide, ozone, nitrogen dioxide, ammonia and carbon monoxide. Oxides of carbon, sulphur and nitrogen are important constituents of the atmosphere, and are pollutants at higher levels. The most abundant hydrocarbon is methane, CH_4, released from underground sources as natural gas and produced by the fermentation of organic matter.

Figure 3: Atmosphere from outer space

IMPORTANCE OF THE ATMOSPHERE

There are many layers in the atmosphere like troposphere, stratosphere, mesosphere; thermosphere prevents the entry of various harmful cosmic rays that affect the living organisms. It allows electromagnetic waves ranging from 300-2500nm and absorbs the rest of the radiations. Ultraviolet radiations that are considered to be very harmful for living organisms are being absorbed by these atmospheric layers. Absorbed solar energy is re-emitted to space because the atmosphere reabsorbs much of the infrared radiation; the atmosphere stabilizes Earth's temperature, preventing the tremendous temperature extremes that occur on planets.

STRATIFICATION OF THE ATMOSPHERE

The atmosphere is divided into different layers based on the temperature/density relationship.

The lowest layer of the Earth's atmosphere is troposphere ranging from the surface of the earth to the height of 8 to 18 Kms in altitude. Air is warmer at the bottom of troposphere and gets colder as the altitude increases. With increase in altitude, the air pressure and density also decrease. Most type of climate changes occur in this region.

Stratosphere is the second layer in the atmosphere next to troposphere. This layer ranges around 50 Km from the earth's surface. This layer consists of Ozone, a type of oxygen molecule, which absorbs the Ultraviolet radiations coming from the sun. Since it absorbs energy from the UV rays, this layer has increased temperature. This layer of atmosphere contains very little water vapour.

Mesosphere is the layer found next to stratosphere. It ranges from 50 to 85 Kms from the earth's surface. There is very little information about this layer, the temperature decreases with increase in altitude in this layer.

Thermosphere is the next layer above mesosphere. Ionosphere and exosphere are the other atmospheric layers.

CHEMICAL AND PHOTOCHEMICAL REACTIONS IN THE ATMOSPHERE

Unpolluted atmosphere, polluted atmosphere and a range in between them comes under atmospheric chemistry. The same general phenomenon governs all, and produces one huge atmospheric cycle in which there are numerous sub cycles. Gaseous atmospheric chem2ical species fall into the following somewhat arbitrary and overlapping classifications: inorganic oxides, oxidants, reductants, organics, oxidized organic species, photo chemically active species, acids, bases, salts and unstable reactive species. Both solid and liquid particles in atmospheric aerosols and clouds serve as sources and sinks for gas-phase species, as sites for surface reactions and as bodies for aqueous-phase reactions.

SOIL ENVIRONMENTAL CHEMISTRY

Soil chemistry is the study of characteristics of soil. Soils are mixture of heterogeneous components such as air, water, inorganic and organic solids, and microorganisms. Soil chemistry deals with the chemical reaction associated with these stages. Soil chemistry has traditionally focused on the chemical reactions in soil that affect plant growth and plant nutrition. However, in the 1970s and certainly in the 1990s, as concerns grew about inorganic and organic pollutants in water and soil and their effects on plant, animal, and human health, the emphasis in soil chemistry now shifted to environmental soils. On chemicals. It is the study of chemical reactions between soil and environmentally important plant nutrients, radionuclides, metals, metalloids and organic chemicals.

Figure 4: Soil environment

CONTAMINANTS IN SOIL

There are many inorganic and organic pollutants that are important in soil. These include plant nutrients such as nitrates and phosphates; heavy metals such as cadmium, chromium and lead; oxygen such as arsenite, arsenate and selenite; Organic chemicals; inorganic acid; Radionuclides. Sources of these contaminants include fertilizers, pesticides, acid deposition, agricultural and industrial waste materials, and radioactive fallout.

HAZARDOUS WASTES

The disposal of hazardous wastes and their effects on human health and environment are important topics that are to be discussed. These include mining waste, waste from paint and allied industries, pesticide use, inorganic fertilizers and municipal solid waste. A solid waste comes under hazardous waste.

SOIL DECONTAMINATION

Several attempts are being made to decontaminate contaminated soils using an array of both in-situ and non-in-situ techniques. None of these is a panacea for remediation of contaminated soil and often more than one technique may be needed to optimize the clean-up effort. The complexity of soils and the presence of many pollutants also make remediation efforts difficult and costly.

IN SITU METHODS

In situ methods are used in the area of contamination, therefore the soil in that area need that be removed.

- **Biodegradation:** *In situ* biodegradation involves the growth of naturally occurring microorganisms by stimulating their number and activity. The microbes then help break down the pollutants in the soil. It is important to realize that a microbe may be effective at reducing one form of a specific contaminant nut and not another.
- **Phytoremediation:** The use of plants to disinfect soil and water can be quite effective. There are hundreds of plant species that can remove pollutants. For example, sunflower can absorb Uranium, some ferns have high affinity for As, alpine herbs absorb Zn.
- **Leaching:** This method involves leaching soil from site to site with water and often with a surfactant to remove contaminants.

- **Vitrification:** In in-situ vitrification, contaminants are coagulated with an electric current, resulting in their immobilization. Vitrification can stabilize pollutants for up to 10,000 years. Since a large amount of electricity is required, this technique is expensive
- **Isolation:** With this method contaminants are kept in place by installing subsurface physical barriers such as soil liners and slurry walls to reduce lateral migration

CONCLUSION

Major of the environmental issues is caused by human and human made activities. The level of the pollutants affecting the atmosphere, soil and aquatic environment are increased by such activities. Exposure of humans and other living organisms in these polluted environments may lead to various adverse health issues. People must be aware of the increasing pollutants like carbon monoxide, lead, nitrogen oxides and ozone that affect the atmospheric environment leading to various respiratory illnesses. Phosphorous and nitrogen containing runoff waters affect the soil and the aquatic environment leading to undesired growth on the surface. Minimizing the usage of these chemicals will reduce the further contamination and pollution making it suitable for further use.

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Chapter
2

SUSTAINABLE AGRICULTURE: ESTABLISHING ECO-FRIENDLINESS

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ABSTRACT

The world's most significant industry is agriculture. Agriculture is the practice of growing plants and rearing domesticated animals to provide food, feed, fiber, and other desirable items. In a true sense, it is a productive unit where people receive the free gifts of nature—land, light, air, temperature, rainwater, humidity, etc.—all of which are combined into a single basic unit that is essential for humans. Long-term and excessive chemical use in crop cultivation has led to risks to human health, degradation of the environment, and contamination of ground water. The current debate centers on whether to stick with chemical input-intensive technology or return to more environmentally friendly agricultural methods like organic farming for sustained. Pesticides are assessed in agrology for having the fewest possible adverse environmental impacts. Germicidal, antibiotic, antibacterial, antiviral, antifungal, antitrotozaol, and antiparasite chemicals are examples of biocides. Typically, pesticides were applied as sprays or dusts. Biopesticides make up a large portion of ecological pesticides. Environmentally friendly agricultural technologies for food safety are necessary in order to provide food security, improve human health, and restore and preserve the environment for the benefit of future generations. These technologies must not harm the environment in any way.

KEYWORDS: Sustainable Agriculture, Organic farming, Environmental Impacts, Agriculture Technologies, Eco friendliness.

INTRODUCTION

Today, there is a growing understanding of the harm that industrial agriculture does to the environment. This is brought on by a number of destructive farming practices. Therefore, agricultural advancements like eco-friendly farming techniques should be used. A variety of approaches, including vermicomposting, crop rotation, green manure, animal husbandry, bio fertilizers, and biological pest management, are used in organic farming. Organic farming is a method of cultivating crops or plants using eco-friendly organic manures that sustain the life of the soil and other beneficial organisms in the soil. In developing nations, farmers have adapted the method of organic farming, which involves using animals to till the soil and creating manures from the dung and other animal waste. A farming technique that uses less non-renewable energy and requires fewer agrochemicals a sustainable method that avoids dirt and uses water sparingly.

These environmentally friendly techniques are viewed in this context as an inexpensive, renewable, biodegradable, selective, and safe option for use in organic farming systems. Organic farming refers to the use of natural plant protection techniques in place of pesticides and fertilizers, as well as the use of organic nutrients. Crop rotations, crop residues, animal manures, legumes, green manures, mineral-bearing rocks, and biological pest control methods are all used in organic farming to the maximum extent possible to maintain soil productivity, supply plant nutrients, and control insects, weeds, and other pests.

SUSTAINABLE AGRICULTURE METHODS

CROP ROTATION

It is a method of planting several crops in the same place at different times of the year in order to preserve soil fertility and keep agricultural pests at bay. The most ideal method of sustainable agriculture is cropping rotation. However, its main objective is to prevent the negative effects of repeatedly growing the same crop in the same soil. Due to the fact that many pests favour particular crops, this helps to combat pest issues. Rotation also disrupts an insect's reproductive cycle. Farmers can plant certain crops that add extra nutrients to the plants during rotation. Rotation disrupts the bugs' reproductive cycles. Farmers can plant specific crops during rotation to restore plant nutrients. These organic crops reduce the need for chemical fertilizers, nevertheless.

GREEN MANURES

Green manures are plant leaves and plant waste that are covered in soil, buried there, and then act as nutrients that improve soil fertility.

VERMICOMPOSTING

It is a method of composting that makes use of several worms, including earthworms, red wrigglers, and white worms, to prepare compost from a mixture of vegetable and kitchen waste. This is used as fertilizer in agricultural fields and is high in nutrients.

PERMACULTURE

A food production technique called permaculture was created for intelligent farming to cut down on resource waste and boost productivity. These design strategies include multipurpose plants, spiral gardens, keyhole and mandala gardens, hooglyculture garden beds, and growing grains without ploughing.

COVER CROPS

There may be unanticipated repercussions if farmers always grow crops in the same land and never leave it barren. The farmer can accomplish his objectives by planting cover crops like clover or oats, which will reduce soil erosion, improve soil quality, and restrict the growth of weeds. Additionally, the use of cover crops minimizes the demand for fertilizers and other chemicals.

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SOIL ENRICHMENT

The agricultural ecosystem's core element is soil. Stronger crops can be produced as well as higher yields with the aid of good soil. The quality of the soil can be improved and maintained in a number of ways. Examples include using composted plant material or animal manure, as well as releasing agricultural wastes back into the ground after harvest.

NATURAL PEST PREDATORS

It is essential to consider the farm as an ecosystem rather than a factory in order to maintain successful pest control. As an illustration, numerous animals and birds are innate predators of agricultural pests. Manage your farm accordingly so that it can support populations of these bug predators. Chemical pesticides, however, run the risk of indiscriminately killing insect predators.

BIO INTENSIVE INTEGRATED PEST MANAGEMENT

An approach called integrated pest management relies more on biological than chemical techniques. Crop rotation is emphasised by the integrated pest management as a key strategy for managing pests. Integrated pest management will make sure that chemical remedies are only utilised as a last resort once the pest problem has been recognised.

POLYCULTURE FARMING

Crop rotation, which seeks to use natural principles to produce the best yield, is a farming practice comparable to polyculture. As a result, it practices agricultural farming in a single area using various crop species. Additionally, these species typically work well together and support each other in producing a wider range of goods on the same plot while utilizing all of the resources. Since there is a lot of biodiversity, the polyculture sustainable farming system is more adaptable to seasonal changes.

AGROFORESTRY

Farmers in dry areas with soils susceptible to desertification now have a powerful tool in agroforestry. Along with growing crops or grazing area, it also engaged in agriculture and the growth of trees and plants. And when done sustainably, forestry techniques are the best means of ensuring long-lasting, fruitful, and diverse land uses.

BIODYNAMIC FARMING

Based on the "anthropology" principle, biodynamic farming integrates holistic and ecological growth techniques. Additionally, it emphasizes putting measures like composting animal manure application, supplemental crops, or rotating cover crops into use. Additionally, these methods produce the soil fertility required for food production.

BETTER WATER MANAGEMENT

The first step in water management is selecting the proper crops. Local crops that are suitable to the local climate are also chosen. Additionally, dry areas should choose crops with low water requirements.

ROLE OF SUSTAINABLE AGRICULTURE

Modern Agri-tech companies may play a significant role in enhancing farmer income, empowering farmers, promoting sustainable agricultural practices, reducing crop losses, and deepening domestic and international market links.

India's agriculture industry is at a turning point in its evolution. The most notable period in Indian agriculture was the green revolution, which was characterized by intense contemporary farming methods, high yielding variety (HYV) seeds, and fertilizers. However, with growing global and Indian concerns about food safety and sustainable agriculture, it is essential to rethink how India's agro industry will develop in the future.

Since 42% of the workforce in India relies on the agricultural industry for their primary source of income, agriculture is frequently referred to as the foundation of the Indian economy. Its importance to the national economy is demonstrated by the 19.9% GDP contribution.

As one of the oldest and most labor-intensive businesses in the world, farming demands innovation and resilience not only to increase production but also to ensure the sector's overall sustainability. Without a doubt, COVID-19 has made reforms in the agricultural sector even more necessary.

Over the past ten years, horticulture—the largest subset of agriculture—has experienced consistent development. It already makes up 30% of the GDP in agriculture and will keep expanding.

The overall Agri-policy framework for India has continuously given horticulture a high priority. Consequently, it is predicted that overall horticulture production will reach 327 million tonnes in 2020–21, an increase of nearly 6 million tonnes from 2019–20, and will overtake cereal production by a wide margin. However, the adverse impact of climate change creates a disproportionate impact on this critical sector.

The unpredictable weather brought on by climate change makes production more challenging. This results in increased usage of pesticides and other chemicals, which furthers environmental degradation and starts a vicious cycle. At the same time, markets and consumers are become increasingly more aware of the need of sustainable farming practices, safe and hygienic food processing, and food safety. For instance, food traceability is quickly gaining ground. With such advanced technology, consumers may find out more about who, where, and when the crop was grown. They can also get information on the footprint of the crop's trip from pre-harvest to the market shelf.

This makes it possible for customers to distinguish between "safe food" and "unknown fruit," which opens up a market opportunity that is essential to guaranteeing that farmers may receive fair returns and rewards for implementing and adhering to sustainable practices. The most important factor in connecting consumers' needs for "safe and sustainable food" with farmers' ability and desire to produce it is the supply network between farmers and consumers. It may be the only way to stop the vicious cycle and begin a virtuous one as well. Not only is production system transparency essential for gaining consumer trust, but contemporary technology makes it simplest and most effective to reduce supply chain waste (we will need to manufacture 25% less). Thus, the solution to one of the largest problems that humanity is currently facing is integrated value chains from farmers to consumers. These interconnected value chains have already had a favorable impact. For instance, the changes to the banana value chain over the past ten years have shown us the way. In spite of not participating in international commerce a decade ago, India is now the world's largest producer of bananas, accounting for approximately 25% of total production.

The absence of infrastructure, poor quality standards, and inadequate farm-level production processes were to blame for this. The exports of this value chain have steadily increased to over 300,000 tonnes annually, making it India's largest fruit export in terms of volume. This requires extensive training of farmers in order for them to embrace modern methods, deploy a drip irrigation system that uses 100% less water, increase production by 30%, and meet international requirements for food safety and quality. Shelf life was extended by over 50% through the development of infrastructure, complete traceability, and packaging advancements. As a result, organizations exceeded any global benchmark and reduced wastes to below 2%. And all of this was accomplished by substantially raising the income of farmers.

As more and more Agri-tech companies and innovative businesses emerge, the technologies and creativity needed to create sustainable food production and consumption will continue to advance. The good news is that we already have solutions that will dramatically enhance sustainable production methods for people and the environment.

Ingenious packaging, cold chain infrastructure, increased use of organic fertilizers, and modern package of practices leading to safe food are all here and now. Drip irrigation systems resulting in water conservation, safer chemicals, precision agriculture, increased use of organic fertilizers, and improved transportation resulting in minimal wastages are also here and now.

Furthermore, the shifts in consumer tastes result in the creation of demand and compensation for sustainable activities.

The agriculture industry needs to be reoriented from a production-driven to a demand-driven, sustainable farming approach on a wide scale. This will require the development of adequate Agri-reforms and incentive systems to encourage farmers to embrace sustainable practices. In India, the prospects for promoting sustainable agricultural methods are currently improving. Modern Agri-tech companies may play a key role in enhancing farmer income, empowering farmers, promoting sustainable agricultural practices, reducing food wastages, and more. Crop loss can be reduced and problems can be lessened with the help of technologically driven agricultural interventions and improved climate forecasting capabilities.

Additionally, our dedication to control and improve agricultural output, maximize farmer income, and increase public knowledge of food safety will guarantee the sector's long-term viability.

ADVANTAGES OF SUSTAINABLE AGRICULTURE

- Nutrition

- Free from chemicals
- Quality food
- Long Time Store Organic food has the capability of longer time storage due to its Metabolic and structural integrity in their cellular
- Low input cost expenditure

In the modern world, the majority of food consumed contains hazardous chemicals that are unintentionally or purposely causing a variety of ailments. This can be decreased through sustainable agriculture. If this trend continues, agricultural land will become unusable and future generations would struggle to meet their food needs and be unable to produce high-quality food. The majority of farmers use traditional agriculture in order to achieve high yields and rapid results, but this method gradually reduces the soil's fertility, and if this kind of behaviour is not stopped, the land will no longer be suitable for farming. In order to prevent such a significant issue, sustainable agriculture practices help the soil to remain healthy.

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Chapter
3

A REVIEW ON VALORISATION OF FOOD WASTE AND BY PRODUCT UTILIZATION

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ABSTRACT

Food wastes have been an issue of common interest for the stockholders in food industry viz. producers, processors, retailers, and consumers in recent years. Food waste is the potentially consumable food or the inedible parts of the food that are consciously discarded by the consumers or the retailers during various phases of food processing. Food waste is seen as an environmental, social as well as economic issue. It has created several environmental degradations and also depletion of several natural resources. Because of its ramifications for the economy, the environment, and ethics, waste behavior is inherently social. Food waste has a variety of negative effects but it also presents a large number of opportunities. Some of the important as well as economical applications of waste valorization include- development of novel functional food ingredients as well as bio-refinery products like biofuels, biomass and bio-fertilizers. In the present review we have discussed various aspects of food waste and their reutilization.

KEYWORDS: waste valorization, byproducts, environmental, social and economic impact.

INTRODUCTION

A large amount of waste is produced during agricultural production and agro-industrial processing and it has negative impact on the environment (Leon *et al.,* 2018). Food wastes are typically solids and liquids (wastewater) left over when food is processed from agriculturally sourced raw materials. Over the past few decades, the significance of food loss and food waste has increased tremendously (Gustavsson *et al.,* 2011; Corrado *et al.,* 2019). Across the whole food supply chain, more than 1.3 billion tonnes of food are wasted each year, which is nearly one-third of the world's production of food for human consumption and more than one-quarter of the world's agricultural output (FAO, 2013; International Food Policy Research Institute, 2019). The rapid increase in global population and food consumption patterns are considered as the main causes of food loss and waste (Kannah *et al.,* 2020).

Cereals and pulses, fruits and vegetables, meat and animal products, roots, tubers, and oil-bearing crops are the principal dietary types that contribute to nutrient as well as food waste or loss (FAO, 2019, Chen *et al.*, 2020, Rao *et al.*, 2019).The global yearly food waste is made up of 30% of cereals, 40%–50% of root crops/fruits/vegetables, and 20% of oilseeds, .Food waste is produced across the food chain, including 42% in households, 38% in food processing, and 20% in other activities, without taking agricultural food losses into account. Municipal solid waste is primarily generated from kitchen and yard garbage. Instead of being dumped and placed in landfills, this garbage can be used for the conversion of valuable products or energy generation at a very low cost (Hansen, 2006). When the food supply chain is taken into account, the beverage industry generates 26% of the food waste. Dairy and ice cream production accounts for 21.3%, fruit and vegetable production and preservation accounts for 14.8%, grain and starch product manufacturing accounts for 12.9%, meat production, processing, and preservation accounts for 8%, production and preservation of vegetable and animal oils and fats accounts for 3.9%, production and preservation of fish and fish products accounts 0.4% and other food product manufacturing accounts for 12.7% (Baiano, 2014). The consequences of food waste can be summarized in fig-1.

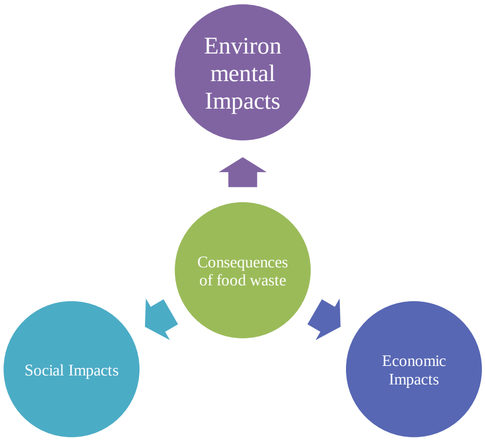

Fig. 1: Consequences of food waste (FAO, 2019)

Although food waste causes several negative impacts however, it also offers ample number of potentialities. This review emphasizes the treatment of food wastes and utilization of the food waste as different by-products.

Food loss and waste reduction are important ways to reduce production costs and increase food system efficiency, as well as to contribute to environmental sustainability (Bárbara *et al.*, 2021).

CURRENT APPLICATIONS OF FOOD BY-PRODUCTS AND FOOD WASTES

The waste generated from food is a significant source containing complex carbohydrates, lipids, proteins, phytochemicals and different pigments like carotenoids, anthocyanins etc. The potential health benefit of food waste relies on the contents of biologically active compounds (Ravindran *et al.*, 2015, Dueñas et al.,2020). The discarded food has a very high potentiality in terms of nutrient loss and world hunger rate and even it might theoretically provide millions of people with the nutritional gap (Conrad *et al.*, 2021).

Table 1: provides an overview of prospective uses for high added-value compounds derived from Agri-food wastes and byproducts as well as technical factors to consider for efficient utilization (Ben-Othman *et al.*, 2020)

Types of Food Processing Sector	Food Waste and by-products	Technological Development	Applications
Fruit and vegetables Processing	Peels, Pulp, Pomace, Stalk, leaves, Seeds, enzymes, antioxidants, polyphenols, pectin (Mazumdar *et al.*, 2021)	Drying, Solid State Fermentation with microbes as pretreatment methods. Ultrasound and microwave assisted extraction, Pressurized liquid extraction, Supercritical CO_2 extractions as Green extraction techniques.	Novel Functional food ingredients Has a great potential for being transformed into valuable products like enzymes, ethanol, and bio colors because of the high presence of cellulose, hemicellulose, pectin, minerals, and vitamins (Sharma *et al.*, 2016).
Dairy industry	Whey, dairy sludge's and wastewater (Ahmad *et al.*, 2019)	Micro and nano-filtration Aerobic and anaerobic treatments Recent biotechnological processes	Can lead to key industrial products such whey-derived goods, bio plastics, biofuels, and bioenergy as well as organic acids, bioactive peptides, enzymes, and more (Ahmad *et al.*, 2019).
Animal products Processing	blood, skin, horns, bones, viscera	Solid state fermentation, enzymatic hydrolysis	Animal blood has long been used to make blood sausages, blood pudding, biscuits, bread. It is also employed for non-food products such binders, feeds, and fertilizers. Food contains blood as a nutritious ingredient, an emulsifier, a stabilizer, a clarifier, and an additive for colour (blood meal). It is a great source of most trace minerals and is used as a protein supplement, milk alternative, lysine supplement, or vitamin stabilizer (Kulkarni *et al.*, 2015).

Fish and seafood products Processing	Skin, fish bones and viscera, Fish oil, fish protein hydrolysates	Solid state fermentation, enzymatic hydrolysis	Used for production of functional foods, nutraceuticals, antifreeze substances, surimi, fish protein hydrolysates, fish protein concentrates, fish enzymes, gelatin, collagen, carotenoids, chitin, chitosan, glucosamine, and fermented fish products (Kim *et al*., 2014).

Besides some other applications includes bio-refinery products like biofuels, biomass, bio-fertilizers and also chemicals are obtained from the bio-technological transformation of different other food wastes and by-products as an outcome of anaerobic digestion, fermentation and composting technologies (Nayak *et al*., 2019).

FUTURE PERSPECTIVES AND CONCLUSION

Food waste management is a major issue around the world, and new approaches and processes are being created and implemented in an effort to lessen their impact while boosting the value of food by-products. Even so, a small percentage of works included safety evaluation investigations such physicochemical/quality, microbiological and/or pollutants determination, despite the fact that safety concerns are becoming more and more prevalent in this field. The findings showed that the development and deployment of these techniques require more than only the evaluation of the enrichment of components that promote health or the manufacture of new products with superior features employing by-products. A lot of work needs to be put into developing effective processes that provide adequate processing without jeopardizing the safety of the finished products, as well as methodologies that allow the selective and sensitive determination of any hazardous substance.

In addition, the use of fresh approaches to confirm the security of these novel by-products and the end items made from them is essential in this field of study. In this regard, new global strategies such as Foodomics combined with new cellular models to investigate toxicity, without using animals, can also play an interesting role, since they can provide details about the substance (or substances) responsible for toxicity and at which level of expression is impacting by utilizing transcriptomics, proteomics, and/or metabolomics techniques (Acunha *et al*., 2018)

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Chapter 4

EFFECT OF PESTICIDE ON ENVIRONMENT AND HUMAN HEALTH

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ABSTRACT

This chapter examines the numerous types of pesticides, their hazardous action, and the various routes through which they contaminate our land, water, and air. Pesticide is a general word that describes numerous groups of insecticides, Fungicides, herbicides, garden chemicals, household disinfectants and rodenticides that are operated to both destroy and protect from pests (He, 1994, Eldridge, 2008, El Nemr *et al.*, 2012, El Nemr *et al.*, 2012). The continued use of pesticides worldwide, however, could have negative effects on ecosystem and human health. This condition makes it even more urgent to create pesticide formulations helped by nano-biotechnology that are very effective and have minimal adverse effects. Several biological and physicochemical mechanisms, such as microbe-based degradation and sophisticated oxidation processes, may be used to remove pesticide residues in the eco-system. Biotechnology alternatives to traditional pesticides are highlighted (Nehra, M., Dilbaghi & *et al.*, 2021) society needs to adopt a new agricultural model for food production that is safer for people and the environment. (Stamatis, P & *et al.*, 2016)

KEYWORDS: Pesticides, Toxicity, Hazardous Effect of Pesticide, Human Health Effects, Health Risk Factor.

INTRODUCTION

To supply the rising demand for food and fibre, today's agro ecosystem is heavily dependent on pesticides. To improve the production, massive amounts of synthetic pesticides are used. Because 98% of sprayed pesticides impact non-target organisms directly or indirectly, this scenario poses a serious hazard to them. According to several studies, 80% of pesticides that are sprayed directly pollute the environment. The consequences of pesticides on the ecosystem, natural biodiversity, pollinators, food chains. Agro-lands' water sources are contaminated with pesticides to an extent of over 90% and soil respiration is reduced by 35% as a result of the threat to microbial life. European countries have recorded a 70% reduction in insect biomass and a 50% decline in farmland birds. Similarly, species richness decreased by 42% in North America, Europe, and Australia. Bees are harmed by pesticide a residue, which ultimately reduces their ecological value. The United Nations issued a warning that 40% of invertebrate pollinators, including bees and butterflies in particular, were in risk of going extinct on Earth.

Due to harsh weather, there has been a nearly 30% decrease in honey bee populations in American and European countries (Ali, S& *et al.*, 2021)

PESTICIDES CLASSIFICATION

Depending on their sources, chemical pesticides are divided into four categories: carbamate, organophosphate, organochlorines, and pyrethroids pesticides. A different category of pesticides known as Biopesticides, on the other hand, is made up of naturally occurring or derived substances, particularly from living creatures like plants, fungi, bacteria, etc. The three main categories of Biopesticides are plant-incorporated protectants, microbial pesticides, and biochemical pesticides.

INSECTICIDES

These are of two types

Natural - Plant based & Mineral oils, Synthetic - Inorganic & Organic

Organic divided into 4 types

1) Organochlorines -eg- DDT, BHC
2) Organophosphate eg-Malathion, Temephos. Fenthion, Dichlorvos, Fenitrothion, Primiphos methyl
3) Carbamates- Propoxur, Bendiocarb, carbaryl
4) Pyrethroids – Deltamenthrin, Cyfluthrin, Bifenthrin, Lamda cyhalothrin, Premethrin

INSECTICIDES CLASSIFICATION (Yadav & Devi, 2017)

EFFECT OF PESTICIDE ON ENVIRONMENTAL FACTOR

Water-Rain, ground water, streams, rivers, lakes, and oceans can all contain pesticides. Pesticides can enter water through four main pathways: it may move from the region where it was sprayed, It might accidently spill runoff might carry it; it might leach through the soil.

Soil -The overall biodiversity of the soil is decreased by the usage of pesticides. Without chemicals, soil quality is higher, allowing for greater water retention, which is essential for plant growth.

Plants - Pesticides contained in soil prevent nitrogen fixation, which is required for the growth of many big plants. Crop yields may significantly decrease as a result of this. **Animals** - Pesticide residues that linger on food after spraying can poison animals. Pesticide poisoning can also move up the food chain; for instance, eating insects or worms that have absorbed pesticides can affect birds.

Birds - Fungicides used in agriculture may kill earthworms, which may lower populations of the animals and birds that eat them but are only marginally hazardous to birds and mammals. Furthermore, because some pesticides are available in granular form, birds and other species may mistake the granules for food grains and ingest them. A few pesticide granules are sufficient to kill a little bird

Marine Life - Pesticide-contaminated water may affect fish and other aquatic biota. Herbicide application can kill aquatic vegetation, reducing the oxygen content of the water and suffocating fish. Fish can have behavioural and physiological changes as a result of repeated exposure to particular pesticides. (https://www.pan-uk.org/our-environment/)

RESULT AND DISSUSSION

Determine the connection between exposure to pesticide residues and semen quality. Methods used as In Sabah, Malaysia, 152 farmers took part in the study, and 62 of them had experienced varied levels of exposure to paraquat, Malathion, or both. In accordance with WHO recommendations. The relationship between semen parameters and pesticide exposure was highly significant. With a p value of 0.005, the exposed group's mean values for volume, pH, sperm concentration, motility, and WBC count were substantially lower than those in the non-exposed group. Pesticide exposure increased the likelihood of abnormal semen parameters compared to the non-exposed group, with p values less than 0.05. The findings indicated that participants who had been exposed to pesticides had significantly lower sperm quality, decreased sperm motility, and an increase in the percentage of teratospermia in subjects who had been exposed to pesticides. (Hossain, F& *et al.,* 2010) People from 14 distinct fruit and vegetable farm stations in Pakistan's Gadap (rural area) were tested for pesticide residues in their blood samples, including DDT, DDE, polytrin-C, diazinon, and monocrotophos. Liver and renal problems were reported by exposed individuals. Repeated exposure to pesticides over an extended length of time altered the normal operation of several organ systems and may have caused distinctive clinical effects like hepatitis, dyspnea, and a burning feeling in the urine. (Azmi, M. A *et al.,* 2006) the impacts of pesticides acting as endocrine disruptors, the cumulative toxicity of organophosphates and organochlorines leading to estrogenic effects. (Hernández, A. F &*et al.,* 2013) Over the past ten years, regulatory science's understanding of consumer exposure to pesticide residues has advanced quickly information tool for quantitative risk management and supporting the assessment of cumulative exposure as risk assessments continue to be developed. (Harris, C. A & etal 2001) the pesticide-exposed tobacco growers in Pakistan's district of Sawabi farmers had multiple pesticide residues above the allowable daily intake. Pesticide residues were positively linked with cytotoxic alterations brought on by excessive pesticide exposure in the hepatic and renal biochemical indicators (Khan, D. A & *et al.,* 2008) the widespread indiscriminate use of agricultural pesticides in emerging nations has undesirable side effects. The possible negative impacts on human, animal, and higher plant health from prolonged exposure. (Igbedioh, S. O. 1991). Depending on the type of pesticide many more people may be at risk of developing chronic effects (such as cancer, poor reproductive outcome, and immunological effects) (Al-Saleh, I. A. 1994) In 100 women, the transmission of organochlorine pesticides from the mother to the foetus has been investigated. The levels of organochlorine pesticides in the mother's blood, placenta, and umbilical cord blood of the same mother and child were investigated. (Saxena, M. C *et al.,* 1981) By using an electron capture detector and a gas liquid chromatograph, 50 samples of placenta and related fluid were randomly selected from women in the general population are detected. The placental tissue and ancillary fluid contained BHC, Lindane, DDT, DDE, DDD, and aldrin. Aldrin, DDE, and Lindane were more commonly found. (Saxena, M. C 1980) Gas-liquid chromatography with electron-capture detection was used to check for organochlorine pesticides in the umbilical cord blood of 100 Indian mothers who were in labour. Alpha-, beta-, and gamma-isomers of BHC as well as significant quantities of p, p′-DDT and its metabolites, p, p′-TDE and p, p′-DDE, were estimated. (Siddiqui, M. K & *et al.,* 1081) In Florida, Lindane, dieldrin, DDT, DDE, and DDD levels are examined in the fat, liver, kidney, brain, and gonads of 71 individuals. The gas chromatographic process was streamlined. Kidney, the level of dieldrin appears to rise with age; Workers in farms are those who are exposed to pesticides on the job, levels of pesticides in these workers are around twice as high as those in the general population. (Fiserova-Bergerova & *et al.,* 1967) Residues in food and drinking water. Although these risks can have short-term (e.g., skin and eye irritation, headaches, dizziness, and nausea) or long-term effects (e.g., cancer, asthma, and diabetes), (Kim, K. H.& *et al.,* 2017) 27 pesticides were examined in human milk in Jinhua, a medium-sized inland Chinese city, extraction and gas chromatography-mass spectrometer (GC-MS) detection was used. Hexachlorobenzene (HCB), hexachlorocyclohexane (HCH), and p, p′-Dichloro diphenyl-trichloroethylene (p, p′-DDE) had detection rates of 83.6%, 36.4%, and 58.2%, respectively, for OCPs. Regarding OCPs, the mean values of p, p′-DDE, Hexachlorobenzene (HCB), hexachlorocyclohexane (HCH), and p, p′-Dichloro diphenyl-trichloroethylene (p, p′-DDE) were 29.4, 32.0, and 85.2 ng/g lipid, respectively. The order of the mean levels of OCPs in human milk was p, p′-DDE>-HCH>HCB. (18) The use of arsenic compounds for things like wood preservatives started to increase in the elevated risk of cancer in people exposed to organic arsenicals in occupational and environmental settings, especially skin and lung cancer. Several pesticides have been investigated in regulatory processes for a range of acute and chronic toxicities, including the risk of cancer and birth abnormalities. Numerous organic and metal-based pesticides can also be transferred from the mother to the foetus through the placenta, possibly resulting in birth abnormalities, aberrant immune system development, and foetal mortality. (Repetto, R & *et al.,* 1996) Pesticide pollution in the environment has increased as a result of frequent and careless application. It causes up to 220,000 deaths and over three million cases of poisoning every year, mostly in developing nations. Some are extremely toxic and can be fatal if spilled on the skin, breathed, or used improperly in any other way. Pesticide exposure can have both acute and long-term effects on humans that are teratogenic, genotoxic, carcinogenic, and oncogenic. (Singh, N. S& etal 2018) determination of the pesticide concentrations in surface water points to negligible risk for estuarine creatures. ((Rodrigues, E. T& *et al.,* 2018) pesticide residue findings in grain from Kazakhstan is reported that Barley, oat, rye, and wheat samples. There were 180 pesticides, and 10 active ingredients were found. Cereal grains included banned pesticides such DDTs, -HCH, aldrin, and diazinon. (Lozowicka, B &*et al.,* 2014) Dalian's primary drinking water sources in China. The findings indicated that six heavy metals, including mercury (Hg), cadmium (Cd), copper (Cu), zinc (Zn), nickel (Ni), arsenic (As), and cadmium (Cd), as well as two pesticides (acetochlor and atrazine), and were found in water samples. (Dong, W. & *et al.,* 2020)

Insecticides, herbicides, fungicides, and fumigants are only a few of the key functional classes of pesticides whose chemicals have been found to have substantial relationships with a variety of cancer locations. (Alavanja, M. C., & Bonner, M. R. 2012) some illnesses and respiratory symptoms that have been linked to work-related pesticide exposure. People who are exposed to pesticides at work have also been found to have impaired lung function, chronic bronchitis. The link between occupational pesticide exposure and lung cancer had conflicting evidence. (Ye, M., Beach, & *et al.,* 2018). Excess cases of lung, colorectal, breast, uterine, ovary, prostate, testis, kidney, and bladder cancer were found in urban areas, while cases of stomach, cervical, penile, and skin cancer were found in rural areas. In coffee-growing regions where paraquat and lead arsenate were widely used, there were excessive amounts of skin malignancies (lip, melanoma, non-melanocytic skin, and penile cancer). (Wesseling, C & *et al.,* 1999) differential DNA methylation is linked to pesticide-induced pathogenesis of airway disease. (Van der Plaat & *et al.,* 2018)

CONCLUSION

India is an agricultural nation. In India, pesticides, herbicides, and fungicides were first utilised in the middle of the 1960. They are now widely used. Initially, the use of pesticides decreased pest attack and made space for a predicted increase in crop productivity. The pesticide residue concentrations in various season crops demonstrate that the winter veggies have the highest levels. According to the levels of pesticide residue found in vegetables from various seasons, winter vegetables are the most contaminated, followed by summer and wet season veggies long-term ingestion of such veggies can cause receptors to develop high levels of pesticide accumulation in their bodies, which can be lethal for the human population. (Lozowicka, B & *et al.,* 2014)

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Chapter
5

RECENT TRENDS IN BIOTECHNOLOGY

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ABSTRACT

Over the years, there has been significant progress in the field of agriculture, from the green revolution to the genetic revolution. There is no doubt that the use of traditional methods has greatly improved important hereditary traits, but this process can take a very long time. The recent trend in agricultural biotechnology has made it easier to achieve results in a shorter time frame. This is due to the fact that biotechnology encompasses the use of a range of scientific techniques to modify and improve the properties of various economically significant organisms. This, in turn, allows for greater access to a broader variety of genes.

KEYWORDS: Genetic revolution, agricultural biotechnology, economically significant organisms.

INTRODUCTION

It was once predicted that the most innovative advances in the 21st century will come when biology and technology work together and this is already happening, because it is biotechnology which is booming today. Biotechnology is the field of science that uses living organisms to develop novel products or improve existing ones.

Continued population growth poses a serious challenge to global food security. The world population is projected to reach 9 billion by 2050.In a world facing a global food crisis, biotechnology is making it possible to grow crops that are more resistant to pests and diseases,which can potentially produce higher yields of nutrient-dense foods that are low in toxic ingredients, that negatively impact your health.This is a major step forward in mitigating the effects of the food crisis and ensuring that everyone has access to healthy food.Agricultural biotechnology is a branch of science that uses various biotechnology tools to modify plants to improve agricultural productivity.

The rate at which biotechnology has progressed over the past few decades has been very impressive. Biotechnology tools are constantly evolving, and new techniques are being added to help plant breeders. Biotechnology tools can be used to change the sequence of DNA in a plant. DNA editing can involve altering the sequence of DNA segments, either adding or deleting pieces, or altering the function of a gene. The newer biotechnological tools make it easier to make more accurate genetic modifications of plants more quickly, which is likely to result in more successful crops.

Biotechnology is a fast-growing industry in India as it is considered the preferred destination for biotechnology; ranking 3rd in Asia Pacific and 12th globally. The purpose of this review paper is to provide an overview of recent trends in biotechnology.

CONVENTIONAL BREEDING TOOL AND BIOTECHNOLOGICAL TOOL

- Conventional plant breeding takes a long time, but biotechnological tools can help speed up the process by eliminating the need for long-term trials.
- Conventional plant breeding involves transferring both desirable and undesirable genes, which can lead to the loss of many important desirable genes. Biotechnological methods help to only transfer desirable genes, so there is no loss of genes from the original genome.
- The traditional way of breeding plants cannot create varieties that are resistant to diseases or can survive in different climates. However, by using biotechnology, it is possible to create such plants.

RECENT BIOTECHNOLOGICAL TOOLS USED IN AGRICULTURE

Biotechnological tools are used by farmers to help them grow crops that can adapt to climate change. These tools have been helping farmers for more than 20 years. The use of these tools help farmers work more efficiently and sustainably while also keeping the soil healthy. Recent biotechnological tools that are helping farmers to produce better crop varieties in an easier and faster ways are:

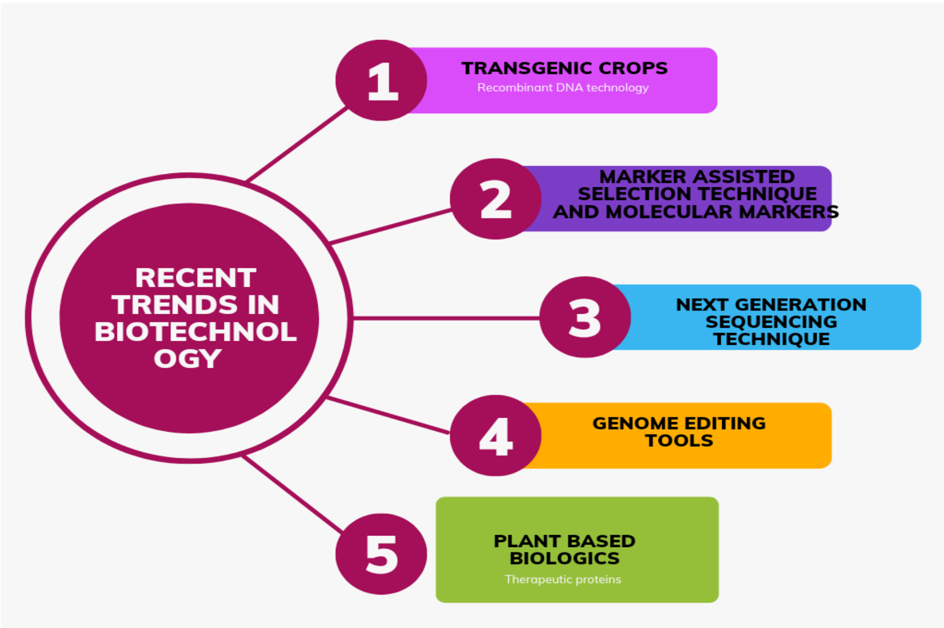

Figure 1: Recent biotechnological tools

TRANSGENIC PLANTS THROUGH TRANSGENESIS TECHNIQUE

Transgenic or genetically modified organisms are produced through a biotechnology technique called transgenesis or recombinant DNA technology. There are several types of transgenic crops that can be produced using biotechnological methods, such as those that are resistant to insects and diseases, and also tolerant to herbicides and abiotic stressors. These methods can help to improve crop yields and reduce losses due to pests and diseases.

MOLECULAR MARKERS AND MOLECULAR MARKER ASSISTED SELECTION (MAS) TECHNIQUE

MOLECULAR MARKERS

Molecular markers (DNA fragments that are very specific) are usually developed based on genes associated with specific characteristics. These markers are considered as phenotypically neutral markers and help scientists and researchers analyze the genetic diversity of plants, and they can also be used to identify clones, cultivars, identity of a particular plant, create linkage maps for different types of crops.

TRAITS OF AN EFFICIENT MOLECULAR MARKER

An efficient molecular marker should possess these important traits:

- An efficient molecular marker should be Polymorphic in nature i.e. detect high levels of polymorphism.
- An efficient molecular marker should be Co-dominant in nature.
- An efficient molecular marker should be reproducible in nature.
- An efficient molecular marker should be distributed evenly across the genome.

TYPES OF MOLECULAR MARKERS WIDELY USED IN AGRICULTURE

- Restriction fragment length polymorphism (RFLP, first generation marker) was one of the very first molecular markers to be discovered, back in the 1980s. Since then, there have been great advancements in biotechnology, and various other potential molecular markers have been discovered by scientists that are widely used in agriculture. There are different types of molecular markers that scientists use to study plants. First generation markers are the oldest and most basic type. Second generation markers are more sophisticated and can provide more information. New generation markers are the most advanced and efficient ones as they do less errors. Molecular markers are both PCR and hybridized-based, and both of these methods are used extensively in agriculture (crop improvement)
- Random amplified polymorphic DNA (PCR based molecular marker)- Also abbreviated as RAPD, are PCR-based dominant markers that analyze the genetic diversity of plants, and they can also be used to identify clones, cultivars, to study population genetics and are mostly non-coding markers. RAPD markers are used to study genetic diversity between different populations of Geum reptans. These molecular markers cover the entire genome and they have high levels of polymorphism.
- Simple sequence repeats marker or Microsatellite (PCR based molecular marker)-Also abbreviated as SSRs, these are extensively used on crops for their improvement. These are also considered as non-coding markers and are mostly used in studying population genetics. They also cover the entire genome, are highly reproducible and have high levels of polymorphism. Microsatellites like chloroplast microsatellite (cpSSRs), and mitochondrial microsatellite are mostly used in agriculture.

MARKER-ASSISTED SELECTION TECHNIQUE

Marker-assisted selection (MAS) is a plant breeding technique that uses molecular markers (DNA segments used to track specific genes) to help identify plant varieties with desirable traits for agriculture. MAS are a technique that helps you choose the traits you want in a plant at the seedling stage, which can save your time. MAS ensure that we will have enough food to eat in the future, and that our natural resources will not disappear.

The main disadvantage of MAS is that it requires expensive equipment and trained personnel, which many developing countries cannot afford. This technique also sometimes uses radioisotopes to label DNA. These radioisotopes can be dangerous for our health if we are exposed to them.

NEXT GENERATION SEQUENCING/ DEEP SEQUENCING/ MASSIVELY PARALLEL SEQUENCING/ HIGH-THROUGHPUT SEQUENCING

Next-generation sequencing (NGS) tools have the potential to provide high-resolution analysis of plant genomes. This type of sequencing will allow scientists and researchers to more effectively gain a deeper or more detailed understanding of the genetic composition or makeup and behavior of the plant genomes.

Next-generation sequencing is a powerful tool that can rapidly generate large amounts of sequencing data at a reasonable cost. The data provides valuable information about how nucleotides vary, and identify markers that may be associated with certain functions, which can help identify markers for certain plant traits that are economically important.

GENOME EDITING TOOL / GENE MANIPULATION TECHNIQUE

The field of biology has been revolutionized by the advent of genome-editing techniques. A recent gene-manipulation technique that has made it possible for scientists and researchers to control the activity of any gene with great precision. This powerful technique can be used to delete or insert genes of interest in genomic DNA.This technique uses enzymes called endonucleases to cut both strands of DNA in the gene we want to change. The ability to study the function of genes more closely allows them to produce new phenotypes. The use of genome-editing tools in plants has resulted in a revolution in crop improvement because it allows farmers to grow more food with fewer inputs and also helps them to create new varieties of crops.

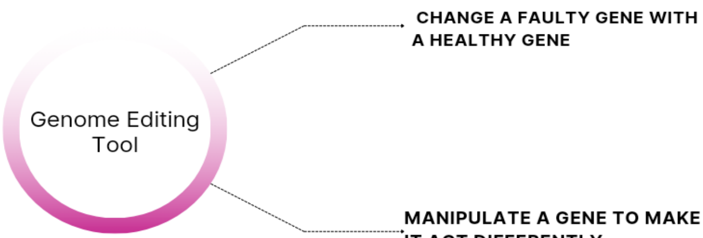

Figure 2: Genome editing tool

- **Zinc Finger Nuclease aka ZFN or Artificial nucleases (Discovered in 1990)**

Zinc finger nucleases (ZFNs), chimeric proteins are composed of DNA binding proteins, zinc fingers (Cys2-His2) that are linked to FokI, an endonuclease, which helps cut the DNA.Three scientists, YG Kim, J Cha, and S Chandrasegaran, discovered this in 1990 and is the first ever genome editing tool. This gene editing tool has been used to edit genomes of Arabidopsis, maize rice and also applied in woody fruit plants like fig and apple.

- **TALENs /Transcription Activator Like Effector Nucleases (Discovered in 2009)**

TALENs are proteins secreted by plant bacteria, Xanthomonas that infects plants. These proteins are made up of highly conserved repeats and act like scissors, cutting DNA at specific locations. It also has two domains like ZFN, TALE DNA binding domain (at amino-terminal) and DNA cleavage domain (at carboxy-terminal FokI).This genome editing tool is simpler than ZFNs and can also be used to make crops that are resistant to herbicides. This gene editing tool has been used to edit genomes of tomato, potato, sugarcane and various other plants.

- **CRISPR CAS9 Technology aka Clustered Regularly Interspaced Short Palindromic Repeats- CRISPR associated protein 9 (Discovered in 2012)**

Crisper is a tool that was discovered in Escherichia coli, is an easy-to-use yet effective sequence specific nuclease genome editing tool. CRISPRs are Short Palindromic Repeats that are associated with an endonuclease called CAS9, helps to cut and edit pieces of DNA. Scientists say that it is easy to use this tool to perform unimaginable genetic experiments. This tool is helpful for scientists and researchers who want to make changes to DNA sequences and alter gene function. This technology has many potential uses, and crop improvement traits are one of them. Scientists have used this tool to produce crops resistant to herbicides, like herbicide-resistant rice. Crops that are produced using this method are of higher quality and are less susceptible to disease. This gene editing tool has been used to edit genomes of cucumber, sorghum, zucchini and many other plants. The CRISPR/SpCas9 system (type II) from Streptococcus pyogenes is a useful tool that can be employed for various genome-editing tasks. The CRISPR/Cas9 is a popular choice for genome editing because it is relatively easy to use and is both efficient and flexible. This tool is designed for easy laboratory use and is also the most economical and easy-to-use tool. In 2020, Emmanuelle Charpentier and Jennifer A. Doudna won the Nobel Prize in Chemistry for their discovery of CRISPR/Cas9.

- **Site directed nuclease (SDN)**

A type of CRISPR/CAS Genome editing technique, in which scientists make small changes to a gene that is already present in the plant without introducing foreign genes. It is of two types SDN-1 and SDN-2. This method is considered to be faster and more accurate than traditional plant breeding methods. Even though some countries have not yet approved this technique, it is safe to use because there is no foreign DNA involved. Many countries have not yet approved the use of genome-edited crops because they do not have enough information about them. It is therefore important to communicate with these countries about these techniques and dispel any misconceptions they may have.

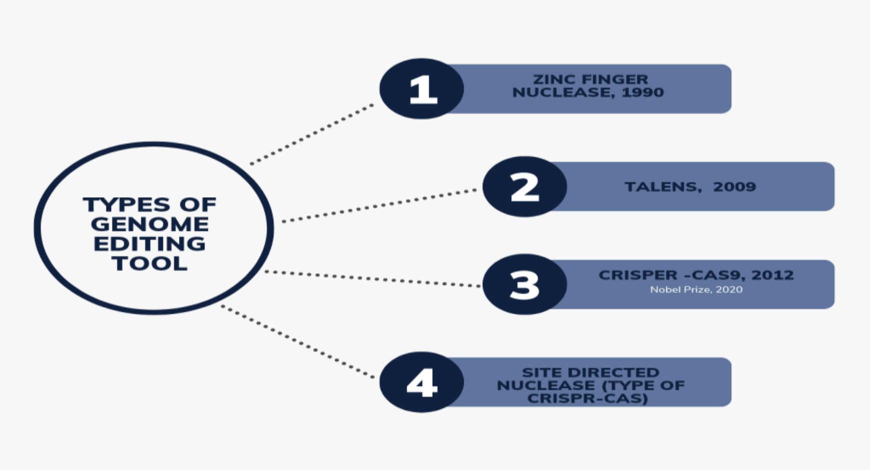

Figure 3: Types of Genome Editing Tool

PLANT MADE OR PLANT-BASED BIOLOGICS

Plant-based biologics are a type of biotechnology in which plants are used to produce therapeutic proteins. This is an important area of research, as these proteins have the potential to provide new treatments for various diseases that pose a significant risk of death. The plants most commonly used for the production of biologics are tobacco (*N. benthamiana* and *N. excelciana*), alfalfa, carrots, and various other plants. These plants are chosen for their ability to produce large quantities of proteins, which are then used to create biologics.

CONCLUSION

Traditional agricultural methods took a lot of time, but now there are biotechnological tools that make it much easier for farmers to produce traits that can withstand any climate conditions and have more nutritive values. The growth of biotechnology is a trend that is spreading throughout the world. This field is becoming increasingly popular, and its potential benefits are being recognized by more and more people. Biotechnology has been responsible for several significant advancements in the life sciences in recent years. The current value of the global biotechnology market is estimated to be around 752.8 billion US dollars, and the popularity of biotechnology is likely to continue growing in the years to come, as it has many potential benefits.

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Chapter
6

REVIEW OF NANOMATERIALS' CURRENT FUNCTION IN POLLUTION CONTROL

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ABSTRACT

Natural pollution is unavoidable, but human pollution is harming human health and causing water and food shortages. Traditional water remediation methods and materials are inadequate for removing organic, inorganic, and microbiological contaminants; thus researchers are turning to nanotechnology. Nanomaterials have increased surface area, reactivity, and performance compared to bulk materials. Given the size effect of nanoparticles, future technologies will focus on developing low-cost nanotechnology goods for high-end users. This chapter examines the role nanostructured carbon family compounds, metal oxides, and magnetic materials play in cleansing dirty surroundings. We describe nanoparticles' usefulness in water purification, antimicrobial coatings, and biosensors.

KEYWORDS: Nanomaterials, Environment, Water treatment, Photocatalysis, Sensors · Antimicrobial.

INTRODUCTION

Brundtland Commission advocated sustainability. 1987 report: "sustainable development meets existing goals without damaging future generations" (Wood 1993). Humans' devastation of nature is a problem in this millennium. Future generations face ozone hole, global warming, biodiversity loss, and radioactive and hazardous wastes. "Environmental protection must be part of growth," declared Rio Earth Summit in 1992 (United Nations 1992). At the 2012 Rio Earth Summit, four primary topics were addressed: hazardous and radioactive chemical production, the need for renewable energy to replace fossil fuels, vehicle emissions, and the lack of noncontaminated water (Tollefson and Gilbert 2012; Cardinale *et al.,* 2012; Haines *et al.,* 2012). Despite slowing growth, the world's population will reach 9.2 billion by 2040.

Humans and nature affect water quality. Organic chemicals and bacteria pollute groundwater. Water pollution can be point (urban/industrial) or dispersed (agriculture). Widespread nonpoint-source contamination affects groundwater more than point-source pollution. WHO assists nations on health-related goals and policies and organizes global waterborne disease prevention efforts (WHO 2018). Poor sanitation and contaminated water spread cholera, dysentery, hepatitis A, typhoid, and polio. WHO: Half the world's population will be waterstressed by 2025. 38% of low- and middle-income hospitals lack clean water, 19% need better sanitation, and 35% need handwashing water and soap.

SDWA defines physical, chemical, radiological, and biological pollution (WHO 2004; Faust and Aly 2018). (EPA) Water pollution is physical. Soil erosion creates sediment and organic debris in lakes, rivers, and streams. Chemical pollutants are natural or man-made. Nitrogen, bleach, salts, insecticides, metals, and bacterial toxins are chemicals. Organic and inorganic pollutants exist. Common organic pollutants.

POPs are halogenated and nonhalogenated (Pan and Zhang 2013; Jobst *et al.,* 2013; Li *et al.,* 2014; Adeleye *et al.,* 2016). Soils and source water affect groundwater inorganics. When source water moves through soil, both phases change. Degrading soils, sediments, rocks, and minerals. Inorganic contaminants Pb, Cr, Cu, Zn, Co, Mn, Ni, Hg, and Cd influence water and soil; radioactive contaminants Pu, Cs, and Sr. Phosphates, arsenate, borate, nitrates are contaminants (Manahan 2017).

Bio pollutant waterborne microorganisms. Parasites, viruses, bacteria, protozoa (Ashbolt 2015). Radiation is emitted by radioactive pollutants. Because ionizing radiation is natural, radioactive pollutants in drinking water are compared to 100 mrem per year of background radiation. Cesium, plutonium, uranium are radioactive.

WATER TREATMENT USING NANOMATERIALS

Improve water quality through Nano sorbents, nanocatalysts, bioactive nanoparticles, and nanostructured catalytic membranes. Nanotechnology advances suggest nanoparticles can improve filtering and desalination. Nanotechnology-derived goods can reduce dangerous substances to sub-ppb levels. This could be due to pollutant particle size. Due to the scale effect, developments in desalination technologies are exciting and promising. Demonstrates nanocomposites' characteristics and implanted nanoparticles can swiftly detoxify contaminated water. Industrialized nations and developing countries would benefit immensely. Nanoparticles purify industrial wastewater.

NANOCARBON

Nanotechnology has created metallic and carbon-based nanoparticles. Graphene, graphene oxide, and carbon nanotubes can purify water. Due to their large surface area, ease of chemical or physical modification and capacity to remove organic and inorganic contaminants, carbon-based nanomaterials and nanocomposites are used in water treatment. Graphene's large specific surface area and ease of broad functionalization offer abundant "anchoring" sites for functional nanoparticles, such as magnetic Fe_3O_4, photo reactive TiO_2, antimicrobial Ag and Au, and multifunctional nanocomposites such as graphene–TiO_2–magnetite and graphene–Au–magnetite. Carbon-based nanomaterials include graphene and CNTs. Chemically oxidizing graphene or CNTs forms graphene oxide and functionalized CNTs, which are water-soluble.

Carbon nanoparticle functionalization has two benefits (Hebbar *et al.,* 2017). First, it improves CNTs and Graphene’s hydrophobicity, boosting water dispersion. Better dispersion exposes more nanoparticles to microbiological and chemical contaminants. Second, nanomaterial surfaces can be modified to maximize contaminant surface charge properties. Electrostatic interaction induces heavy metal adsorption by CNTs or graphene oxide. ACN has more mesoporous than GAC, which has more micropores. Mesopores let large and tiny pollutant components access adsorbent surfaces (Smith and Rodrigues 2015).

GAC filters absorb metals. This approach fails to meet regulatory standards due to low removal efficacy and slow adsorption rates. CNTs and graphene oxide remove heavy metals. SWNTs remove Pb2+, Zn2+, Cd2+, and Cu2+ from aqueous solutions. Heavy metal ion affinity for CNTs is inconsistent. Studies show pH affects CNT adsorption. Nanomaterials outperform standard adsorbents in similar settings. Antibacterial coatings and membranes use graphene. Physical disruption, oxidative stress, and phospholipid extraction damage bacterial membranes (Jiang *et al.,* 2016).

NANOMETALS

Nanosized metals and oxides can affordably remove pollution (Saravanan *et al.,* 2011). Inorganic nanoparticles having fundamental properties are used in biomedicine, catalysis, fuel cells, sensors, and magnetic data storage (Wu *et al.,* 2016). Innovative anisotropic NPs have diverse physical and chemical properties due to their surface kinks and step edges (Tran & Lu, 2011). High-index polyhedral Au NPs are catalytic and optical. Nanosized zero-valent iron, ferric, aluminum, manganese, titanium, magnesium, and cerium oxides are frequent. Alumina absorbs more than -alumina and nanosized ZnO removes contaminants selectively. Made-ZnO featured tiny crystallites, surface defects, a broad band gap, and prevented electron-hole recombination (Kumar and Rao 2015). This photo catalyst destroys germs. Adding Fe, N, Cu, Zr, Co, or Ce to nanosized metal oxides increases their photocatalytic activity and how nanocrystals form affects behavior. Collins *et al., et al.,* TiO2 nanoparticles are popular as water-cleaning photocatalysis. TiO2 particles. Nakata and Fujishima (2007) and Hernandez-Alonso *et al.* (2009) say they can oxidize and reduce organic and inorganic pollutants.

NANOMAGNETS

Nanomaterials can cure water when coupled with polymers or magnetic particles. With these nanohybrid materials, nanoparticles can be utilized to clean water safely, since all of the nanomaterials can be reused. Before employing nanocomposites to clean water, it will be vital to research how well they remove biological and chemical pollutants and if they can be reused. This reduces tech costs. ZVI purifies water. nZVI's reply is better. nZVI can be injected into aqueous slurries and disseminated under the ground to clean up polluted areas. As (V) removal can be accelerated up by one to three orders of magnitude by reducing ZVI from microns to nanometers. nZVI's high reactivity may be due to its active sites and surface area. nZVI eliminated nitrate, dyes, EPTs, and antibiotics through adsorption, oxidation, reduction, and coprecipitation. Nanosized iron oxides have strong sorption, are easy to employ, and can be used creatively to treat wastewater. Goethite and hematite have major geochemical oxy-anions and cations. They absorb pollutants well and cheaply.

NANOMATERIALS FOR CHEMOSENSORS AND BIOSENSORS

Nanoscale metals and oxides can cheaply clear pollutants. Inorganic nanoparticles are employed in biomedicine, catalysis, fuel cells, sensing, and data storage (Wu *et al.,* 2016). Innovative anisotropic NPs have unique physical and chemical properties because to their kinks and steps. Polyhedral Au NPs are optical and catalytic. Zero-valent iron, ferric, aluminum, manganese, titanium, magnesium, and cerium oxides are common. Absorbs more than alumina Selective nanosized ZnO eliminates impurities. Made-ZnO had small crystallites, surface imperfections, a large band gap, and electron-hole recombination (Kumar and Rao 2015). Photocatalysts kill bacteria. Fe, N, Cu, Zr, Co, or Ce boost nanosized metal oxides' photocatalytic activity. How form affects behavior. Collins etc. Photocatalysts made of TiO2

Table 1: Contaminants of Organic and Inorganic

Organic contaminants			Inorganic Contaminants	
Halogenated	Nonhalogenated	Pharmaceutical	Aluminum	Cesium-137
1,1,2-Trichloroethane	Acetonitrile	Atenolol	Antimony	Iodine-131
1,1,1-Trichloroethane	Atrazine	Bisphenol A	Arsenic	Lead-210
1,2-Dibromo-3-chloropropane	Bis/tris solutions, cyclohexane	Carbamazepine	Barium	Radium-226
1,2-Dibromoethane	Butylated hydroxytoluene	Chloramphenicol	Beryllium	Radium-228
2-Chlorophenol	Caffeine	Chlorhexadine	Cadmium	Strontium-90
Alachlor	DAPI	Clofibric acid	Chloride	Thorium-228
Benzalkonium chloride	DEET	D-gluconic succinic acid	Chromium	Tritium
Bromodichloromethane	DEP	Diazinon	Copper	
Bromophenol blue	DMSO	Diclofenac	Cyanide	
Carbon tetrachloride	DOCDD	Doxycycline	Dissolved solids	
Chloroform	EDTA	Gemfibrozil	Fluoride	
Crystal violet	Ethyl ether	Ibuprofen	Hardness	
DCB	Fluorescein	Iopamidol	Iron	
Endrin	Hematoxylin	Ketoprofen	Lead	
Eosin	HEPES	Lincomycin	Manganese	
Heptachlor	Hexanes	Norfloxacin	Mercury	
Hexachlorobenzene	Hybridization buffer	Ofloxacin	Nickel	

Hexachlorocyclohexane (lindane)	Isopropyl acetate	Oxytetracycline	Nitrates	
Hexachlorocyclopentadiene	Methyl orange	Paracetamol	Nitrite	
Methoxychlor	Naphthalene	Phenazone	Selenium	
Methylene blue	NBBS	Primidone	Silver	
Methylene chloride	Oil Red O, petroleum ether	Propyphenazone	Sodium	
PBDEs	Phenol 2-propanol ≥24%	Salicylic acid	Sulfate	
PCBs	Simazine	Sulfametazine	Thallium	
Rhodamine B	TAE	Sulfamethoxazole	Zinc	
Safranin	TBE	Tetrabromo-bisphenol		
TCB	TEMED	Tetracycline		
TCE	Tert-butanol	Triclosan		
Tetrachloroethylene				

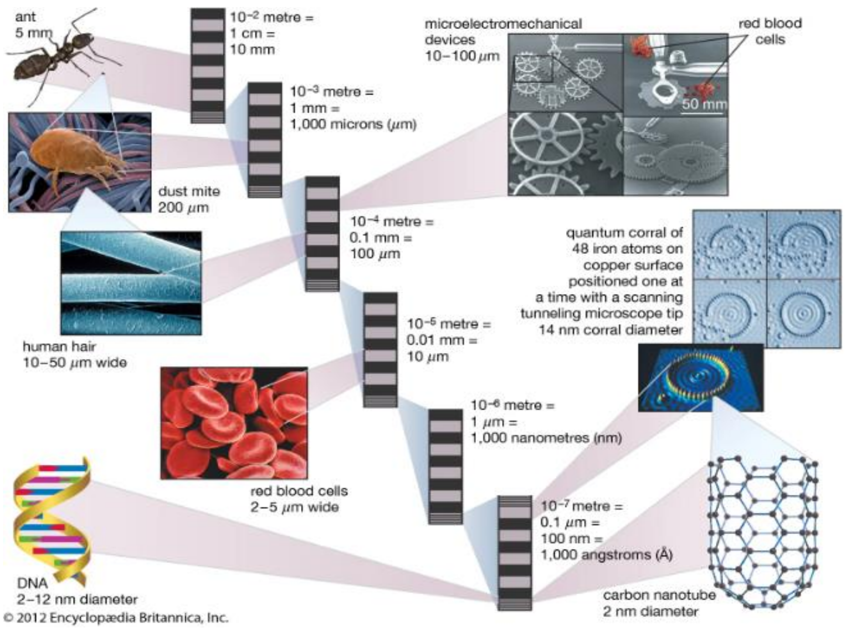

Figure 1: Different "orders of magnitude" are shown by examples from the biological and mechanical worlds (powers of 10), from 10^{-2} metre down to 10^{-7} metre. (https://www.britannica.com/science/nanoparticle)

Nanoparticles purify water. Particles of TiO2 and Hernandez-Alonso *et al.* (2009) suggest they can oxidize and decrease organic and inorganic contaminants

PROTECTIVE NANOMATERIALS

Antibacterial compounds destroy or slow bacterial development in a small area without affecting surrounding tissue. Antibacterial agents are needed to tackle infectious infections.

Most resistance is caused by evolutionary changes during treatments like antibiotic medication and can be passed down. Resistance can also develop by conjugation, transduction, or transformation. Antibiotics taken in large doses due to drug resistance often have terrible adverse effects. This has led to new bacterial illness treatments. Nanomaterials are antibacterial. Several forms of antimicrobial nanoparticles and nanosized antibiotic transporters have been found to treat infectious infections, even antibiotic-resistant ones, in in vitro and animal models. Gram-positive (+) and Gram-negative () cell wall structure doesn't alter species sensitivity alone. Other factors affect NP susceptibility and tolerance. Escherichia coli are susceptible to CuO NPs, whereas Staphylococcus aureus and Bacillus subtilis aren't. Ag NPs are more effective than Cu NPs against E. coli and S. aureus. NiO and ZnO nanoparticles damage S. aureus and B. subtilis more than E. coli.

Antibacterial medications can't destroy biofilm-forming bacteria (such S. aureus (+)). Ag NPs can block bacteria from settling on biofilm and slow its growth and spread. Antimicrobial MgF2 NPs prevent E. coli and S. aureus from forming biofilm. MgF2 NP-modified catheters can limit biofilm formation. Glass surfaces coated with ZnO NPs can produce ROS that halt E. coli and S. aureus biofilms.

SPIONs coated with gold and silver exhibit the strongest antibacterial effectiveness against biofilms. Monodisperse, silver-ring-coated, and silver-ring-coated, gold-coated SPIONs are hazardous in biofilms. When magnetic and laser fields are applied, the SPION core and intermediary gold shell heat up. These NPs' heat can also kill microorganisms.

SUMMARY

Everyone deserves clean water, air, food, and health care. Clean water is crucial for people's health and for food, electronics, and pharmaceutical businesses. World struggles to meet rising demand for clean water. Long-lasting droughts, population increase, harsher health laws, and competing user needs cause this. Nanoscience and nanotechnology could lead to new techniques to clean water because nanoparticle size impacts its qualities and effectiveness. Small. Nanomaterials have a vast surface area, therefore only little amounts are needed.

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Chapter 7

BIO-ENZYMES: A SUSTAINABLE ALTERNATIVE TO VARIED CHEMICAL AGENTS

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ABSTRACT

The complex interactions between diverse ecosystems is critical for the progression of naturally occurring environmental cycles. The maintenance of these interactions is necessary for clean and healthy environment which can be achieved only through practising sustainable strategies. Use of bio enzymes is an emerging approach to replace chemical agents in various industrial fields. The bio enzymes are secreted by microorganisms which turn natural resources including food and agricultural wastes into soluble nutrients; thereby increasing its bioavailability. Though bio enzyme application is not a new concept, its potential has been severely under-rated in the present chemical-dominated global market. With proper implementation of protocols, bio enzymes have the potential to replace chemical based fertilizers, insecticides, pesticides, herbicides, household cleaning agents and many other products. Moreover, it can be produced using municipal wastes and is completely free. In this review, we describe the potential of bio enzymes in agriculture and other fields.

KEYWORDS: Bioavailability, Bio enzymes, Environmental cycles, Municipal Wastes, Nutrients.

INTRODUCTION

We currently live in a society which is highly influenced by chemical products due to its ease of manufacturing and cost effectiveness. Every industry including food, agriculture as well as pharmaceuticals is largely dependent on chemicals for maintaining their quality and productivity. Over the years, the use of chemical based fertilizers, pesticides, weedicides, insecticides and plant hormones has gradually affected soil stability. In turn, this has reduced agricultural productivity [1]. Increased environmental exposure to chemicals is also recognized as the main culprit to climate changes [2]. To overcome the detrimental effects of chemical exposure on environment, the use sustainable products are the most recent industrial trend with an aim to reduce the use of chemicals or replace it entirely. Among the various sustainable approaches implemented in agriculture and other industries, bio enzymes are the most promising tool.

Bio enzymes are microbial proteins that are produced in response to the available raw materials during fermentation. These enzymes are metabolic products of micro-organisms that breakdown organic matter into soluble nutrients. During fermentation, organic acids and salts are produced which increases the bioavailability of nutrients. The interaction of these compounds with soil components improves formation of aggregates which enhances stability. It also improves the porosity of the soil which aids in nutrient and oxygen diffusion in plant tissues [3].

PREPARATION AND CHARACTERISTICS OF BIOENZYMES

In organic farming, bio enzymes are believed to be a potent microbial product that can enable a sustainable green revolution in near future. The commonly referred terms like 'Compost tea', 'Garbage enzyme' or 'Fermented plant juice/tea' are nothing but rich concentrates of bio enzymes that breakdown organic matter (leaves, fruits and vegetables) into a form that can be easily absorbed by plant roots. It is important to highlight that moist black soil collected from forest areas are also a rich source of bio enzymes since it is composed of decaying leaves and diverse micro biome. Farmers in India are slowly being introduced to the concept of bio enzymes. For large scale production, they use a combination of jaggery/molasses and agricultural/kitchen wastes for preparation of potent bio enzymes. Here, agricultural/kitchen wastes serve as a raw material for increasing the diversity of enzymes and molasses aid in enrichment of soil flora to facilitate the fermentation process [4].

Like all proteins, bio enzymes are sensitive to pH, temperature and soil moisture levels. Under natural environmental conditions, most soil microbes prefer slightly acidic to neutral pH (6-7) level for their growth and proliferation. Consequently, their cellular activity is optimum at above pH, and moderate temperature and moisture levels. Major fluctuations in any of these parameters can inhibit the beneficial effects of bio enzymes [3, 5].Though the process of fermentation is universal for preparation of bio enzymes, the diversity of raw materials used in the process allows a range of applications. For instance, most kitchen wastes like fruit and vegetable peels can be converted in bio fertilizer using bio enzymes. On the other hand, using citrus peels can turn the product into a natural all-purpose household cleaner [3].

USES OF BIOENZYMES IN AGRICULTURE

Agriculture is the backbone of Indian economy. Hence, encouraging and implementing strategies for agricultural development in rural areas will ensure overall development of India. In a recent review, Patolia *et al.,* [5] briefly outlined the role and potential of bio enzymes prepared from fruit and vegetable wastes. They described the efficacy of bio enzymes, thus prepared, in reducing groundwater contamination and soil stabilization. An in-depth review presented by Sethi *et al.,* [3] further described the functions of bio enzymes and the challenges we may have to overcome for its successful application in near future. They narrated that most of these challenges are associated with awareness and acceptance by farmers, and promotion by government entities. The above review also described evidence based studies carried out by Sri SriInstitute of Agricultural Sciences and Technology Trust (SSIAST), India and regional group of farmers from different sectors of India. All these studies reported better crop management, fruit/vegetable yield and reduced infestation by pests on use of bio enzymes in their field.

The basic advantage of using bio enzymes in agriculture is its nutritional potency. The slight acidity imparted by bio enzyme solution to top soil improves bioavailability of nutrients and enhances nutrient absorption by plants. This is especially necessary for uptake of nutrients that can precipitate and form stable salts in soil, like phosphorous. Besides, a byproduct of bio enzyme production is formation of ozone which not only promotes root development and plant growth but also reduces emission of greenhouse gases. Overall, it prevents premature dropping of fruits and flowers [3, 6]. Various advantages and applications of bioenzymesare represented in Table 1. After preparation of bio enzymes, the cellulose and lignin containing leftovers of agro-wastes can be added to compost piles. These compounds breakdown slowly by microbial processes, but they aid in proliferation of earthworms that improves oxygen transfer in farm soil. Earthworms further improve the texture, moisture retention capacity and porosity of soil that helps in increasing agricultural productivity [4, 7]. Bio enzymes added to compost piles can also accelerate the speed of decomposition of organic wastes [3].

Table 1: Applications of Bio enzymes in Agriculture

Applications	Activity	Reference
Organic Fertilizer	Natural fermentation processes make an organic solution not only rich in basic nutrients (Nitrogen, Phosphorus and Potassium) but also in minerals and micronutrients. Hence, bio enzymes are potent fertilizers that can improve plant growth and crop yield.	7
Source of nitrates	Nitrates are among the most important nitrogen source for plants. Bio enzymes convert organic compounds into nitrates; thereby improving bioavailability of waste products in soil.	5
Antimicrobial	Bio enzymes are produced by beneficial bacteria. At the same time they inhibit pathogenic microorganisms by making the environment acidic. The formation of salts also discourages propagation of pathogenic microorganisms.	6
Natural pesticide and insecticide	During fermentation, concentrated phytochemicals and salts also act as pesticide and insecticide. Besides, it also significantly repels cockroaches and rats from the field.	8
Natural weedicide	Bio-enzyme solution is acidic due to presence of organic acids formed during fermentation process. Hence, application of concentrated bio enzymes on crops also effectively kills weeds.	3

NON-AGRICULTURAL USES OF BIOENZYMES

Besides agriculture, bio enzymes can be used for various purposes. They can presumably replace chemical cleansers, cosmetic toners, depilatory agents and deodorizers available in the market. Since bio enzymes are produced by completely natural process using plant wastes, they are safe for use. Infact, they are freely available, and do not leave any residues after its disposal.

Bio enzymes enable recycling of nutrients in nature and thus benefit both humans and ecosystems. Few non-agricultural applications of bio enzymes are represented in Table 2.

Table 2: Non- agricultural Applications of Bio enzymes

Applications	Activity	Reference
Air Purification and Deodorization	Bio-enzymes prepared using appropriate raw materials effectively kill germs that cause foul odor. Alternatively, they degrade compounds responsible for causing bad smell. Hence, they have the ability to purify and deodorize air.Bioenzymes also release ozone that absorbs CO_2 and heavy metals. Thus, it prevents the consequent toxicity.	6
Household cleaning	The chemical cleansers use enzymes like lipases, proteases, amylases and cellulases for cleaning of different household materials. Difficult stains like blood stain can be effectively removed using proteases. Greasy stains can be removed using lipases. These enzymes can be easily induced in bio enzyme solution using citrus or starchy fruit peels.	9
De-clogging of drains	Since, the bio enzymes efficiently degrade organic components, they help in de-clogging of drain pipes.	9
Solid Waste Minimization	Since garbage enzymes are prepared using municipal wastes, the process literally turns thrash into treasure. Municipal solid wastes disposal in an increasing problem in urban cities. Thus, utilizing it as raw material reduces the need for its disposal. Moreover, there are reports on use of bio enzymes in reversing the toxic and unhealthy environment surrounding the landfills.	6
Stabilization of soil at construction sites	Bio enzymes are also beneficial in construction sites for stabilization of soil structure to make it suitable for pavements, roads and other amenities. Use of bio enzyme for construction is approved by WHO and UNESCO.	10

CONCLUSION

Perfection can be achieved through mimicking natural environmental activities. In order to truly understand the environment, it is necessary to acknowledge that there is no concept of 'Waste' in its processes. Environmental processes are capable of recycling organic compounds completely without compromising its quality and health. Bio enzymes presents a perfect example of such sustainable and natural environmental process which convert fallen fruits, vegetables and agricultural/kitchen wastes into soluble nutrients. By mimicking nature, promising innovation is possible, and utilizing municipal, kitchen or agriculture wastes for production of bio enzymes has endless potential for improvisation in agricultural and industrial fields.

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Chapter
8

PHARMACOLOGICAL IMPORTANCE OF *MIMOSA PUDICA* (TOUCH ME NOT)

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ABSTRACT

Mimosa pudica is an herb belongs to the family mimosaceae. It is commonly known to as touch me not and shame plant. It is a prostrate or semi erect shrub of tropical America and Australia. It is also found in India. The plant has been a part of Traditional medicines in the India, china, America and in Korea. It has been used in centuries in traditional medicines to cure various diseases like fever, ulcers, diabetes, jaundice and dyspepsia. The phytochemical compounds are widely used in many herbal formulations. Pharmacological activities like anti-cancer, anti-diabetic, anti-oxidant, anti-inflammations, hypertension, neurological disorders, osteoporosis, antidepressant etc., Apart from these activities it possesses antibacterial, antivenom, antifertility, anticonvulsant, aphrodisiac properties. The herb has been used in the treating urogenital disorders, piles, dysentery, sinus and wounds traditionally. The objective of this chapter is to explore the medicinal activities of the plant.

KEYWORDS: *Mimosa pudica*, Anticancer, Antidiabetic, Antivenom, Antidepressant

INTRODUCTION

Mimosa pudica is a creeper. It is an annual or perennial herb. *M. pudica* possess sedative, emetic properties. It is known as lajjalu in Ayurveda and has antidepressant, analgesic and aphrodisiac properties. It is widely used traditionally in the treating various ailments like diarrhea, dysentery, tumor and in urogenital infections. Phytochemical studies of *M. pudica* have been investigated the presence of alkaloids, non -protein amino acids, flavonoids C-glycosides, sterols, terpenoids and fatty acids.

A diffuse prickly under shrub, is about 45-90 cm in height. Leaves are bipinnately compound and pinnate 2-4 delicately arranged with 10-20 pairs of leaflets, rachis with ascending bristles. Flowers pink with globose heads, pricky penduncles, Fruits are arranged in bristly pods, flat, straw colored consisting of 3-5 one seeded segments. The roots and leaves are used in treating cooling vulnerary, alexipharmic, diuretic antispasmodic, emetic, constipation.

Figure 1: *Mimosa pudica*

Kingdom	:	Plantae
Division	:	Magnoliophyta
Class	:	Mangnoliopsida
Order	:	Fabales
Family	:	Fabaceae/ Mimosaseae
Sub – family	:	Mimosoideae
Genus	:	*Mimosa*
Species	:	*Pudica*

Table 1: Botanical variation among the major species of *Mimosa* (Tomar *et al.*, 2014), (Reed-guy *et al.*, 2017)

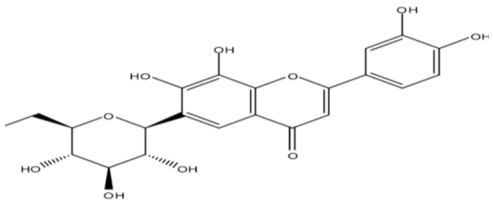
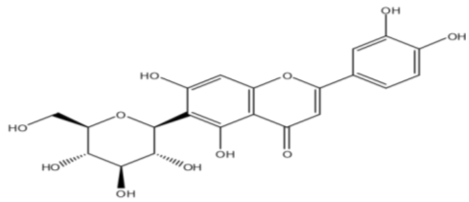
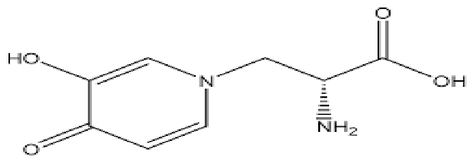
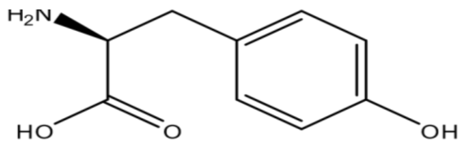
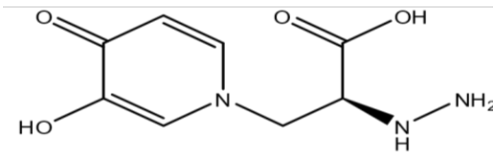
Characters	*M. pudica*	*M. himalayana Syn. M.rubicaulls*	*M. hamata*
Plant	Small woody plant and low spreading shrub with hairy. The hairs are glandular and have prickly branches.	This is a large straggling shrub which is straw coloured.	This is an armed shrub. It has the numerous straw coloured Straight prickles.
Leaves	Leaves are sensitive to touch which bipinnate with 1-2 pairs of pinnae. 10-20 pairsof leaflets can be linear and glabrous.	Leaves are bipinnate with rachis hooked. 5-11 pairs of leaflets in pinnae are long and oblong.	These leaves are pubescent with 2 pinnae. Sometime it is prickly and contains 6-10 Leaflet pairs.
Flowers	It has a small hair with pink purple. Flowers are peduncled, globose and petals crenate towards base.	The numerous flowers can see with globose heads and peduncles at the ends of branchlets.	It has 4 merous in globose heads. The peduncles axillary which are at the end of the branches.
Pods	Pods are closely prickly on the sutures and 1.5-2.5 cm long.	The one seeded joints and 7-10 cm long pods are persistent but are not prickly.	5-7cm long pods can see with 4-8 one seeded joints together. Pods are pubescent and falcate.

Table 2: Chemical constituents in different parts of Mimosa Pudica (Molina M 2011)

Parts	Chemical Constituent
Leaves	nor-epinephrine, b-sitosterol, d-pinitol, alkaloids- mimosine, terpenoids, flavonoids, glycosides, alkaloids
Seed	D-xylose, D-glucoronic acid 4-O(3,5-dihydroxybenzoicacid)-b-Dglucoronide, Tubulin, Cglycosylflavones, phenolic ketone, buffadienolide
Root	flavonoids, alkaloids, amino acids, phytosterol, tannins, glycoside, and fatty acids ascorbic acid, crocetin, D- glucoronic acid, linoleic acid.
Plant	c-tetrahydroxyl-6-C-[alpha-lrhamnopyranosyl--b-D- trihydroxyl8-C-[a-l-rhamnopyranosyl--b- Dglucopyranosyl flavo-tetrahydroxyl6-C-[a-l-rhamnopyranosyl-- b-Dglucopyranosyl flavone
Stem	m-[N-(3-hydroxypyridone-4)]-aminopropionic acid 5-MeODMT, mimosine
Aerial Part	O-glycosyl flavonoids like isoquercitrin, avicularin and apigenin-7-O-D-glucoside, and also four C-glycosyl flavonoids, cassiaoccidentalin B, orientin and isoorientin are found in the aerial part of the plant

Figure 2 :Medicinal Values of *Mimosa pudica*

Table 3: Chemical constituents in *Mimosa Pudica* (Kaur *et al.*, 2011), (Azmi, Singh and Akhtar, 2011)

Chemical name	Structure
7,8,3'',4''-tetrahydroxyl-6-C-beta-D- glucopyrano-sylflavone	
5,7,3',4'-tetrahydroxyl-6-C-beta-D- glucopyranosyl flavones	
Mimosine	
Tyrosine	
Mmimosinamine	

ANTICANCER ACTIVITY

Chimsook *et al.* (2014) reported on the in vitro anticancer activity levels of different leaves extracts (PE, EtOAc, absolute EtOH, and Aq.) of *M. pudica* are tested against three human cancer cell lines derived from lung (CHAGO), liver ($HepG_2$), and colon (SW620) samples using an MTT assay. The EtOAc extract showed to be potent (IC_{50} = 29.74 μM) against CHAGO cells, while the EtOAc and absolute EtOH extracts inhibited the SW620 cells, with IC_{50} values of 11.12 and 5.85 μM, respectively. $HepG_2$ cell growth was inhibited by EtOAc (IC_{50} = 29.81 μM) and absolute EtOH (IC_{50} = 10.11 μM) extracts. The results were compared with standard amonafide, which showed significant cytotoxicity in CHAGO (IC_{50} = 1.05 μM), SW620 (IC_{50} = 0.32 μM), and $HepG_2$ (IC_{50}= 1.71 μM) cell lines.

Parmar, F *et al.* (2015) screened the anticancer activity of the Hy-EtOH extracts of *M. pudica* plant samples and L-mimosine using MTT assay against the Daudi cell line. At concentrations of 12.5–400 μg/mL, the IC_{50} values were found to be 201.65 μg/mL and 86.61 μM at 72 h for *M. pudica* extract and L-mimosine, respectively.

ANTIMICROBIAL ACTIVITY

The antimicrobials of plant are effective against infectious diseases (Thi *et al.,* 2016). The process behind antibacterial activity of the *Mimosa pudica* plant extracts is the disruption of bacterial membrane potential leakage of the cellular contents (Joseph, George and Mohan, 2017).

ANTI-ULCER ACTIVITY

The extracts used for the activity were, 90% ethanol, methanol, chloroform and diethyl ether extract. The activity was investigated in albino rats. The models used were aspirin induced model, alcohol induced model and pylorus ligation induced ulcer and the parameters evaluated were ulcer protection, gastric ulcer protection and reduction in total volume of gastric juice, free and total acidity of gastric secretion, gastric ulcer respectively (Vinothapooshan G & Sundar K 2010)

ANTI-DIARRHOEAL ACTIVITY

Diarrhea is the condition of having three or more loose or liquid bowel movements per day. The ethanolic leaf extract of M.pudica has been evaluated in wistar albino rats to check the anti-diarrhoeal potential. The ethanolic extract at 200 and 400 mg/kg showed significant inhibited diarrhoea. The anti- diarrhoeal property may be due to presence of tannin and flavonoids in the extract. (Saifiddin Khalid MD *et al.*, 2011)

ANTIVENOM ACTIVITY

Aqueous extract of dried powdered roots of *M. pudica* was used to test the inhibitory activity on lethality, phospholipase activity, fibrinolytic activity and haemorrhagic activity of *Naja* and *Bangarus caerulus* venoms. The aqueous extract showed a significant inhibitory effect on the lethality, phospholipase activity, fibrinolytic activity and hemorrhagic activity. 0.14 mg and 0.16 mg of *M. pudica* extracts were able to completely neutralize the lethal activity of $2LD_{50}$ of *Naja naja* and *Bangarus caerulus* venoms respectively (Meenatchisundaram S *et al.*, 2009)

ANTIHYPERGLYCEMIC ACITIVITY

Chloroform extract of *M. pudica* leaves has been used to screen hypolipidemic activity against atherogenic diet in wistar albino rats. Serum levels of different biochemical parameters such as total cholesterol, triglycerides, high- density lipoprotein, very low-density lipoprotein and low- density lipoprotein cholesterol were determined. Atherogenic index shows the measure of the atherogenic potential of the drugs. Chloroform extract showed significant hyperlipidemic effect by lowering the serum levels of biochemical parameters such as significant reduction in the level of serum cholesterol, triglyceride, LDL, VLDL and increase in HDL level which was similar to the drug Atorvastatin. Chloroform extract exhibited significant atherogenic index and percentage protection against hyperlipidemia. The biologically active phytoconstituents like flavonoids, glycosides alkaloids present in the chloroform extract of *M. pudica*, indicates the significance of hypolipidemic activity. (Rajendran *et al.*, 2010)

ANTICONVULSANT

The decoction of *M. pudica* leaves were administered intraperitoneally at dose of 1000-4000 mg/kg which safe guarded mice against pentylentetrazol and strychnine- induced seizures. *M. pudica* have no effect against picrotoxin-induced seizures. It also antagonized N-methyl-D-aspartate- induced turning behavior. (Ngo Bum E *et al.*, 2004)

ANTI - HEPATOTOXIC ACTIVITY

The ethanol extract of *M. pudica* leaves was analysed for its hepatoprotective against carbon tetrachloride (CCl_4)-induced liver damage, in Wistar albino rats. The ethanol extract of *M. pudica* (Mimosaceae) leaves (200 mg/kg body weight, p.o.) was administered to the experimental rats for 14 days. The hepatoprotective activity was measured using various serum biochemical parameters as glutamate oxaloacetate transaminase (SGOT), glutamate pyruvate transaminase (SGPT), alkaline phosphatase (ALP), bilirubin, and total proteins. Malondialdehyde level as well as the activities of superoxide dismutase, reduced glutathione and catalase was determined to explain the possible mechanism of activity. The substantially elevated levels of serum SGOT, SGPT, ALP and total bilirubin, due to CCl_4 treatment, were restored towards near normal by *M. pudica* (Mimosaceae), in a dose. Reduced enzymatic and non-enzymatic antioxidant levels and elevated lipid peroxide levels were restored towards near normal, by administration of *M. pudica*. The ethanol extract of *M. pudica* showed significant dose dependent hepatoprotective an antioxidant effects in CCl_4-induced hepatic damage (Muthukumaran P *et al.*, 2010)

ANTIHELMINTHIC ACTIVITY

The present study was undertaken to evaluate anthelmintic activity of different extracts of seeds of *M. pudica*. The different extracts namely petroleum ether, ethanol and water using *Pheretima posthuma* as a test worm to the different concentrations (100, 200, 500 mg/kg) were tested for bioassay against paralysis and time of death of the worms. Crude alcoholic extract and aqueous extracts significantly demonstrated paralysis and also caused death of worms in dose dependent manner as compared to standard reference albendazole. While Pet. Ether extracts shows weak anthelmintic effect compared to standard, ethanol and aqueous extracts. (Bendgude RD *et al.*, 2012)

ANTIDEPRESSANT

In Mexico, aqueous extracts from dried leaves of M.Pudica are used to increase depression. The behavioral actions of aqueous extracts of M.Pudica at various concentrations were tested. Rats received saline (0.9%; 0.30 mL; I.P.), clomipramine, desipramine, or several dosage of aqueous extracts from M.Pudica (m_1 = 2.0 mg/kg; m_2 = 4.0 mg/kg; m_3 = 6.0 mg/kg; m_4 = 8.0 mg/kg) during a 30-day period, forced swimming test were carried out. And to the test for differential reinforcement of low rates of response at 72 s (DRL-72 s). The data suggest that M.Pudica produces antidepressant effects in the rat. Diazepam increased the open-arms exploration time in the elevated plus-maze test, but M.Pudica did not show any comparable action at any tested dose. M.Pudica therefore produced an anti-depressant like profile similar to two tricyclic anti- depressants (Molina M *et al.*, 1999)

CONCLUSION

The features of the plants featured in the texts of 'Ayurveda', i.e. the traditional Indian system of medicine. The literature shows that there are wide potential compounds in this herb in view of therapeutics. It is of greater benefits as it is economically viable, easily available and a reservoir of significant medicinal properties (Muthumani P *et al.*, 2010)

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Chapter
9

ADVERSE EFFECTS OF PESTICIDE APPLICATION ON CROP

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ABSTRACT

A pesticide is a toxic substance or mixture of substances that are intentionally applied in the environment in order to avert, deter, control, or kill pests or to revert, prevent or reduce the damage they cause. The introduction of pesticides in the crop field not only kills the weeds but also contaminates the air, water, and soil. Isoproturon, an herbicide changes the ultrastructure of photosynthetic apparatus, decreases ribulose bisphosphate carboxylase activity ultimately leads to a decrease in chlorophyll content. Besides herbicides, insecticides and fungicides also have an adverse effect on oxygen scavenging potential as well as on the growth and development of the plant. Copper and Sulphur-based fungicides may affect stomatal closure. Fenitrothion, an insecticide lowered plant height. A considerable decrease in the available nitrogen and phosphorus levels of the organophosphate insecticide-treated soil has been investigated. Water contamination and soil logging in the field, unavailability of macro and micronutrients and bioaccumulation of toxic compounds after the application of rodenticide in the field are observed. A significant investigation of the in-crop impacts of rodenticide is currently ongoing.

KEYWORDS: Pesticides, Herbicide, Fungicides, Insecticides, Rodenticide, Adverse effect

INTRODUCTION

The term agriculture encompasses all the different ways in which crops and domestic animals provide food and other products to the human population for their well-being. Undoubtedly, agriculture will remain the backbone of the Indian economy for a long time. Almost 17 percent of the world's population is supported by Indian agriculture. (Pandey, 2009)

The late nineteen sixties witnessed India's evolution from a food-deficient country with a heavy reliance on imports to a global agricultural powerhouse. Even so, Indian agriculture still faces challenges such as adaptation to climate change disturbances, fragmentation of landholdings, decreased productivity, and increased flexibility of food prices. There is a need to implement a generational shift in farming, such as cultivating climate-resilient crops; adopting environment-friendly farming technologies like the application of new tools which generate less pollution (Biopesticides and biodegradable material); establishing a market for land consolidation, and improving post-harvest practices such as storage and transport.

Among these, pesticides are one of the most widely studied matters. Its beneficial and adverse effects on crops, animals and the environment have been taken into consideration while applying pre and post-harvesting practices.

WHAT ARE PESTICIDES?

A pesticide is a toxic substance or mixture of substances that are intentionally applied in the environment to avert, deter, control, or kill pests or to revert, prevent or reduce the damage they cause. When a pesticide is introduced to the environment, it attracts, seduces and then destroys the pests. Pesticides can be natural compounds, or they can be synthetically produced. In addition to their application in agricultural fields, they are used in-house as sprays, poisons, and powders to control the population of cockroaches, mosquitoes, rats, fleas, ticks, and other pests.

Since 1952, India has been a significant producer of pesticides, with the establishment of a plant to produce BHC near Calcutta. India ranks 12th globally and 2nd in Asia for pesticide production. The use of pesticides has increased many folds over the past few decades. Approximately 5.2 billion pounds of pesticides are used annually around the world.

WHAT ARE PESTS?

Pests can be broadly defined as "the plants or animals that jeopardize our food, health and comfort". The usual pests for the crops are bacteria, weeds, fungi, insects and rodents.

CLASSIFICATION OF PESTICIDES

Major classes of pesticides include organochlorines, carbamates, organophosphates, and noenicitinoids. They are classified based on various criteria (Table 1) (Akashe *et al.,* 2018).

Table 1: Classification of pesticides

Based on the target pest	
Algicide	Copper Sulphate, diuron
Bactericides	Streptomycin, tetracycline
Herbicides	Paraquat, 2,4-D
Fungicides	Cymoxanil, thiabendazole, strobilurin, Bordeaux mixture
Insecticide	Azadirachtin, DDT, chlorpyrifos, malathion
Rodenticides	Strychnine, Warfarin, zinc phosphide
Based on the Mode of Entry	
Systemic Pesticides	2,4 –D, glyphosate
Contact pesticides	Paraquat, diquat
Stomach poisons	Malathion
Fumigants	Phosphine
Repellents	Methiocarb

Based on the Mode of Action	
Physical poison	Activated clay
Protoplasmic poison	Arsenicals
Respiratory poison	Hydrogen cyanide
Nerve poison	Malathion
Chitin inhibition	Diflubenzuron
On sources of origin	
Bio-pesticide	Microbial pesticides (Bacterial toxins produced by *Bacillus thuringiensis* and *Bacillus sphaerius*)
	Plant incorporated protectants (Azardirachtin)
Chemical pesticides	Organochlorine, organophosphate, carbamates and pyrithroids

PATTERN OF PESTICIDE APPLICATION IN INDIA

Bactericides, herbicides, fungicides, insecticides and rodenticides are more commonly used pesticides in India. Figure 1 shows the application pattern of various pesticides in India. 76% of the pesticide in India used is an insecticide. In contrast, the use of herbicides and fungicides is significantly less. The primary use of pesticides (45%) in India is for cotton crops (45%), followed by paddy and wheat (Pandey, 2009).

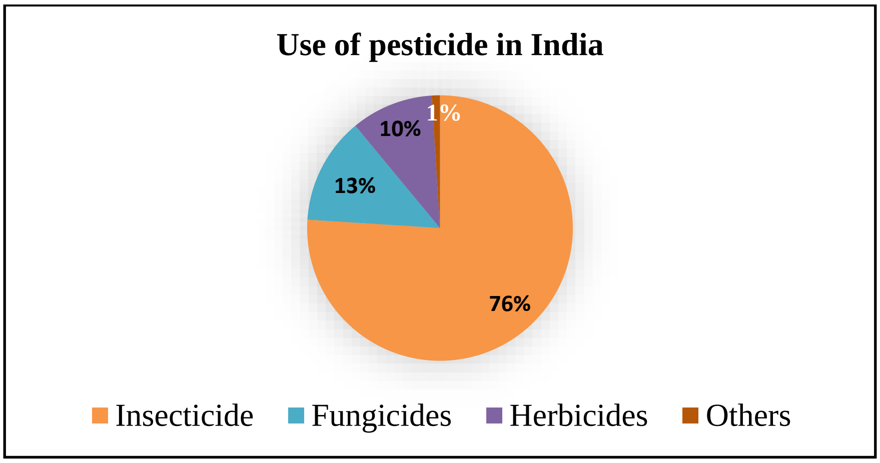

Figure 1: Pattern of pesticide application in India

When a pesticide is introduced to the crop field, it not only kills the weeds but contaminates the air, water, and soil. Because crops absorb the nutrients from the soil likewise absorb and accumulate pollutants. Hence, besides the target and non-target pests, crops also show some response to them, and their effects persist in the crops. Discussed in the following are some adverse effects of various groups of pesticides on the crop. (Aktar *et al.*, 2009)

EFFECT OF HERBICIDES ON THE CROP

Herbicide is a chemical or mixture of chemicals used to kill or inhibit or eradicate the growth of weeds and other unwanted plant pests.

Herbicides have become popular among Indian farmers as an alternative to traditional weed control methods such as crop rotation, manual hoeing or tractor-drawn cultivators, and costly labour. Given the significance of these situations, it is vital to choose the appropriate chemicals that are capable of eliminating the different types of weeds efficiently and affordably.

1. Effect on photosynthesis:

- An herbicide named isoproturon changes the ultrastructure of photosynthetic apparatus in *Triticum aestivum* (wheat) when applied against two fresh-water rooted macrophytes *Elodea densa* and *Ludwigia natans*. (Varshney *et al.*, 2012)
- It also decreases the activity of ribulose bisphosphate carboxylase (Rubisco), one of the most crucial enzymes of photosynthesis.
- In addition to the above, a decrease in protein and chlorophyll content was also observed.
- When the chlorophyll fluorescence technique, used to study the photosynthetic activity, was carried out, it revealed that the photosystem II was inhibited inside the leaves, followed by changes in the fluorescence intensity after droplets of isoproturon were accumulated on leaves from wheat and maize plants.
- Other organochlorine herbicides like dalapon and diuron used against a wide variety of annual and perennial weeds, algae and mosses inhibit the photosynthesis in many crop plants like *Triticum aestivum* L., *Saccharum officinarum* L., *Medicago sativa* L., and *Gossypium herbaceum* L. by decreasing oxygen production and blocking the electron transfer of photosystem II.

2. Effect on oxygen scavenging potential:

- Accumulation of O_2 and H_2O_2 in leaves of several plants from crop fields occurs when treated with chlorotoluron, a phenyl urea herbicide. This results in the lipid peroxidation of the plasma membrane in plant leaves.
- The activity of superoxide dismutase (SOD) and glutathione S-transferase (GST) gets retarded when wheat and maize crop fields are subjected to metribuzin, isoproturon and diflufenican. This ultimately leads to the persistence of xenobiotic compounds in plants. Hence, the crop shows a phytotoxic effect in response to those herbicides.

3. Effect on growth and development:

- Leaf chlorosis, necrosis, plant deformations, smaller-sized plant, withering of leaves, and growth retardation are some common impacts of herbicides on plants.
- Along with the above-mentioned herbicides, atrazine and carfentrazone-ethyl minimize the nodulation (nodule number and dry mass) in *Vigna radiata* L. (green gram).
- Poor grain yield was also observed in some plants.

EFFECT OF FUNGICIDES ON CROP

A fungicide is a chemical or mixture of chemicals used to kill, inhibit, or eradicate the growth of fungi or molds.

Several chemical compounds, primarily based on copper, sulphur, or fludioxonil, are employed in non-systemic management strategies to avoid agricultural plant disease. Copper is widely introduced in agriculture as a pesticide (e.g., Bordeaux combination) and an algicide. When fungicides are applied, the crop's physiology changes, including how it grows and develops and uses nitrogen or carbon. This former physiological characteristic, which is expressed by both the photosynthetic rate and mobilization of carbohydrate stores, is crucial for crop cultivation. (Gikas *et al.,* 2022)

1. Effect on photosynthesis:

- As a component of several proteins, notably those involved in both the photosynthetic (plastocyanin) and respiratory (cytochrome oxidase) electron transport chains, copper is thus a crucial micronutrient for plants. A large amount, nevertheless, is very phytotoxic for crops.
- Chlorophyll fluorescence investigation of copper-based fungicide Bordeaux mixture on cucumber leaves showed modification in chloroplast ultrastructure, inhibition of Rubisco, lower chlorophyll content, inhibition of photosystem I and II. (Petit *et al.,* 2012) (Vinit-Dunant *et al.,* 2002).
- Growth inhibition does, in fact, reduce the export of carbohydrates from leaves, accumulate starch and sucrose, and ultimately produce a feedback inhibition of photosynthesis (Vinit-Dunant *et al.,* 2002).
- Barley crops show a similar effect when exposed to copper-based fungicides, which inhibit pigment accumulation and retards chlorophyll.

2. Effect on stomatal closure:

- Copper and Sulphur-based fungicides, when accumulated in plants' leaves, affect the opening and closing of stomata. Due to this, the transpiration rate of the plant gets affected.

3. Effect on respiration:

- Fungicide strobilurin belonging to the group of Beta-methoxyacrylate compounds prevents fungus from respiration by attaching to the inner mitochondrial membrane's cytochrome bc1. In addition to fungi, strobilurin can inhibit respiration in spinach, corn and wheat plants (Glaab and Kaiser, 1999).

EFFECT OF INSECTICIDE ON THE CROP

An insecticide is a chemical or mixture of chemicals used to inhibit or kill insect pests, for example, mosquitoes and cockroaches.

Insecticide application has typically become necessary for crop protection in India. Hence, the use of insecticide is comparatively more than the other pesticides. Insecticides include contact poisons, fumigants (inhaled poisons), and stomach/gastrointestinal canal poisons (poisonous upon intake). Insecticides that are often used include Dichloro- diphenyl- Trichloroethane (DDT), endosulphan, which belongs to the group of insecticide known as organochlorines and is mostly used to control mosquitoes, whiteflies, aphids, leafhoppers, Colorado potato beetles, and cabbage worms. To exterminate ants, the agricultural field is treated with the organochlorine pesticide Mirex. In Asian nations, organophosphates like malathion, parathion, and fenitrothion are often utilized. In India, fennitrothion is used to control mosquitoes (Pandya, 2018). Thiamethoxam is a second-generation neonicotinoid insecticide commonly introduced to the agricultural field against winter worker honey bees.

1. Effect on the height of crop:

- Thiamethoxam treatment in soybean fields results in a positive outcome. In addition, thiamethoxam may function as a growth regulator, causing the plant to grow taller.
- On the treatment of *Gossypium hirsutum* L (cotton) and *Abelmoschus esculentus* L. (okra) seeds with thiamethoxam, a similar effect on plant height was observed. (Gnanadhas *et al.*, 2012)
- On the contrary, the toxic impact of fenitrothion, which prevents plants from using reserve resources, lowers the activities of hydrolytic enzymes, and disrupts protein metabolism, may be the reason for the lowered plant height on treatment.

2. Effect on photosynthesis:

- Thiamethoxam treatment increases the amount of soluble protein in plants *like Oryza sativa* L. (Asian rice) and *Phaseolus vulgaris* L. (common beans), which improves the efficiency of carbon dioxide fixation and speeds up photosynthesis.

3. Effect on mineral nutrients:

- A considerable decrease in the available nitrogen and phosphorus levels of the organophosphate insecticide-treated soil.
- This ultimately leads to a deficiency of mineral nutrients in plants. In addition, this condition will interfere with many metabolic pathways, like nitrogen metabolism and amino acid synthesis.

EFFECT OF RODENTICIDE ON THE CROP

Rodenticide is a chemical or mixture of chemicals used to prevent or kill rodents like rats and snakes. Rodenticides are commonly added to baits as their small amounts are extremely fatal to rodents. Sodium fluoroacetate, fluoroacetamide, strychnine, crimidine, yellow phosphorus, zinc phosphide, cholecalciferol and thallium sulfate can cause extreme toxicity. Humans and domestic animals are less vulnerable to anticoagulants, indandiones and red squill. (Abhilash & Jayakaran, 2020)

1. Effect on yield:

- The study of the rodenticide effect usually resulted in an increase in the yield of crops. Plants showed tolerance to the rodenticides applied in the field. (Salmon, 1987)
- The common adverse effects are surface water contamination, water and soil logging in the field, unavailability of macro and micronutrients and bioaccumulation of toxic compounds.

A significant investigation of the in-crop impacts of rodenticide is currently ongoing. As a result, much information is not accessible.

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Chapter 10

PROBLEMS OF RADIATION EXPOSURE FROM MOBILE PHONES AND LAPTOPS

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ABSTRACT

Cell phones and laptops are unavoidable, and we can't live without them. The rising usage of cell phones and laptops in modern civilization has a negative impact on health. People who work in information technology have a hard time integrating cell phones and computers into their daily routines. Other digital wireless systems, such as data communication networks, emit similar radiation. Radiofrequency in the 0.7–2.7 GHz band is generated by 2G, 3G, and 4G. The frequency spectrum up to 80 GHz is planned to be used by 5G (fifth generation) cell phones. The normal functioning of human cells, the brain, and the immune system may be disrupted by electromagnetic radiation emitted by mobile phones, raising the risk of a variety of disorders. According to a study of University College, London, staying in front of a computer or watching television is just as hazardous for our hearts as smoking. Although evidence suggests that mobile phones are not dangerous but long-term risks and consequences must be defined. Children are extremely worried as their developing brains and bodies are more vulnerable to radiation effects than adults. We should be concerned and endeavors to reduce radiation exposure by taking the necessary precautions.

KEYWORDS: Mobile phones, Laptops, Radiation exposure, Radio-frequency, Health hazards.

INTRODUCTION

Cell phones and laptops are indispensable, and their use is unavoidable. In modern civilization, the increasing use of cell phones and laptops has a serious effect on health. The people in Information technology struggle with the use of cell phones and computers in their everyday activities. In 2020, global smartphone usage is allowed to increase by 78 percent. This is based on a global population of 7.8 billion people and a projected 6.4 billion smartphone subscriptions (Statista, 2021). Mobile phones are the only means of communication in certain parts of the world. Mobile phones have grown more trustworthy as a form of communication since they allow people to communicate in real-time, even while they are traveling. Cell phones utilize electromagnetic waves delivered by mobile phone operators in the form of radiofrequency (RF) and microwave signals (Singh and Kapoor 2014). The antennas on mobile phones, including smartphones, generate radiofrequency (RF) radiation, which can be absorbed and converted to heat by the parts of the head or body closest to the antenna. Scientists have been investigating whether the now-ubiquitous radiation connected with mobile phone antennas or cell phone towers affects human health since the 1990s (NIH, 2021). Mobile phone networks use a variety of radio frequency bands, which some overlap with microwave frequencies. Other digital wireless systems, such as data communication networks, emit similar radiation. RF energy, non-ionizing electromagnetic energy constituted of waves of electric and magnetic fields, is known to be emitted by cell phones (Sage and Carpenter 2009). The World Health Organization's International Agency for Research on Cancer declared electromagnetic fields from cell phones and other sources to be "possibly carcinogenic to humans" in May 2011 and encouraged the public to take precautions to limit their exposure (IRAC, 2011).

RADIATION OF WIRELESS DEVICE

Radiation is a mixture of electrical and magnetic energy that moves at the speed of light through space. Electromagnetic radiation is the sort of radiation emitted by mobile phones. It utilizes radiofrequency (RF) waves to make and receive calls. If our body is nearest to the antenna, it can absorb this energy and converted it to heat. Mobile phone networks use a variety of radiofrequency bands, some of which overlap with microwave frequencies. Other digital wireless systems, such as data communication networks, emit similar radiation. 2G, 3G, and 4G generate radiofrequency in the 0.7–2.7 GHz band. Cell phones in the 5G (fifth generation) are expected to use the frequency band up to 80 GHz (NIH, 2021). All of these frequencies are in the nonionizing area of the spectrum, which means they are low frequency and low energy. This does not lead to significant causes, but it results in temperature increases as well as other health complications. These RF waves are used by cell phones to broadcast and receive signals from neighbouring cell towers (base stations). This type of energy falls between FM radio waves and microwaves in the electromagnetic spectrum. When we make a call, the phone communicates with a nearby base station by emitting radiofrequency (RF) radiation through its antenna. The amount of RF radiation emitted by mobile phone base stations is relatively consistent. The handsets emit varying quantities of RF radiation depending on mobile usage time, the distance between device and body, and the distance between device and base station. The device increases its radiation output to compensate for weak connectivity to the base station (Better health channel, 2014).

HEALTH CAUSES

It is thought that electromagnetic radiation released by mobile phones can disrupt the biological functioning of human cells, the brain, or the immune system, increasing the risk of numerous diseases (Jorgensen and Marko 2011). Young children are more vulnerable to the electromagnetic radiation released by cell phones than adults due to their thinner skulls and higher tissue conductivity (Sallomi 2012). When RF radiation reaches a high enough level, it has a 'thermal' impact, since it elevates body temperature. Low amounts of RF radiation emitted by mobile phones have been linked to health problems such as headaches and brain tumors. Mobile phones associated with Airborne contaminants exposure has been linked to disorders such as eye cancer, ear tumors, brain tumors, high blood pressure, memory loss, Parkinson's disease, migraines, dizziness, sleeping problems, loss of libido, and infertility (Bhalerao *et al.,* 2013). According to the study, RF-EMR reduces sperm count and motility and increases oxidative stress (La Vignera *et al.,* 2012), (Agarwal *et al.,* 2014). According to a 2021 evaluation, 5G radio frequencies in the range of 450 MHz to 6,000 MHz influence male fertility, may also affect female fertility, and may have negative consequences on the development of the embryo, foetus, and neonates. Due to a lack of relevant investigations, no conclusions could be formed for higher frequencies (Belpoggi, 2021).

According to the European Research Institute for Electronic Components in Bucharest, Cell phone radiation causes a lack of blood hemoglobin. The study of University College London indicates that staying in front of a computer and television is just as bad for our heart. People who spend four hours or more per day on computers or watching television are 125 percent more likely to develop severe heart disease than those who spend two hours or less. The bad news is for anyone who works at a computer from 9 a.m. to 5 p.m is worse, the research reveals those persons who spent too much time looking at a computer or television screen had a 48 percent higher risk of mortality from any cause (The Economic Times, 2011). The other effect is using a cell phone while driving increases the chance of a traffic accident substantially. In all countries, driving while using a hand-held mobile phone is forbidden.

CANCER-RELATED RESEARCH

NTP (National toxicology program) conducted two-year toxicology experiments in rats and mice to assist clarify potential health risks, including cancer risk, from exposure to RFR such as that applied in 2G and 3G cell phones, which operate in the 700–2700-megahertz range (MHz). According to the NTP investigations, increased exposure to RFR (900 MHz) used by cell phones was linked to the strong evidence of a link between malignancies in male rats' hearts. Malignant schwannomas were the tumours. There is some evidence of a link between malignancies in the brains of male rats. Gliomas were malignant tumours. There is some indication of a link with malignancies in the adrenal glands of male rats. There were three types of tumours observed such as benign, malignant, and complex mixed pheochromocytoma. The $30 million NTP research took over ten years to complete and is the most thorough examination of health consequences in animals exposed to RFR modulations used in 2G and 3G cell phones to date. When the studies were created, 2G and 3G networks were standard, and they are still utilized for phone calls and texting (NTP, 1999). As a result of using cell phones, children are more prone than adults to develop brain tumours. Their neurological systems are still developing, making them more susceptible to cancer-causing factors (Naeem, 2014).

PRECAUTIONS TO REDUCE RADIATION EXPOSURE

Evidence suggests that Mobile phones are not hazardous, but long-term dangers and effects are clarified. We should have concern and try to decrease the exposure to radiation. Some precautions such as select a smartphone with a low specific absorption rate, which relates to the amount of RF radiation absorbed by body systems. For long conversations on the phone, use an earphone or Bluetooth. The reason behind this is when the distance between the phone and the subject (ourselves) increases, the radiation exposure decreases exponentially. This one exploit lowers your cell phone radiation exposure by 55% to 98 percent. Calls in a low-network area should be limited. In a low-network location, a mobile phone has worked multiple times harder to reach the signals, resulting in substantially higher radiation. When you're gaming, go to airplane mode. The reason for this is that children are more vulnerable to mobile radiation than adults. While gaming, use airplane mode to protect your children from excessive radiation. Depending on the number of hours spent gaming, this hack can lower radiation exposure for your children by 15% to 60% or more (Deccan Chronicle, 2017). The California Department of Health advised people to keep their cell phones several feet away from them on sleep. When we sleep, our body defenses are at their lowest and biological repair processes begin while we are sleeping.

Using low-frequency radio signals to send information, mobile phones put us at the hazard of unsafe radiation, particularly when streaming or uploading large files. Radiation levels are reduced by 98 percent when moving the phone 20cm away from the head. So, instead of putting the phone beneath our pillow put it on a bedside table. Radiation and electromagnetic fields (EMF) can interfere with biological repair and induce restless sleep (DNA, 2018). Refuse to talk on the phone while driving or riding. Because cell phone calls aren't the only thing that causes accidents when driving. The metal construction of the vehicle concentrates the RF radiation, amplifying the RF effect on the body. Avoid placing the mobile front side near to us. The antenna is normally located on the phone's front side. We may establish a distance differential by keeping the backside away from the body, which minimizes the amount of EMF radiation absorbed by the body. If don't need Bluetooth, WI-Fi, or a hotspot on the phone should turn it off. Because all of these operations are radiation functions, they transfer EMF radiation and actively contribute to excessive radiation. Phones were never intended to be carried in pant front sockets. It causes the effect of EMF radiation on male fertility. Carry the phone in a hip pocket or on a belt clip purse (Deccan Chronicle, 2017).

CONCLUSION

It is really sensible to take the necessary precautions where children are extremely worried as their developing brains and bodies are more vulnerable to radiation effects than adults. We need to think of our cell phone as a tiny microwave that carries with us all time, so we may choose to be more responsible with it. We should have concern and try to decrease radiation exposure by following the precaution measures.

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Chapter 11

NANO CHEMISTRY AND THEIR APPLICATIONS

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ABSTRACT

Nanoscience is interesting in part of course because it by definition is new. But a more profound and important reason is that it deals with objects which are only slightly larger than an atom. This means that the properties of the objects can be influenced by direct manifestations of quantum mechanics. It is also possible that nanoscale objects do behave just like as expected from (semi)classical physics, but the downgrading in size opens possible new applications.

KEYWORDS: Nanoscale, Nano Chemistry, Magnetic Resonance Imaging Detection.

INTRODUCTION

The development of novel techniques for producing nanoscale materials is the focus of the newly growing field of nanochemistry, which belongs to the chemical and material sciences. The chemical and material sciences have a new field of study called nanochemistry.It focuses on the creation of novel techniques for making nanoscale materials. In contrast to the nanoengineering and nanophysics approaches, which work from the bulk "down," Ozin originally adopted the term "nanochemistry" in 1992 to describe the use of chemical synthesis to afford nanoparticles in a reproducible manner. In contrast to the actual generation of matter, nanochemistry concentrates on solid-state chemistry, emphasizing the synthesis of building blocks that depend on size, surface, shape, and defect features. Iron oxide (rust) can be used in nanochemistry to create the most effective contrast agent for MRI, which can identify cancer and eradicate it in its early stages. Lights can be bent or stopped in their tracks using silica (glass). Silicone is often utilised in developing nations to produce fluid detecting circuits for pathogens. The building blocks of functional structures that could be helpful for electronic, photonic, medicinal, or bio analytical issues self-assemble as a result of nano-construct synthesis. Carbon nano materials including carbon nanotubes, graphene, and fullerenes, which have attracted interest recently due to their extraordinary mechanical and electrical properties, can be produced using nanochemical techniques.

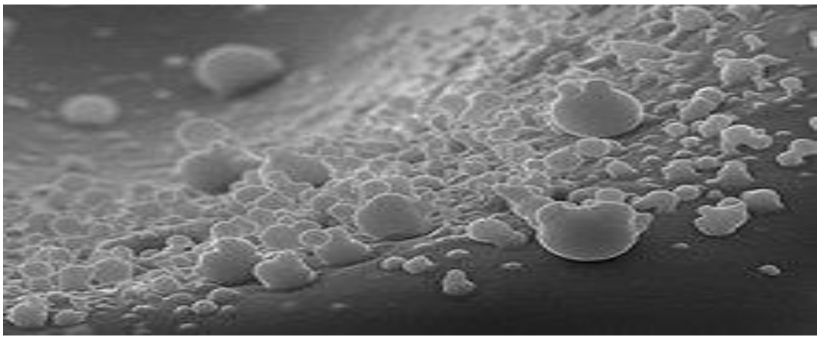

Figure 1: Selenium Nanoparticles

MEDICINE

MAGNETIC RESONANCE IMAGING DETECTION (MDR)

The most effective contrast agent for MRI imaging can be made from iron oxide (rust), which can detect tumours and eliminate them in their early stages. Silica can be used to bend or stop lights in their tracks (glass). Developing countries also use silicone to make methods for filtering the liquids used in pathogen detection the building blocks of functional structures that could be used for electrical, photonic, pharmacological, or bio analytical problems self-assemble during nano-construct synthesis. Nanochemical methods can be used to create carbon nanomaterials such as fullerenes, graphene, and carbon nanotubes. Because of these materials' remarkable mechanical and electrical properties, attention has been drawn to them recently. Uses particular light wavelengths to release the cargo. A version of MSN containing gold molecules employs nano valve-controlled cargo release that uses low-intensity light and plasmonic heating to discharge the cargo. Near-infrared light wavelengths are used by the two-photon activated photo-transducer (2-NPT) to cause a disulfide bond to rupture; releasing the several creative new medicinal techniques have been developed as a result of the distinctive structure of carbon nanotubes. The ability of carbon nanotubes to detect and treat diseases is improving as more medicine is created at the nanoscale. Candidate for novel therapeutic approaches and detecting techniques. In particular, carbon nanotubes can be modified into complex biomolecules that enable their detection through variations in the fluorescence spectra. Moreover, carbon nanotubes can be made to fit a small drug's size and be endocitoized by a target cell, turning them into delivery agents. Cargo Lately, nano diamonds have shown promise for drug administration due to their non-toxicity, skin-based spontaneous absorption, and blood-brain barrier penetration.

BARRIER

Several creative new medicinal techniques have been developed as a result of the distinctive structure of carbon nanotubes. Carbon nanotubes are a stronger possibility in new medical applications as more medicine is developed at the nanoscale to revolutionise how people diagnose and cure illnesses.

TISSUE ENGINEERING

Because cells are extremely sensitive to Nano topographical characteristics, tissue engineering has pushed towards implantation through surface optimization. A meticulously designed 3-

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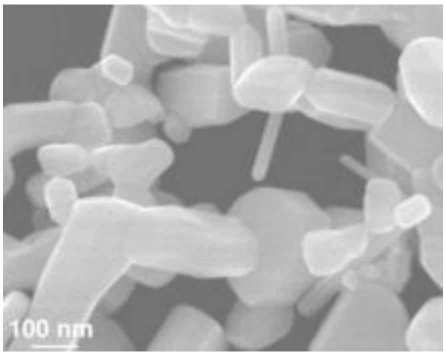
dimensional framework is utilised to guide cell seeds towards the formation of artificial organs when the circumstances are right.

The three-dimensional scaffold includes several nanoscale elements that regulate the environment for the most effective and appropriate functionality. The scaffold mimics the extracellular matrix seen in living organisms and provides the complex biological components required for successful artificial organ growth in vitro.

WOUNDS HEALING

Nanochemistry has proven applications for accelerating the healing of wounds and abrasions. In biological tissue engineering, electro spinning is a polymerization technique that can also be utilised for drug administration and treating wounds. This results in the creation of nanofibers with regulated antibacterial and cell growth characteristics. These characteristics are visible at the macro scale, but versions at the nanoscale may function more effectively because of their Nano topographical characteristics. Targeted contacts between nanofibers and wounds have better in vivo surface area interactions. There is proof that certain silver nanoparticles can help stop some germs and viruses.

COSMETICS



Zinc oxide nanoparticles

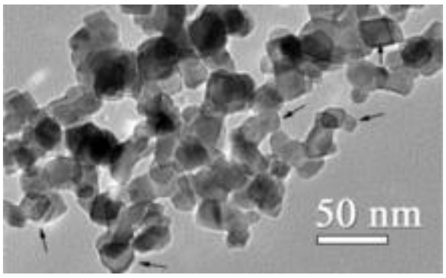


Figure 2: Titanium dioxide nanoparticles

Materials used in some cosmetics, including sunblock, moisturizer, and deodorant, may benefit from the application of nanochemistry. By facilitating oil nano emulsion, manufacturers are aiming to improve the efficacy of various cosmetics. These substances have pushed the limits of how to treat aged skin's wrinkling, dehydration, and inelasticity. Although they can pass through skin, titanium dioxide and zinc oxide nanoparticles in sunscreen are efficient UV filters. These substances shield the skin.

ELECTRICS

NANOWIRE COMPOSITIONS

Several different nanowire compositions with controllable lengths have been developed by scientists. Using vapour and solution phase techniques, the diameter, doping, and surface structure were investigated. The semiconductor nanowire devices used in these orientated single crystals include such as sensors, lasers, logic circuits, and transistors. The one-dimensional structure of nanowires results in a high surface-to-volume ratio, which increases the diffusion resistance. Decreases. In addition, the quantum confinement effect, which increases electron transit efficiency, causes their electrical characteristics to be slightly perturbed.

CATALYSIS

NANOENZYMES (OR NANOZYMES)

The small size of Nano enzymes (or nanozymes) (1–100 nm) has provided them with unique optical, magnetic, electronic, and catalytic properties. Moreover, the control of surface functionality of nanoparticles and the predictable nanostructure of these small-sized enzymes have allowed them to create a complex structure on their surface that can meet the needs of specific applications.

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NANODIAMONDS

SYNTHESIS

Nanodiamonds Synthesis Fluorescent nanoparticles are in high demand. They have wide applications, but their use in macroscopic arrays allows them to be used effectively in plasmonics, photonics, and quantum communication applications. Although there are many methods to assemble nanoparticles, especially gold nanoparticles, they are generally weakly bound to the substrate and therefore cannot be used in wet chemical processing steps or in lithography. Nanodiamonds allow greater access variability, which can later be used to combine plasmonic waveguides to realize quantum plasmonic circuits. Fluorescent Nanodiamonds surrounding living hela cells Nanodiamonds can be synthesized using nanoscale carbon seeds created in a single step using an unmasked electron beam-induced positioning technique to add amine groups. It combines Nanodiamonds. The presence of dangling bonds on the Nanodiamonds surface enables their functionalization with multiple ligands. Living hela cells are encircled by fluorescent Nanodiamonds. Nanoscale carbonaceous seeds made in a single step utilizing a mask-free electron beam-induced position approach can be used to make nanodiamonds. Groups of amines. This puts nanodiamonds together into an array. The nanodiamond surface has dangling bonds that can be functionalized with a variety of ligands. These nanodiamonds' surfaces have carboxylic acid group terminations, allowing for carbodiimide coupling chemistry to enable their attachment to amine-terminated surfaces. This method depends on covalent interaction between the carboxyl and amine functional groups on amorphous carbon and nanodiamond surfaces in the presence of EDC to produce a high yield. They can therefore tolerate processing and treatment for various device applications, unlike gold nanoparticles

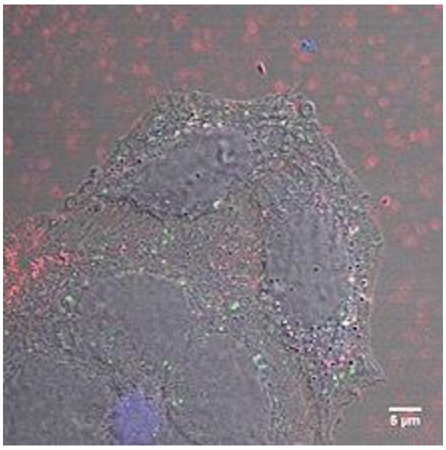


Figure 3: Fluorescent nanodiamonds surrounding living HeLa cells

FLUORESCENT (NITROGEN VACANCY)

Nitrogen-vacancy (NV) centres, which are nitrogen atoms adjacent to a vacancy, are what give nanodiamonds their fluorescent features. It was created to use fluorescent nanodiamond (FND).in 2005 and has since been applied to other academic disciplines.[29] A US patent was issued for the invention in 2008 States7326837 B2 United States 7326837 B2, Chau-Chung Han; huancheng Chang & Shen-Chung Lee *et al.*, "Clinical applications of crystalline diamond particles", issued February 5, 2008, assigned to Academia Sinica, Taipei (TW), and a later patent in 2012 States8168413 B2 United States 8168413 B2, Huan-Cheng Chang; Wun (TW). By bombarding nanodiamonds with high-energy particles (such as electrons, protons, and helium ions), followed by vacuum annealing, NV centres can be produced.

DRUG-DELIVERY AND BIOLOGICAL COMPATIBILITY

Delivery of medications and biological compatibility with the ability to self-assemble, nanodiamonds can bind a variety of small molecules, proteins, antibodies, medicines, and nucleic acids, enabling the administration of drugs, protein mimicry, and surgical implants. Additional possible biomedical uses for nano diamonds include solid-phase peptide synthesis support, detoxification and separation sorbents, and biomedical imaging with fluorescent nano diamonds. Nano diamonds possess the features required for a drug delivery platform, including biocompatibility, the capacity to carry a wide range of treatments, water dispersability and scalability, as well as the potential for tailored therapy. Nano diamonds' small size, stable core, rich surface chemistry, capacity for self-assembly, and low cytotoxicity has sparked ideas that they might be utilised to mimic other materials.

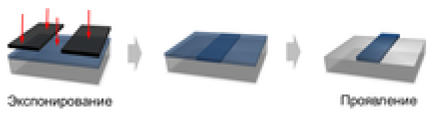
NANOLITHOGRAPHY

Nanolithography is a technique for patterning materials and building nanoscale devices. Nanolithography is often used in combination with thin film deposition, self-assembly and self-assembly techniques for various nanofabrication purposes. Many practical uses it uses nanolithography involving computer semiconductor chips. There are many types of nanolithography including:

- Photolithography
- Electron beam lithography
- X-ray lithography
- Extreme UV lithography
- Photo coupled nanolithography
- Scanning probe microscope
- Nano imprint lithography
- Dip-pen nanolithography
- Soft lithography

Each nanolithography technique has resolution, time consumption, and cost. There are three basic methods used in nanolithography. One is a resist material that acts as a "mask" to cover and protect areas known as photoresist a surface that should be smooth. Exposed parts can now be etched It is removed using the protective material as a template. The second method is directlyarve the desired pattern. Etching may involve the use of beams of quantum particles.

B. Electronic or optical, or chemical methods such as oxidation or self-assembly Single layer. The third method is to place the desired pattern directly on the surface, a final product that is a few nanometers thicker than the original surface. To visualization of the generated surface, the surface should be visualized at nano resolution Microscopes including scanning probe microscopes and atomic force microscopes microscope. Both microscopes can also be integrated into the final product processing.



Negative photoresist

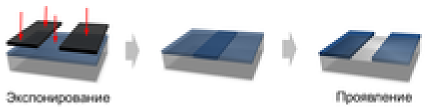


Figure 4: Positive photoresist

PHOTORESISTS

A photoresist consists of a polymer, a sensitizer, Solvent. Each element has a specific function. Polymers change their structure. Exposed to radiation. Solvents allow the photoresist to be spun and thinned a layer above the wafer surface. Finally, if a sensitizer or inhibitor is Photochemical reactions in the polymer phase. Photoresists can be classified as positive-acting or positive-acting. Negative. In positive photoresist, the photochemical reaction that occurs during exposure is it weakens the polymer and makes it more soluble in developer to maintain a positive pattern Reached. The mask therefore contains an exact copy of the pattern it is intended to hold. On the wafer, as a template for further processing. For negative photoresist the exposure causes the photoresist, the negative resist, to polymerize. It remains on the exposed substrate surface and developer. Remove only the unexposed areas. Masks used for negative photoresist include:

The reversal of the transferred pattern or photographic "negative". Both negative Positive photoresist has its own advantages. Advantages of negative photoresist Good adhesion to silicone, low cost, and shortening of processing time can be expected. Advantage of positive photoresists has better resolution and thermal stability.

NANOMETER-SIZE CLUSTERS

Nanometer-sized clusters monodisperse nanometer-sized clusters (also called Nano clusters) are synthetically generated. Grown crystals whose size and structure affect properties through effects quantum confinement. One method of growing these crystals is reverse micellization. Cages in non-aqueous solvents. Study of optical properties they compared mos2 Nano clusters with corresponding bulk crystals and analyzed them absorption spectrum. Analysis reveals this size dependence of extinction. The spectrum of bulk crystals is continuous, whereas the absorption spectrum of nano is clusters have discrete energy levels. This indicates a shift from solid-like to molecule-like behavior that occurs in the reported clusters with sizes of 4.5–3.0 nm. Interest in the magnetic properties of Nano clusters exist for their potential use in magnetic recording. Ferrofluids, permanent magnets, catalysis. Analysis of Fe clusters shows behavior consistent with ferromagnetic or superparamagnetic behavior with strong magnetism interactions within a cluster. The dielectric properties of Nano clusters are also interest due to potential applications in catalysis, photocatalysis and micro capacitors, microelectronics, and nonlinear optics.

NANO THERMODYNAMICS

T. L. Hill first put up the concept of nano hermodynamics in 1960, explaining the distinctions between differential and integral forms of attributes owing to small scales. The power law, or its proportionality, between a nanoparticle's attributes and its environment depends on its size, shape, and environment. The proportionality shifts from exponential to power while moving from macro to nano. Hence, there is a conceptual connection between statistical mechanics and nano thermodynamics.

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Chapter
12

SILK IN MEDICAL APPLICATIONS

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ABSTRACT

Sericulture is method of rearing silkworms on mulberry or non-mulberry plants for the production of silk fibres. Silk fibres are a natural polymer synthesized by special f=gland of the silkworm. The silk contains a natural protein fibroin and sericin. This silk protein is considered to as a potential material for various biomedical applications. Silkworm is used as a bio factory to produce functional protein, which promotes the resource for valuable biomaterial in modern applications. The Silkworm protein and the cocoon are used in various biomedical and healthcare textiles. The natural silk fibroin and sericin are used in various human tissues like skin, bone nerve etc. Apart from this they have properties of anti-cancer, anti-tyrosinase, anti-coagulant, anti-oxidant, anti-diabetic and anti-bacterial. In health care textiles natural fibre applications are been focused globally. Silk is biocompatible, biodegradable, and easy to functionalize and have very good mechanical properties. The by-product of sericulture is cocoons. The proteins found in the cocoon are used in wound dressings, hepatoprotective, and antigenotoxicity. Apart from these, they are used as a fertilizer and as an animal feed.

KEYWORDS: Sericulture, fibroin, sericin, cocoons, silk proteins

INTRODUCTION

Sericulture, a silkworm rearing technique, is done on an economic scale in most developing countries around the world. The core objective of sericulture is to produce silk fiber. India ranks second in the world for silk production. India produces 4 varieties of silk; mulberry (79.23%), eri

(13.32%), tasar (6.8%), and muga (0.54%) (Savithri *et al.*, 2013). Apart from the primary product from the cocoon, various by products are also have significant economic importance (Buhroo *et al.*, 2018).

Sericin and fibroin are the two main proteins generated by the silk- worm as the main component of the cocoons of silk fiber, which is a special structure that is ideal for the transformation of larval meta- morphosis into adults (Mondal *et al.*, 2007; Pandey *et al.*, 2011). Fibroin turns into the raw silk and is used in the manufacture of various cate- gories of silk fabrics. In recent years various research studies have been carried out in cocoon of *B. mori*, fibroin and sericin, due to its importance in the field of polymer science, biomaterials, cosmetics, and the food industries (Bandyopadhyay *et al.*, 2019; Holland *et al.*, 2019; Ye *et al.*, 2020). In the textile industry, sericin is produced after degumming the cocoons. The protein sericin, composed of 18 amino acids, comprises 25–30% of the total weight of the mulberry cocoon (Aramwit *et al.*, 2012a, 2012b). The dead silkworm pupae is the major wastes from the silk industry, which comprises 60% of the cocoon's dry mass. The main composition of pupae is a protein (50%) and fat (30%). The biological importance of sericin has been recently attracted the researchers interest (Tomotake *et al.*, 2010a). Sericins and pupae collected from cocoons are recovered from degumming wastewater, which can be utilised as a valuable natural polymer. This Natural polymer has a wide spectrum of implementations in the field of pharmacology.

Figure 1: Sericulture Applications in Various sectors ((Krishna Kumar Jaiswal *et al.*, 2021)

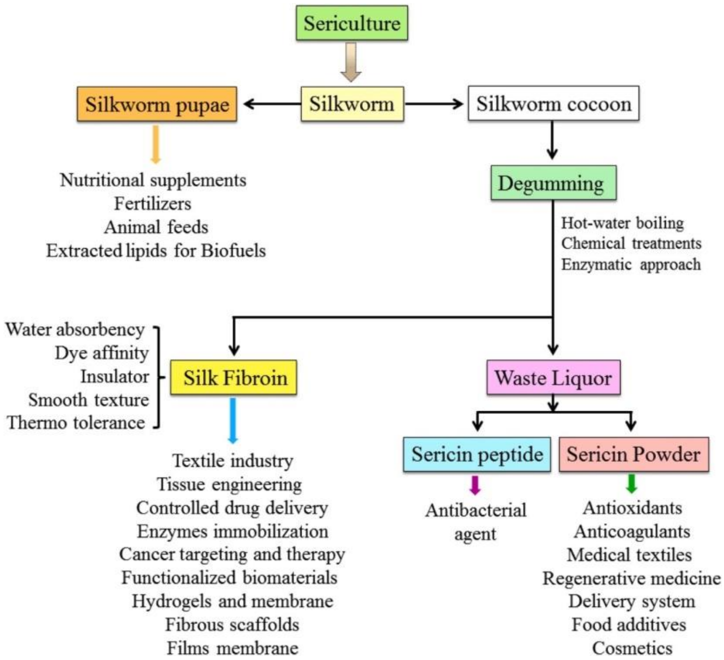

Figure 2: Potential applications of silkworm product and by-product (Krishna Kumar Jaiswal *et al.*, 2021)

Silk cocoons constitute of over 95% proteins and about 5% impurities (mineral salts, waxes, ash). Two proteins viz sericin (gum) and fibroin (fibers) are found in raw silk. The types and composition of the amino acids of sericin and fibroin will differ each other. Non-mulberry silk has lower sericin with high levels of impurities compared to mulberry silk (Padaki N, Das B, Basu A 2015). After degumming, the sericin and other impurities are removed from the raw silk fibers. Therefore, degummed silk will have more fibroin protein (Gupta *et al.*, 2000, Hearle JW, Morton WE 2008).

SILK IN WOUND DRESSING

Recent studies reported that silk fabricated through non-weaving and electro spinning are used in wound dressings, and as drug carriers (Altman G *et al.*, 2003, Li G *et al.*, 2015, Wharram S *et al.*, 2010, Farokhi M *et al.*, 2018. Xia *et al.*, 2009 reported that silk fibers coated with silver nanoparticles shown special antibacterial properties in a wound dressing material. A double layered wound dressing was developed from a wax-coated silk woven fabric, a sericin sponge and a bioactive layer of glutaraldehyde cross-linked silk fibroin gelatin was reported to reduce the size of the wound, collagen and epithelialization (Wang M *et al.*, 2006, Kamalathevan P *et al.*, 2018, Chouhan D *et al*.m 2020). He *et al.*, 2019 shows that fibroin hydrogel from B. mori cocoons have good healing properties due to its biocompatibility nature, low biodegradability and immunogenic properties. On the other hand, Chouhan *et al.*, 2018 reported that Nano fibrous mats of silk, coated with Poly Vinyl Alcohol, (as a blend) mat supported diabetic wound healing. These mats promoted tissue re-modelling and also regulated extracellular matrix.

SILK IN SUTURES

Sutures are important material in surgical operations for primary wound closure. Various materials have been used in making sutures. These materials used in making sutures can be either organic or synthetic according to their origin, or absorbable and non-absorbable based on the durability in the body (Silverstein L *et al.*, 2009) significant properties of a good suture includes high tensile strength, elasticity, wound safety, knot safety and tissue reactivity (Lilly G *et al.*, 1968, Chu C 2013)

Silk, a natural non-absorbable suture material has been used for several decades. However, other degradable synthetic sutures have been widely used in recently. Still, silk suture is preferred in cardiovascular, ocular and other neural surgery due its superior properties like good knot strength, ease of processing, minimum susceptibility to tear through tissue and biocompatibility (Chu C 2013)

To improve the tensile strength, elongation at break and the knot strength, various modifications have been carried out adding poly vinyl alcohol into silk fibroin (Lee KH *et al.*, 2007). To reduce the capillarity of silk sutures, silk filaments are coated with fibroin Bloch & Messores 1969. Viju & Thilagavathi 2013 reported that silk-braided sutures coated with chitosan will improve the antimicrobial activity, tenacity and knot strength. For Wound closure and wound healing antimicrobial silk suture with drug has been developed (Sudh *et al.,* 2017). Choudhury *et al.,* 2016 prepared a low-temperature O2 plasma-treated (Antheraea assama) silk fibroin (AASF) yarn permeated with amoxicillin trihydrate. Thus, producing a controlled antibiotic-releasing suture (AASF/O2/AMOX) will prevent the site from bacterial infection and fastens the wound healing process.

SILK PROTEIN IN DRUG DELIVERY

Many Researchers have been shown that the use of silk fibroin in delivery system for different drugs (Moses JC *et al.*, 2018, Lv Q *et al.*, 2007, Li A *et al*.,2015)

Table 1: Silks in Drug delivery

Type of Drug Delivery System/ material	**Similar active ingredient**	**Results**
Silk sponges	Erythromycin	Drug release and prolonged antimicrobial activity against *Staphilococcus Aureus*
Silk films	Horseradish peroxidase (HRP)	Enhanced stability
	Glucose oxidase (GOx)	Increased enzymatic activity
	FITC-dextran	Controlled drug release
	Epirubicin	Controlled drug release
Silk lyogels	Hydrocortisone IgG	Enhanced efficacy, stability and sustained release
Insertable Silk discs	IgG and HIV inhibitor	Enhanced stability and modified

	5P12-RANTES	release
Silk nanoparticles	Curcumin	Modified release profile and enhanced cellular uptake
Silk microspheres	Horseradish peroxidase (HRP)	Altered the profile release
Silk coated PCL microspheres	Vancomycin	Altered the profile release
Silk coated liposomes	Ibuprofen	Enhanced adhesion to human corneal epithelial cells, tunable drug release
	Emodin	Selective targeting of keloid cells

CONCLUSION

Sericulture has many applications and plays a major part in the textile industry. Sericulture contributes 40% to the silk industry. Apart from the silk industry it contributes to the health care textile and biomedical applications too. However, with increasing demand of more environmentally sustainable materials and products, more bio-based sectors and economies will emerge; hence, an increased uptake of natural biomaterials such as silk, in higher technology application needs more attention and have lot of scope in the biomedical applications.

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Chapter 13

REVIEW OF PESTICIDES RESIDUE ANALYSIS OF FRUITS WITH EXTRACTION AND DETECTION TECHNIQUES

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ABSTRACT

Insecticides have been widely used in agriculture for their beneficial effects on crop yield, quality, and shelf life. However, today's increased pesticide use can be attributed to the world's growing human population and the rapid pace of urbanisation. Constant use of toxic pesticides has harmed ecosystems, ruined crops, and may even threaten human health. Because of this, strict regulations are developed and implemented to monitor these chemicals. The extraction and detection of pesticides can be done using a wide range of methods, from the more traditional to the more cutting-edge. Comprehensive and up-to-date information on the many pre-treatment options, from the more standard ones (like gas chromatography and high-performance liquid chromatography with a variety of detectors) to the more advanced ones, is provided in the current study (such as polystyrene-coated filters).

KEYWORDS: Fruits; pesticides; chromatography; conventional techniques; cutting-edge techniques.

INTRODUCTION

There is a serious issue with the price of food quality due to the widespread use of pesticides. Despite their conventional agricultural knowledge, farmers are at risk due to a lack of technical knowledge regarding pesticides, their applications, and safety precautions(Rome, 2014). Over the past decade, pesticide use has risen in response to the world's growing population and accelerating urbanization (Food, 2020). The accumulation of active components, metabolites, and breakdown products of pesticides in food is potentially dangerous to human health. Consequently, it is crucial to educate consumers on the dangers of ingesting these pesticides through their regular diet. (Boobis *et al.,* 2008).

There are risks associated with ingesting pesticides, and these risks can vary depending on the type of pesticide and its mode of action (Ntzani *et al.,* 2017). Depression, neurological deficits, diabetes, respiratory illnesses like rhinitis, cancer, fetal death, spontaneous abortion, and genetic diseases have all been linked to long-term pesticide exposure. It's obvious that people, especially spray workers, can get sick from being around these pesticides even if they don't ingest them (Azmi *et al.,* 2006).

Insecticides created by humans are Because of their effectiveness, many different types of pesticides, including organochlorine (OC), cyclodiene, organophosphate (OP), carbamate, synthetic pyrethroid, nicotinoid, and triazole, are used in the field.

There have been scant scholarly writings on pesticide quantification reviews over the past decade (Grimalt & Dehouck, 2016) have reviewed the analytical techniques for pesticide residue detection in grapes. (Sharma *et al.,* 2010)have examined the analytical method for estimating organophosphorus pesticide residue in fruits.(Bizuik *et al.,* 2015)have developed a technique for determining currently used pesticides in fruit that is quick, simple, inexpensive, effective, robust, and safe (QuEChERS). Using the QuEChERS method, (Wilkowska & Biziuk, 2011) determined pesticide residues in food matrices. (Hjorth *et al.,* 2011)have determined pesticide residues in fruits from South America. (Syed *et al.,* 2014)have examined the prevalence of pesticide residues in Pakistani fruits. (Neme & Satheesh, 2016)conducted an in-depth analysis of the issues surrounding pesticide residues in plant-based foods, including the health effects and potential solutions.

However, the methods of extraction and chromatographic detection detailed in these reviews are the industry standard. Polystyrene-coated magnetic nanoparticles (Pst/MNPs) are an innovative technique that significantly outperforms the status quo in terms of extraction and sensor-based detection. This paper's goal is to assist food analysts and regulatory authorities in keeping tabs on the quality and safety of fresh food products by analyzing the various pre-treatment, extraction, and detection methods for determining pesticide residues in fruits.

CATEGORIZATION AND TOXICITY OF PESTICIDES

The pesticides are sorted into various categories based on their chemical make-up, country of origin, and intended pest. Both biological and inorganic synthetic (manufactured in a lab) pesticides exist (Biopesticides). In general, synthetic inorganic pesticides are of synthetic origin and directly kill pests. They are majorly classified as I insecticide, (ii) herbicide, (iii) fungicide, (iv) rodenticide, and (v) nematicide. Furthermore, bio-pesticides are made from natural sources like plants and bacteria. There are four main classes of pesticides, including organochlorines (OCs), organophosphates (OPs), carbamates, and pyrethroids. (Sarath *et al.,* 2019).They is carcinogenic, estrogenic, and stable for 10–30 years, making them resistant to the environmental degradation cycle. (Taylor *et al.,* 2013). For agricultural purposes, the use of OCs has been outlawed and has ceased in many parts of the world, including Europe, the United States, and many parts of Asia. Although OCs is being phased out of the environment, they continue to be replaced by other synthetic compounds like OPs and carbamates due to their longevity. These days, OP and carbamate pesticides are commonly used because they are cheap, have a short lifespan in the environment, and are effective against a wide variety of pests. Inhibiting acetylcholinesterase (AChE) is how OPs and carbamates disrupt the normal activity of the CNS in humans and insects. Over 80% of all hospitalizations caused by pesticides are directly linked to the OP compounds, which are most commonly associated with severe human toxicity. (Kumar *et al.,* 2016). However, they are safer than OCs (Narenderan *et al.,* 2019). However, they are safer than OCs. Organophosphate pesticides are organised in Table 1 according to WHO's guidelines for toxicity (WHO, 2010).

Natural chrysanthemum esters, which contain chemicals called pyrethrins, are the source of pyrethroids, another type of pesticide (Ensley, 2018). Natural pyrethroids are less toxic and have a shorter half-life than their synthetic counterparts, but the former are more environmentally stable. This is because of their unique insecticidal activity and low toxicity to mammals. They perform their function by preventing the voltage-gated sodium channel in the neuronal membrane from opening too quickly (Nishimura, 1984).

Despite the widespread use of pesticides in agriculture for pest control, the accumulation of pesticide residues in food products is harmful to consumers and the environment (Carvalho, 2017); (Neuwirthová *et al.,* 2019); (Mostafalou & Abdollahi, 2017); (Narenderan *et al.,* 2019).

Monitoring the concentrations of these residues in food is important because they play a critical role in sustaining plant productivity. A wide variety of methods have been developed for identifying these lingering traces of pesticides. Using search terms like "pesticide residue," "extraction methods," and "detection methods for fruits," a literature search was conducted using Google Scholar, PubMed, and Science goverment (Narenderan *et al.,* 2019).

PRE-TREATMENT AND EXTRACTION METHODS

As shown in Table 2, Pesticide residues in fruits can be determined using a number of different pre-treatment and extraction methods. Unfortunately, when it comes to pesticide extraction in the lab, there are no tried-and-true protocols that everyone follows. Cleanup is a step or series of steps in an analytical procedure wherein the majority of the potential interference co-extracts are removed, either physically or chemically. The extraction procedure involves the release of the desired analyte from the matrices (solid-liquid or liquid-liquid extraction).

Preparing subsamples is the first phase of the extraction process. After being cleaned, the initial material is comprised of 0.5 to 2 kg samples that are homogenized in a mixer. Homogenizing smaller samples (0.5 g to 100 g) facilitates further extraction. Among the most popular solvents for analyzing pesticide residue in fruits are acetonitrile, ethyl acetate, dichloromethane, methanol, and toluene, the study found. Sometimes, a combination of solvents is used to maximize the effectiveness of the procedures for retrieval. Additionally, matrices are neutralized with agents like sodium hydroxide and acetic acid, leading to improved recovery. Both liquid-liquid extraction (LLE) and solid-phase extraction (SPE) were first used because of how easy they were to implement. QuEChERS's micro scale extraction process, however, has led to a dramatic increase in its popularity over the past decade. The QuEChERS method shortens the analysis time, minimizes the number of analysis steps with the use of fewer reagents in smaller amounts, and achieves a high recovery when extracting organic compounds from different matrices (such as food, biological, and environmental samples).(Lehotay *et al.*, 2010).(Afify *et al.,* 2012) reported a method that was compared to the QuEChERS, ethyl acetate, and Luke extraction methods, one of the few published comparisons of extraction techniques. The findings show that the This Luke method significantly impacted the recovery of non-polar and medium-polar compounds, while ethyl acetate significantly impacted the recovery of polar compounds. When compared to other methods, QuEChERS showed excellent recovery for none, medium, and polar samples, with recoveries between 60% and 70%. However, the Luke method was discovered to necessitate the least amount of cleaning when compared to the others. Nonetheless, advancements in extraction methods over the past decade have made sample prep easier, analysis times shorter and toxic solvents obsolete. (Luke *et al.,* 1975)

LIQUID-LIQUID EXTRACTION (LLE)

The process of LLE, also known as solvent extraction and partitioning, involves isolating compounds based on their different levels of solubility in highly immiscible liquids. Since its inception, LLE has proven to be a reliable, flexible, and instrument-friendly method for pesticide extraction. Extraction solvents like hexane, acetonitrile, and ethyl acetate one of the most popular medium-polarity solvents for the extraction of pesticides from their matrices are used in the LLE. (Cho *et al.,* 2013)

In addition to the above solvents, we used a chloroform/dichloromethane mixture and the LLE method to determine the concentrations of seven neonicotinoid insecticides (nitenpyram, dinotefuran, clothianidin, thiamethoxam, acetamiprid, imidacloprid, and thiacloprid). Recoveries ranged from 76% to 123%, and limits of detection (LODs) were calculated to be between 0.002 and 0.005 mg/kg with an R2 of 0.99 (P. Wang *et al.,* 2012). Created a new LLE approach that can detect eleven types of pesticides all at once. A methanol-water extraction was done, and the resulting solution was filtered using nylon syringe filters before analysis. Despite this, LLE is not without its drawbacks; namely, its inability to be automated, its inefficiency when dealing with polar compounds, the length of time required for analysis, and the number of toxic solvents required. The LLE technique also extracts all molecules from the matrix, which leads to significant matrix interferences, and is not analyte specific (Grimalt *et al.,* 2010).

SOLID-PHASE EXTRACTION (SPE)

Because of its low cost, speed, and ability to process a large number of samples while maintaining a high recovery rate, SPE has quickly become the go-to method. Different SPE cartridges are used for pre-treatment and analysis of pesticide residue on fruits. There is a dearth of literature on the use of florisil columns, C18 columns, and Envi-carb cartridges for the analysis of pesticide traces. SPE HLB cartridges and Extrelut NT 20 columns were used to develop an extraction method for analyzing neonicotinoid pesticides (S. Liu *et al.,* 2010). An extraction method using sorbents with different retention mechanisms was developed SAX PAX and GCB sorbent (A. Balinova *et al.,* 2007). Primarily secondary amine (PSA) and graphitized carbon black (GCB) are two common sorbents used in residual estimation.(Bakrc, Acay, Bakrc, & Otleş, 2014) Cleansing processes can be made more sensitive by utilizing a mixture of PSA-GCB-C18 sorbents. Other sorbents, such as multi-walled carbon nanotubes (MWCNTs), are also used for pesticide extraction due to their efficiency. MWCNTs were used as SPE sorbent to remove 36 different pesticide residues from spinach and cauliflower. The recovery rates ranged from 57% to 108%, and the RSD was less than 12% for LODs between 0.1 and 5 g/kg. The results raise the possibility that high-performance MWCNTs could serve as polar pesticides. It is now necessary to acquire a solvent that is suitable for this purpose, as sorbents and organic solvents; either alone or in mixtures, have been used for the extraction and elution of pesticide residues. To analyses a pesticide, one must first determine its molecular properties (ionic and non-ionic) and then choose an appropriate solvent for the job. Acetonitrile, methanol, ethyl acetate, dichloromethane, acetic acid, acetone, hexane, toluene, petroleum ether, cyclohexane, and diethyl ether are all examples of solvents that have been used. According to experts, the SPE technique is the quickest and most accurate way to analyses pesticides. SPE methods offer better separation and recovery from complex matrices, but mastering their application is a time-consuming process. Cartridges may become clogged with sample-suspended material and sorbents may interact with analyte, leading to low recovery. (Fan *et al.,* 2014)

SOLID-PHASE MICROEXTRACTION (SPME)

Simple sample preparation method solid phase micro extraction was developed in 1990. It can be used without the need for any kind of solvent; it works quickly, can be carried around easily, and requires no special training to operate. SPME relies on a phase immobilized on SPME fibre to separate analyte from the matrix (Arthur & Pawliszyn, 1990).

Recently, Using SPME and a GC-ECD system, we were able to detect and quantify eight different pyrethroids (bifenthrin, fenpropathrin, cyhalothrin, permethrin, cyfluthrin, flucythrinate, fenvalerate, and deltamethrin) with a linearity range of 0.3–50 ng/g (S. Zhang *et* *al.,* 2017).The headspace-solid phase micro extraction in fruits with gas chromatography-mass spectrometry analysis was reported in another study GC-MS (Abdulra'uf & Tan, 2015). In a similar fashion, headspace solid-phase micro extraction with gas chromatography-electrospray ionization detection used to determine pesticide residues in strawberry samples (Mee Kin & Guan Huat, 2010).

The experimented with a second SPME method for OPP testing (diazinon, parathion, fenthion, chlorpyrifos). The technique combined a gas chromatography corona discharge ion mobility spectrometer with SPME fibre coated with porous carbon nanotubes-silicon dioxide (CNTs-SiO2) nanohybrids (GC-CD-IMS). LODs were achieved between 0.005 and 0.020 g/L for the prioritized pesticides. The extraction efficiency in this study was higher than that of commercial SPME fibres like polyacrylate (PA) and polydimethylsiloxane (PDMS). The major drawbacks of this technique are its troublesome sample transfer, the fragility of the fibre, and its short lifetime in the extraction process. The low PDMS fibre coating and the interaction between the analytes in the fibre and the analytes in the sample matrix during the sorption process also contribute to the process's inefficiency (Saraji *et al.,* 2016).

MATRIX SOLID-PHASE DISPERSION (MSPD)

The first to describe this method, which can be used to remove both solid and semi-solid samples. MSPD is an efficient, straightforward, and time-saving technique because it combines extraction and cleanup into a single stage. Sample size, dispersant type and amount, and elusion makeup are just some of the many factors that need to be optimised when using the MSPD technique(Barker *et al.,* 1989).Isolated nine organophosphate pesticides (OPPs) from eight fruit species (methamidophos, monocrotophos, mevinphos, methidathion, parathion-methyl, malathion, parathion-ethyl, diazion, ethion). The proposed procedure involved the integration of MSPD with rapid resolution liquid chromatography-tandem mass spectrometry (RRLCMS/MS). RSD was between 2.0% and 11.8%, and the recovery rates varied from 71.2% to 102.8%. We found that the LODs should be set at 0.2 g/kg.(Guan *et al.,* 2011).

In addition, Approximately 105 pesticides were used to compare the MSPD and modified QuEChERS methods. For the SPME extraction, liquid partitioning was used with acetonitrile saturated with petroleum ether. Next, amino propyl was used as the sorbent material, and the final purification was accomplished using an MSPD and a florisil cartridge. Fast liquid chromatography-electrospray time-of-flight mass spectrometry was used for final detection after a series of steps including liquid-liquid partitioning with acetonitrile, dispersive solid phase extraction, and additional cleaning with GCB, PSA, and C18 sorbent (QuEChERS) (LC-TOF-MS). The findings of the study showed that the optimised QuEChERS method was more effective at extraction than MSPD. The limits of detection were found to be between 0.2 and 10 g/kg, with recoveries between 70% and 130%. (Gilbert-López *et al.,* 2010).

QUICK, EASY, CHEAP, EFFECTIVE, RUGGED, AND SAFE METHOD (QUECHERS)

The use of acetonitrile extraction followed by dispersive-solid phase extraction (d-SPE) for clean-up was first introduced in 2003 as the new strategy. This illustrative method of treatment was given the name QuEChERS by the authors. The micro scale extraction procedure used in this method has helped it gain popularity because it is faster, more efficient, and uses less organic solvent than previous methods.(Anastassiades *et al.*, 2003).

Acetonitrile is widely used in extraction processes, so its application is a common practice. It bounced back quickly, which is a good sign. Although acetonitrile and water are miscible, the salt out effect can be used to separate the two before a final cleaning with d-SPE tubes and multiwall carbon nanotubes (Jos ´e Luis Fern ´andez Moreno, A. Garrido Frenich, 2007). The major drawback of ethyl acetate solvent was its propensity to lose basic pesticides in an acidic matrix, but it is still used as an extraction solvent in some situations. Sodium bicarbonate has been proposed as a solution to this problem as it can aid in the recovery of the analytes (Aysal *et al.,* 2007).

In a 2013 study, made use of no sorting or cleaning steps while creating the QuEChERS technique. The proposed method was able to detect 128 analytes with a detection limit of 5 g/kg and a quantification limit of 10 g/kg. The procedure was easy to follow and resulted in high rates of recovery (70-120%) and low RSD values (1%). The matrix effect was also found to be acceptable within the scope of this study (Carneiro *et al.*, 2013).

Also, the impact of pH change on the recovery of specific pesticides using the QuEChERS method is poorly documented in the literature. A high recovery of pH-dependent pesticides is also achieved when an acetate buffer is utilised (Chamkasem *et al.,* 2013). For improved GC detection, a modified version of the QuEChERS technique employing different solvent conditions like methanol and ethyl acetate is utilised. (Collimore & Bent, 2020) and LC (Collimore & Bent, 2020)(Łozowicka *et al.,* 2017). Changes made to the QuEChERS method over the past few years have made it far more effective than older methods. In addition to being easily adaptable to different analyte extraction scenarios, its efficiency in doing so with a minimum of solvent volume has led to its widespread adoption (Narenderan *et al.,* 2019).

Pesticide residues in globe artichoke samples were investigated using the QuEChERS technique. The effectiveness of QuEChERS, MSPD, and dispersive ethyl acetate in the analysis of 98 different pesticides in globe artichoke was compared. CaCl2's ability to dehydrate the sample and form insoluble calcium salts with catholic hydroxyls was used to conclude that the QuEChERS method was improved by including CaCl2 in the clean-up procedure. Moreover, the method's efficacy was evaluated using GC-MS and LC-MS/MS. Both GC-MS and LC-MS/MS had 70-120% recovery at LODs of 0.005-0.025 mg/kg and 0.003-0.015 mg/kg, respectively(Machado *et al.*, 2017).

OTHER EXTRACTIONS METHODS

In spite of the fact that QuEChERS extraction methods are the most frequently used techniques for extraction and clean-up in food samples, other methods are also used in laboratories for the extraction of pesticide residues. Analytes are separated by gel permeation chromatography (GPC), also known as size exclusion chromatography. GPC with ethyl acetate-cyclohexane as the eluent was used to determine the concentrations of 100 pesticides in 240 fruit samples. All of these conventional approaches had drawbacks, including lengthy, multi-step operation times and high costs due to the increased consumption of organic solvents, which made their use in large-scale operations problematic (Knežević & Serdar, 2009).

To identify pesticides, scientists use dispersive liquid-liquid micro extraction (DLLME) have detailed a method for determining pesticide levels in fruit juice, water, milk, and honey that combines the DLLME approach with SPE. The lower limit of detection was between 0.5 and 1 ng/kg.(Shamsipur *et al.,* 2016). Recently, liquid-liquid micro extraction (LLME) for pesticide analysis (Torbati *et al.,* 2018)was reported as an alternative micro extraction technique.

Furthermore, a novel extraction method involving liquid-solid extraction coupled with magnetic solid phase extraction based on Pst/MNPs has been developed for the detection of pyrethroid residue. Study findings suggested that a magnetic core greatly enhances the extraction of target analytes using green solvents (Yu & Yang, 2017).

INSTRUMENTAL TECHNIQUE FOR DETECTION

Due to matrix interference, developing a method for pesticides in real samples becomes challenging. Over the past few decades, gas chromatography (GC) and liquid chromatography (LC) have surpassed other methods for detecting and quantifying pesticides in fruits due to their superior sensitivity, separation, and identification. Pesticide residue in real samples has also been measured using enzyme-linked immunosorbent assay (ELISA) and capillary electrophoresis (CE) (Chen & Fung, 2010). The detection techniques for estimating pesticide residues in fruits are summarized in Table 3.

GAS CHROMATOGRAPHY

The vast majority of the literature on detecting pesticides relies on gas chromatography (GC) in conjunction with a number of different detectors. Electron-capturing detectors (ECDs), flame photometric detectors, and other high-sensitivity detectors (FPD) (Łozowicka *et al.,* 2017), nitrogen phosphorus detector (NPD), and mass selective detector (MSD) are utilised (Bakirci & Hişil, 2012).

In addition, mass detection methods are used to improve method sensitivity, and are equipped with analyzers such as ion trap (IT) (Tao *et al.,* 2009) Quadrupole (de Oliveira *et al.,* 2012) triple quadrupole (QqQ) (Wu, 2017) and time-of-flight mass analyzer (TOF) (Cervera *et al.,* 2012). Further, to minimize matrix interference, selective ion monitoring (SIM) (Lima *et al.,* 2017) or multiple reaction monitoring (MRM) (Walorczyk, 2008) are utilised, where the analyte mass to charge ratio (m/z) is concentrated to achieve a lower detection and quantification limit with less matrix interference. Fast gas chromatography coupled with negative chemical ionization mass spectrometry has been described as a method for analyzing pesticide residues. The majority of GC chromatographic separations are performed using fused silica (30 mm x 0.2 mm i.d., 0.25 m) and either helium or nitrogen as the carrier gas. Over the past decade, GC detection methods have fallen out of favour because of the rise in the use of polar pesticides (less persistence and high toxicity), which are too volatile and thermally unstable to be detected using GC.(Húšková *et al.,* 2009).

LIQUID CHROMATOGRAPHY

Many different liquid chromatography-based techniques have been described for the analysis of pesticide residues, with the majority of these methods utilizing ultraviolet (UV), photodiode array (PDA), diode array detector (DAD), and mass (MS) detectors. The most widely used stationary phase for chromatographic separation is octadecyl (C18), and in order to speed up multi-residue analysis, gradient mode has been implemented. reported a multi-residue method for determining seven neonicotinoid insecticides using high-performance liquid chromatography (HPLC) and DAD, with separation accomplished using an aglient TC-C18 column (P. Wang *et al.,* 2012). HPLC-DAD analysis was used to develop a method for estimating the rate of fenpyroximate breakdown in apple, citrus, and grape. Along with the aforementioned techniques (Abd Al-Rahman *et al.,* 2012) For the HPLC analysis of trichlorfon and monocrotophos, they reported using molecular imprinted solid-phase extraction. The identification of pesticide residues in fruits is complicated, even with the help of liquid chromatography coupled with UV, PDA, and DAD systems, because providing structural information is difficult. Molecular mass and fragmentation patterns can be used in tandem with MS/MS mass spectrometry to reveal structural information and circumvent these interventions (X. Wang *et al.*, 2014)

Liquid chromatography with mass detection is being used in a number of ongoing studies, with different organic phases (acetonitrile and methanol) and buffers being tested on reverse phase columns like C-8, C-12, and C-18 (formic acid, ammonium formate, acetic acid, ammonium acetate). Water-acetonitrile and water-methanol solvent mixtures are sometimes used in gradient mode at flow rates of 0.2 and 1.0 mL/min (Christia *et al.,* 2015)(Jallow *et al.*, 2017).

Due to their ability to ionize both polar and non-polar analytes, electrospray ionization (ESI) ionization sources are frequently used in MS detection (Dzuman *et al.*, 2015) For qualitative and quantitative analysis, mass analyzers such as triple quadrupole (QqQ) (Rong *et al.,* 2018) and Q-Trap (Marinas *et al.*, 2010) are also utilised. In addition to these analyzers, (Bakirci & Hişil, 2012) have reported a single-quadrupole multi-residue method for the analysis of 128 pesticide residues. Another study (Guan *et al.,* 2011) described a rapid resolution LC-MS/MS technique equipped with QqQ-MS and ESI for the estimation of OPPs in fruits. Further, (Tian *et al.,* 2016) have reported a modified QuEChERS method equipped with LC-MS/MS for the simultaneous determination of penflufen and one metabolite in cereals.

Recently, ultra-performance liquid chromatography (UPLC) has been reported as a viable alternative to LC-MS and MS/MS for the analysis of pesticides in fruits because of its chromatographic efficiency and sensitivity. have reported a technique using ESI and TOF detection for identifying pesticide traces in produce (Sivaperumal *et al.*, 2015).

(Carneiro *et al.,* 2013) and (S. Liu *et al.,* 2010) have developed an ESI-based QqQ-MS method for the determination of pesticides in fruits. (Grimalt *et al.,* 2010) describe a method for the quantification and confirmation capabilities of UPLC coupled with triple quadrupole and hybrid quadrupole time-of-flight mass spectrometry in pesticide residue analysis. (Mastovska *et* *al.,* 2010) have described a method for multi-residue analysis in cereal grain by combining the QuEChERS method with automated direct sample introduction in UPLC-MS/MS. (Rong *et al.,* 2018) reported a UPLC-MS/MS method for the simultaneous determination of three pesticides and their metabolites in unprocessed foods other than fruits.

COMPARISON OF CONVENTIONAL EXTRACTION AND DETECTION APPROACHES

It is shown in the paper that a number of extraction and clean-up procedures, including LLE, SPE, GPC, SPME, and MSPD, have been developed and implemented for the extraction and clean-up of various contaminants to generate highly sensitive methods by minimizing matrix interferences. Most recovery techniques work, but they have flaws like a lengthy equilibrium time, carryover, and matrix effect. Due to its high extraction efficiency, the QuEChERS method has been the subject of the most research for multi-residue analysis. (Narenderan *et al.,* 2019); (H. Zhang *et al.,* 2017). This method is found to be user-friendly, low-cost, and instrument-agnostic. New developments in the QuEChERS method, which utilizes multi-walled carbon nanotubes in the cleaning process, have been found to significantly boost the efficiency of the conventional method (Ma *et al.,* 2019). Because of its ability to absorb specific acidic analytes and degrade base-sensitive compounds, the conventional method typically employs PSA material for its clean-up (Bakırcı et al.,2014). Some recoveries were impacted by matrix independence; consequently, a new technique involving buffers like 1% acetic acid was developed and dubbed the buffered QuEChERS method (Lehotay *et al.,* 2010).

The detection of pesticides at lower concentrations is just as important as the extraction process for pesticide residue analysis. Initially, LC-based methods were rarely used with UV, DAD, and fluorescence detectors due to their low sensitivity and selectivity. Since MS's introduction, LC systems have become more popular due to their sensitivity. ESI was found to be an effective analytical method for identifying pesticide traces in food. Due to its higher sensitivity and selectivity in the detection of pesticide residues in fruits, literature suggests that detection methods based on UHPLC coupled with MS/MS (QqQ) have increased in popularity.

It was only possible to quantify volatile and thermally stable compounds using GC detection, while LC detection could measure any compound. The fact that most compounds were non-volatile necessitated the increased use of LC methods for pesticide detection.

ADVANCED EXTRACTION AND DETECTION METHODS

Pesticide levels in produce have been measured using a number of extraction methods. QuEChERS has seen extensive use for pesticide residue extraction, but it does not enrich the extracted material. Therefore, a novel extraction method utilizing polystyrene-coated magnetic nanoparticles is an up-and-coming technique that has the potential to be used for massive-scale pesticide residue analysis processing. There are a number of benefits to using Pst/MNPs rather than more traditional extraction methods. Although magnetic solid phase extraction has many benefits, it is currently only applicable to liquid samples.(Narenderan *et al.,* 2019)

Traditional analytical methods, like gas and liquid chromatography, are typically used to detect pesticides because of their high selectivity and sensitivity at low detection limits. However, these approaches have drawbacks, such as being time-consuming, requiring specialized labour, and necessitating costly machinery. Traditional analytical methods, like gas and liquid chromatography, are typically used to detect pesticides because of their high selectivity and sensitivity at low detection limits. However, there are drawbacks to these approaches as well, including the fact that they are time-consuming, need specialized personnel, and necessitate the use of costly tools and technology. Consequently, a cutting-edge sensor-based technique for identifying pesticides is described, which has many benefits over traditional chromatographic methods, including low cost, simplicity, rapid operation, high sensitivity and selectivity on-site detection, and lower detection limits. Among biosensors, optical, electrochemical, piezoelectric, and molecular imprinted polymer (MIP) biosensors are the most common types of detection devices (Patel *et al.,* 2019).

A biosensor method for detecting carbaryl in tomatoes has been developed. This method employs a strategy based on blocking acetylcholinesterase (AchE). An LOD of 2.0 x 106 molL was established (Caetano & Machado, 2008).

The determination of pesticides has involved the use of nanomaterials (Zhao *et al.,* 2015) Graphene and gold nanoparticles are used for the detection of organophosphate pesticides (OPPs; malathion) and carbamates (carbaryl). The LODs for malathion and carbaryl are 4.14 pg/mL and 1.15 pg/mL, respectively, based on the immobilization of acetylcholinesterases (AchE) by the adsorption method. According to a recently reported method, molecular imprinted polymers (MIPs) based on the functioning of the biological receptor have gained widespread use as selectively sensing materials and for identifying substances with a high molecular weight (W. Liu *et al.,* 2015). They have developed a new MIP-based lab-on-paper device that utilizes chemiluminescence detection. Using a detection limit of 0.8 ng/mL and high selectivity, the designed MIP was able to detect dichlorvos.(Tan *et al.,* 2015).

Another nanotechnology-based method for detecting pesticides in food has been developed for rapid and easy implementation (Chawla *et al.,* 2018). Recently, they performed a colorimetric study using acetylcholinesterase inhibition and indoxyl acetate to detect pesticides in food. The use of nanomaterials like metal and metal oxide nanoparticles in pesticide detection is highly concerning because of their toxicity (Kim *et al.,* 2018). The limited number of pesticides that could be detected was identified as the method's greatest weakness, despite the benefits provided by the method. (Rawtani *et al.,* 2018).

IMPACTS OF PESTICIDE RESIDUE REMOVAL

Global population growth and the resulting increase in food production have created a serious problem with food safety. (Rehman *et al.,* 2013). Although pesticide use boosts agricultural output, residues above the maximum allowable levels have harmful effects on animal and human health. (D. Kumari & John, 2019),(Mebdoua *et al.,* 2017). High concentrations of pesticide residues in recently harvested crops represent a serious threat to public health. Furthermore, pesticide use on horticultural crops contributes to environmental pollution and the retention of pesticide degradation products in human food, which can have negative health consequences such as teratogenic, carcinogenic, and immunosuppressive effects (Khan *et al.*, 2020),(Latif *et al.*, 2012),(Qamar *et al.*, 2017).Evidence of more significant pesticide residues could be discovered (Yuan *et al.*, 2014). Pakistani researchers looked into the levels of pesticides still on fruit in the Hyderabad region. Carbofuran and chlorpyrifos, two of the most commonly used pesticides, were found to have extremely high levels of contamination (Latif *et al.*, 2011). In fruits, pesticides have high organochlorine and organophosphate levels (B. Kumari *et al.*, 2006),(B. Kumari *et al.*, 2003)These residues are increasingly ingrained in the food supply chain (Alshehri *et al.*, 2022). Residues of the pesticides carbendazim and neonicotinoids are commonly found in many countries because they are used on fruits to prevent the spread of sucking insects and fungi. (Anwar *et al.*, 2012),(Lozowicka *et al.*, 2014). These contaminants make their way into our food supply and, when ingested by humans, have a deleterious effect on blood circulation, particularly after eating fresh fruits. Pesticide residues in fruit have been studied extensively, and numerous approaches have been explored (Y. Li *et al.*, 2019).(Wahab *et al.*, 2022)

POSSIBLE MEASURES FOR PROTECTING PEOPLE FROM THESE CONTAMINANTS IN FOOD

Consumers' health is at risk when they consume contaminated food. Both unprocessed and refined fresh fruits have been found to contain these pesticides. Nonetheless, many reports have shown that common food processing methods drastically cut down on pesticide residues in fruits. (Chavarri *et al.*, 2005),(Krol *et al.*, 2000). Fruits, like other foods, are prepared in various ways before being eaten. The amount of pesticide residue on a fruit could be affected by a number of factors, including the pesticides' location on the fruit, the amount of water available for pesticide dissolution, the length of time the pesticide spends in the sun, and the rate at which it degrades. Pesticide residues in food pose a greater threat to human health than any other dietary concern, according to public and scientific opinion. Some methods for removing these residues include washing and boiling. Pesticide residues in vegetables like cabbage and cauliflower can be diminished by boiling. The degree to which pesticide residues are reduced by washing depends on the type of fruit and its characteristics (Kar *et al.*, 2012). The various food processing techniques that deal with the effect of pesticide residues have been summarized in Table 4. Even after harvesting raw agricultural goods, the pesticide residues on those foods can change depending on how they were stored, processed, and ultimately consumed. Fruits were prepared in a variety of ways, including boiling, frying, roasting, cooking, pureeing, peeling, blanching, and washing, for the trials, with the majority of these methods being appropriate for commercial or domestic use. Research on pesticide residues in food should include both processing and storage conditions so that results can be generalized. Except for highly concentrated substances, such as those left behind after juicing fruits or pressing or extracting oil from vegetable seeds, processing methods reduced pesticide residue levels in most foods (Wahab *et al.*, 2022).

Table 1: The WHO recommended hazard classification of commonly used organophosphates in India

	Toxicity class [a]	Pesticide common names
Ia	Extremely hazardous	Phosphamidon; Parathion-methyl; Terbufos
Ib	Highly hazardous	Monocrotophos; Propetamphos; Fenamiphos; Oxydemeton-methyl; Triazophos
II	Moderately hazardous	Chlorpyrifos; Dichlorvos; Fenitrothion; Fenthion; Acephate; Anilophos; Diazinon; Dimethoate; Ethion; Quinalphos; Profenofos; Phenthoate; Phorate; Phosalone; Pirimiphos-methyl; Trichlorfon
III	Slightly hazardous	Chlorpyriphos-methyl; Malathion; Temophos

[a] WHO (2010)

Table 2: Summarization of extraction and pre-treatment method for the estimation of pesticide residues in fruits

Extraction method	Matrix	Class of pesticide (s)[a]	Recovery (%)	Reference
Liquid-liquid extraction (LLE)	Apples, pears, grapes, cherry, peach, and apricot.	Dithiocarbamate fungicide (DMDs, EBDs and PBDs)	97 – 101	(Marinas *et al.*, 2010)
	Orange, banana, strawberry,	Multiclass pesticides	70 - 110	(Grimalt *et al.*, 2010)
Solid phase extraction (SPE)	Berry fruits, Rasberry, strawberry, blueberry, and grape	Multiclass pesticides	63 – 137	(Yu & Yang, 2017)
	apple, banana, grape, mango, orange	Multiclass pesticides	74 - 111	(Sivaperumal *et al.*, 2015)
Solid phase microextraction (SPME)	Apple,	Multiclass pesticides	73 – 118	(Abdulra'uf &Tan, 2015)
	Strawberry	OPPS and OCPs	77.3 – 91	(Mee Kin & Guan Huat, 2010)
	Peach	Pyrethroid	85 - 103.5	(S. Zhang *et al.*, 2017)
Matrix solid-phase dispersion	Apple, grape, strawberry, and banana	OPPs	71.2 - 102.8	(Guan *et al.*, 2011)

(MSPD)				
Quick, easy, cheap, effective, rugged, and safe method (QuEChERS)	Orange, Apple,	Multiclass pesticides	70 - 120	(Cervera *et al.*, 2012)
	Grape	Multiclass pesticides	70 - 125	(Lima *et al.*, 2017)
	strawberry, watermelon, apple and grapes	Multiclass pesticides	85 - 106	(Jallow *et al.*, 2017)
Other extraction methods Gel permeation chromatography (GPC)	Oranges, apples, peaches, pears, grape	Multiclass pesticides	Not stated	(Knežević & Serdar, 2009)
Liquid-liquid microextraction (LLME)	Fruits juices	Pyrethroid insecticides	73 - 92	(Torbati *et al.*, 2018)

[a] DMDs: dimethyldithiocarbomates; EBDs: ethylenebisdithiocarbomate; OPPs: Organophosphorus pesticides; OCPs: Organochlorine pesticides; PBDs: porpylenebis dithiocarbomate

Table 3: Detection techniques for the estimation of pesticide residues in fruits.

Detection method [a]	Class of pesticide	LODs (mg/kg)	LOQs (mg/kg)	Reference
HPLC-UV	OPPs (Trichlorfon and monocrotophos)	1.2 - 4.2	Not stated	(X. Wang *et al.*, 2014)
HPLC-PDA	Pyrethroid (05)	0.02 - 0.039	0.072 - 0.128	(Yu & Yang, 2017)
GC-MS-MS (QqQ)	Multiclass pesticides (140)	0.006-0.008	0.01	(Fernández Moreno *et al.*, 2008)
GC-ECD / NPD	Multiclass pesticides (24)	0.005 - 0.01	Not stated	(Aysal *et al.*, 2007)
GC-MS-TOF	Multiclass pesticides (55)	Not stated	0.01 - 0.5	(Cervera *et al.*, 2012)
GC-MSD	Multiclass pesticides (100)	Not stated	Not stated	(Knežević & Serdar, 2009)
GC-MSD / GC-ECD	Multiclass pesticides (25)	0.0005 - 0.005	0.005 - 0.01	(A. Balinova *et al.*, 2007)
GC-MS (QqQ)	Multiclass pesticides (129)	Not stated	0.005 - 0.07	(Walorczyk, 2008)
GC-MS (Q)	Multiclass pesticides (24)	0.0013 - 0.0065	0.0044 - 0.02	(de Oliveira *et al.*, 2012)
GC-MS	Multiclass pesticides (80)	0.0025 - 0.02	0.01 - 0.1	(Lima *et al.*, 2017)

GC-ECD	OPPS and OCPs (08)	0.01	0.05	(Mee Kin & Guan Huat, 2010)
GC-MS (IT)	Multiclass pesticides (39)	0.02 - 0.1	Not stated	(Tao *et al.*, 2009)
UPLC-MS-MS (Q)	Multiclass pesticides (186)	0.00017-0.0019	0.0004-0.0071	(Bakırcı et al.,2014)
LC-MS-MS (QTrap)	Multiclass pesticides (150)	Not stated	0.01	(Afify *et al.*, 2012)
ELISA	OPPs (chlorpyrifos and fenthion)	0.0002 (chlorpyrifos) 0.0005 (fenthion)	Not stated	(Navarro *et al.*, 2013)
ELISA	OPPs (chlorpyrifos-methyl)	0.00032	Not stated	(Y. H. Liu *et al.*, 2011)
CE-BI	OPPs (trichlorfon, omethoate and monocrotophos)	0.00013	Not stated	(J. Li *et al.*, 2017)
CE-MS-MS	Halosulfuron-methyl herbicide	0.002	Not stated	(Daniel *et al.*, 2015)
Electrochemical Biosensor	Carbamate (carbaryl)	0.4 x 10-3 mol/L	Not stated	(Caetano & Machado, 2008)
Electrochemical Biosensor	OPPs (malathion) and carbamates (carbaryl)	4.14 pg/mL (malathion) 1.15 pg/mL (carbaryl)	Not stated	(Zhao *et al.*, 2015)
MIP biosensor (rGO-AuNps)	Carbamate (carbofuran)	2.0 × 10−8 mol/L	Not stated	(Tan *et al.*, 2015)
MIP biosensor (chemiluminesence)	OPPs (dichlorvos)	0.0008	Not stated	(W. Liu *et al.*, 2015)

[a] BI: Biomimetic immunoassay; CE: Capillary electrophoresis; DAD: Diode array detection; ECD: Electron capture detection; ELISA: Enzyme linked immunosorbent assay; GC-MS: Gas chromatography-mass spectrometry; HPLC: High-performance liquid chromatography; IT: Ion trap analyzer; LC-MS: Liquid chromatography-mass spectrometry; MIP: Molecular imprinted polymer; MSD: Mass selective detection; MS-MS: Tandem mass spectrometry;; NPD: Nitrogen phosphorus detection; PDA: Photo diode array detection; Q: Single quadrupole mass analyzer; QqQ: Triple quadrupole mass analyzer; Q-Trap: Triple quadrupole linear ion trap mass analyzer; Q-TOF: Quadrupole-time of flight mass analyzer; RRLC-MS: Rapid resolution liquid chromatography-mass spectrometry; UV: Ultraviolet; UPLC-MS: Ultra-performance liquid chromatography-mass spectrometry; μECD: Micro electron-capture detection.

Table 4: Summary of various food processing techniques dealing with the effect of pesticide residues.

Fruits	Pesticide	Operations	Conditions	Outcomes	References

	Compounds				
Peaches	Vinclozolin Procymidone Fenitrothion Chlorpyrifos-methyl	Washing Peeling Canning	Residues were determined in raw material.	Peeling was identified as the most effective procedure for reducing residues. However, thermal treatment (concentration and sterilization) substantially reduced residues.	(A. M. Balinova *et al.*, 2006)
Apricot	Dimethoate, fenitrothion, ziram, omethoate	Sunlight and ventilated oven drying	Samples warm for 30 min at 100 ◦C and 12 h at 70 ◦C.	The half-lives of the pesticides ranged from 6.9 to 9.9 days, with pseudo-first-order kinetics and degradation rates of 6.9 to 9.9 days.	(Cabras *et al.*, 1997)
Apple	Phosalone	Rotating 'Hatmaker' drum dryer	Steam pressure (5 bars), discharge rate (150 L/h), rotation speed (5–76 cm/s)	Phosalone levels were reduced from 22 to 77%. Manufacturers should seek the total elimination of surface residues, i.e., peeling the fruit to improve quality.	(Mergnat *et al.*, 1995)
Grape	Dimethoate, diazinon, chlorpyrifos, and methidathion	Oven and sun drying	Direct sunlight for 21 days and in an oven at 50 ◦C for 72 h, at 60 ◦C for 60 h, at 70 ◦C for 48 h, at 80 ◦C for 36 h	The greater the temperature, the faster pesticides degrade in grape drying processes.	(Özbey *et al.*, 2017)

CONCLUSION

Pesticides are useful for getting rid of a wide variety of unwanted pests, including termites, weeds, and insects. Even at low concentrations, pesticides can have a negative effect on human health. It is therefore essential to test food for the presence of pesticides. Pesticide extraction is the process of extracting a pesticide from a chemical or biological sample. This process is used to identify and measure the amount of a specific pesticide present in a sample. It can be difficult for food laboratories to choose the best methods and equipment for determining pesticide residues. It can be difficult for food laboratories to choose the best methods and equipment for determining pesticide residues because the list of target compounds and matrices is constantly evolving. When deciding on a sample preparation technique, it is important to take into account its cost, accuracy, selectivity, and sensitivity. The need to evaluate a wide variety of physically and chemically distinct substances makes the development of sample preparation procedures essential for the detection of pesticide multi-residues in food samples. For instance, despite developments in chromatographic separation and detection, equipment still needs to be cleaned for reliable results.

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Chapter
14

NANOCHEMISTRY A NEW PARADIGM FOR THE ACHIEVEMENT OF SUSTAINABLE DEVELOPMENT THROUGH SCIENTIFIC INNOVATIONS

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ABSTRACT

Nanochemistry is an emerging field of nanotechnology that deals with the chemical properties and synthesis of nanomaterials. The development of nanomaterials like 2D nanomaterials, nanocomposites, Nano polymers, zero-valent Nano metals, photolytic nanocatalysts, etc. plays an important role in the achievement of sustainable development goals. Nanochemistry facilitates the sustainable and ecofriendly growth of the agricultural and industrial sectors. Different Nano carriers created using cutting-edge nanotechnology are serving as efficient medication carriers and revolutionizing the field of medicine. A breakthrough in nanotechnology, 2D nanomaterials have superior physical and chemical properties because of their high surface area to volume ratio and high crystallinity. To lessen their environmental impact, water treatment facilities are increasingly turning to renewable energy sources like solar

and wind power. The development of nanotechnology is crucial to the progress of renewable energy sources. The pollution of groundwater reserves endangers both agricultural and drinking water supplies in drought-prone regions. Arsenic contamination of groundwater is widespread throughout the developing world. Uniquely designed nanoparticles and nanocomposites can efficiently remove a wide range of organic and inorganic pollutants, as well as heavy metals, from groundwater.

KEYWORDS: Nanochemistry, Sustainable development, nanocomposites, novel synthesis of nanoparticles.

INTRODUCTION

The characteristic improvement of matter at the nanoscale brings a paradigm shift in the modern world. Nanomaterials play an important role in addressing the world's current industrial and environmental issues. Nanochemistry is the chemical synthesis of sustainable nanomaterials, which can be further applied in different sectors of the world. Nanoparticles like nanozero-valent iron, titanium oxide, graphene oxide, carbon nanotube, metal oxide nanoparticles, metal nanoparticles, polymer nanomaterials, nanocomposites, bionanomaterials, etc. have the capacity of removing contaminants from agricultural fields through groundwater purification, wastewater treatment, reducing the salinity of the land, etc. The introduction of nanoparticles moderates the dose of fertilizers by increasing their efficiency and revamping the eco-friendly characteristics of conventional fertilizers due to their fabrication based on the nutritional requirements of targets. Around 95% of synthetic fertilizers have side effects due to their activity toward non-target elements, such as genetic modification of crops or contamination of soil nutritional content, resulting in reduced plant growth and agricultural yield. The application of Nano fertilizers reduces the dosage by 50% compared to conventional fertilizers. A single spray of low quantities of boron and zinc nanoparticles increases the pomegranate fruit yield and quality. Biosynthesized zinc nanoparticles increase the crop productivity of pearl millet plants. The use of mixtures of green synthesized zinc and carbon nanoparticles improves the quantitative and qualitative productivity of basil plants and upgrades their therapeutic characteristics. Synthesized manganese-zinc ferrite nanoparticles stimulate the growth of Cucurbita pepo plants and Lactuna sativa seeds significantly. Titanium oxide and zinc oxide nanoparticles increase the sprouting of tomato plants and also stimulate the seed germination and growth of Glycine max plants. Titanium oxide nanoparticles increase the number of proteins, chlorophyll, and nitrogen in Spinacia tolerance plants. Seed germination in sorghum and switchgrass is accelerated by graphene nanoparticles and multi-walled carbon nanotubes. The germination of Catharanthus seeds is also stimulated by the application of multi-walled carbon nanotubes. Different Nano fertilizers also increase the spike length, spike number, grain productivity, and weight of wheat plants. Nanoparticles also have the capability of improving soil fertility by removing pollutants from the soil, such as the use of nanozero-valent iron for the removal of arsenic and mercury from the soil; the use of calcium peroxide nanoparticles in eliminating aromatic pollutants; the use of graphene oxide nanoparticles in the prevention of the spread of acute metal toxicants like copper, lead, and cadmium; the use of calcium phosphate nanomaterials to immobilize cesium, etc.

The contamination of soil and groundwater levels due to increasing industrialization and the unscientific disposal of solid and liquid wastes becomes one of the major environmental issues of our time due to their adverse effects on the fertility of land and the storage of healthy drinking groundwater. Plants, on the other hand, absorb various types of ototoxic pollutants as an effective detoxification strategy for pollution eradication. For this purpose, plants are effectively utilised for the handling of different kinds of toxicants, viz., polyaromatic hydrocarbons, metallic toxicants, organic pollutants, etc.

SCOPE OF NANOCHEMISTRY IN MODERN WORLD

The novel approaches to manufacturing the nanomaterials chemically lead to the production of a wide range of nanochemical that possesses improved characteristics compared to those of macro chemicals. The two or more different types of nanomaterials can be combined to form nanocomposites containing more advanced characteristics than those of the single nanoparticles. The chemical modification of the nanomaterials, viz. doping of nanocatalysts, polymerization of nanomaterials, larger molecular assemblies, 2D nanomaterials, nanotubes, nanocrystals and clusters, nanowires, etc., facilitates the production of a wide range of Nano products through nanochemistry. [1] Chemical and physical properties of chemically synthesized nanomaterials have been shown to be more efficient than normal nanoparticles due to their improved properties. [2]

2D nanomaterials have improved interactions with medicinal molecules due to their distinct lamellar structure and the presence of robust in-plane bonding.2D nanomaterials are synthesized by the micromechanical exfoliation of the 3D objects, which makes the width of the materials below 100 nm. The surface area of the 2D nanomaterials becomes very large in comparison to the volume due to the width of the nanoscopic range, which facilitates more surface charge accumulation as well as an increased rate of reactivity with the drug molecules. The weak van der Waals force of attraction between the layers facilitates the successful release of drug molecules into the target cells. Graphene, hexagonal boron nitrides, and metal chalcogens are the most prevalent 2D nanomaterials. Graphene was the first 2D nanomaterial invented, derived by the micromechanical exfoliation of graphite in 2004. The limited bioavailability of lipid-soluble medication molecules in body fluids prevents them from exhibiting effective bioactivity, a problem that can be effectively remedied by the use of graphene. The organic bioactive components found in medications are successfully interacted with by the graphene molecules' sp2 hybridised carbon atoms and delivered to the target cells. The wide planar structure of 2D nanomaterials improves drug adsorption in cells, improving the biocompatibility of the drug molecules.

Because the waves cannot distinguish between diseased and normal cells, both normal and cancerous cells are harmed by standard chemotherapy. Due to their enhanced light sensitivity and magnetic properties, the use of 2D nanomaterials in chemotherapeutic approaches can lessen the probability of effects on normal cells. Due to their ability to carry genes, 2D nanomaterials can be used effectively in the creation of genetic therapeutics. The efficiency of 2D nanomaterials in carrying genes facilitates the development of advanced treatment procedures based on genetic engineering and biotechnology. To increase the effectiveness of their drug-carrying capacity, 2D nanomaterials are now enclosed in polymers, liposomes, hydrogels, micelles, and other conventional drug carriers. 2D nanomaterials can be a better choice as drug carriers in comparison to nanoparticles and 1D nanomaterial due to their increased surface area to volume ratio. Apart from that, the strong bonds of the 2D planes of the nanomaterials do not participate in any unwanted chemical reactions within the body, which reduces the possibilities of adverse side effects due to drug consumption. Additionally, 2D nanomaterials can be a useful component in the creation of smart drug transport systems, which guarantee the safe delivery of drug molecules into the intended cells and are light-, magnetic-, and pH-responsive. [3]

It is possible to fabricate photovoltaic cells using nanoparticles other than silicon semiconductors, such as titanium and titanium oxides. These nanomaterials can receive more photon particles due to their increased surface area to volume ratio and exposure to more conducting surfaces to solar radiation. Utilizing carbon nanotubes, fullerenes, and quantum dots allows for the creation of solar cells that are less expensive, more efficient, and easier to transport. When a photon strikes a nanomaterial like lead selenide, more electrons are freed. Windmill performance can also be increased by employing nanotechnology. Epoxy with carbon nanotubes makes windmill blades that are both more durable and lighter, which increases the amount of energy produced by the turbines. Nano paints can potentially be used to lengthen the lifespan of wind turbines. [4]

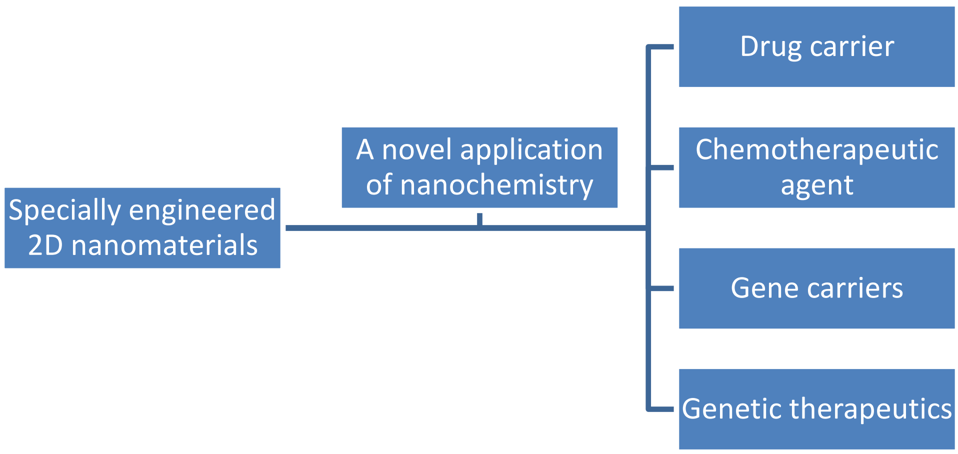

Figure 1: Application of specially engineered 2D nanomaterials

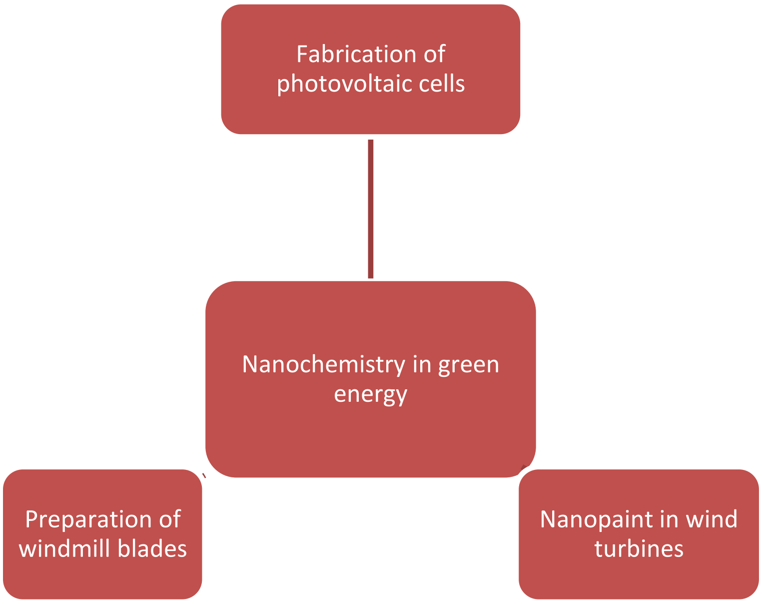

Figure 2: Nanochemistry in Green Energy

Nano-Zero Valent Irons (nZVI) have been shown to effectively filter out pollutants in groundwater reserves at a rate of 80%. The inclusion of iron or iron oxide in the cores of nZVI gives them the dual properties of adsorbents and reducing agents toward the pollutants, as seen in the typical core shell structure of nZVI. Additionally, iron oxide nanoparticles' super magnetic characteristic enables the removal of 99% of arsenic from underground water supplies. Carboxymethylcellulose-carbo-iron alginate (nZVI) is a polymeric structure that removes pollutants from groundwater with 100 percent efficiency. Because of the hydrophobic character of the membrane, organic pollutants are more easily adsorbed after being emulsified with an oil-in-liquid membrane created by biodegradable oil and food-grade surfactants. Trichloroethane can be easily extracted from groundwater through the manufacture of bi-metallic nanoparticles by incorporating metals like platinum, gold, nickel, palladium, etc. with iron nanoparticles. Groundwater can also be purified with the help of carbon nanotubes (CNT) and nano-zeolites, two other nanomaterials that have recently gained attention. Chromium, zinc, and lead, as well as metalloids like arsenic compounds, volatile organic contaminants, and inorganic pollutants like dioxins, can be more effectively removed from groundwater by using CNT arrays arranged in a hexagonal shape. The adsorption efficiency of multi-walled carbon nanotubes (MWCNT) is greater than that of single-walled carbon nanotubes (SWCNT). The adsorption capacity for aromatic pollutants is improved by the combination of MWCNT with iron nanoparticles. Adding azodiisobutyro nitrile (AIBN) and refluxing the mixture with sodium hydroxide improves the probability of interaction between the iron-MWCNT nanocomposites and the aromatic contaminants in water, thereby increasing the solubility of the nanocomposites in water. These nanocomposites, thanks to the iron within them, produce outstanding magnetic separation capabilities, which can be put to use in the process of removing impurities from water.

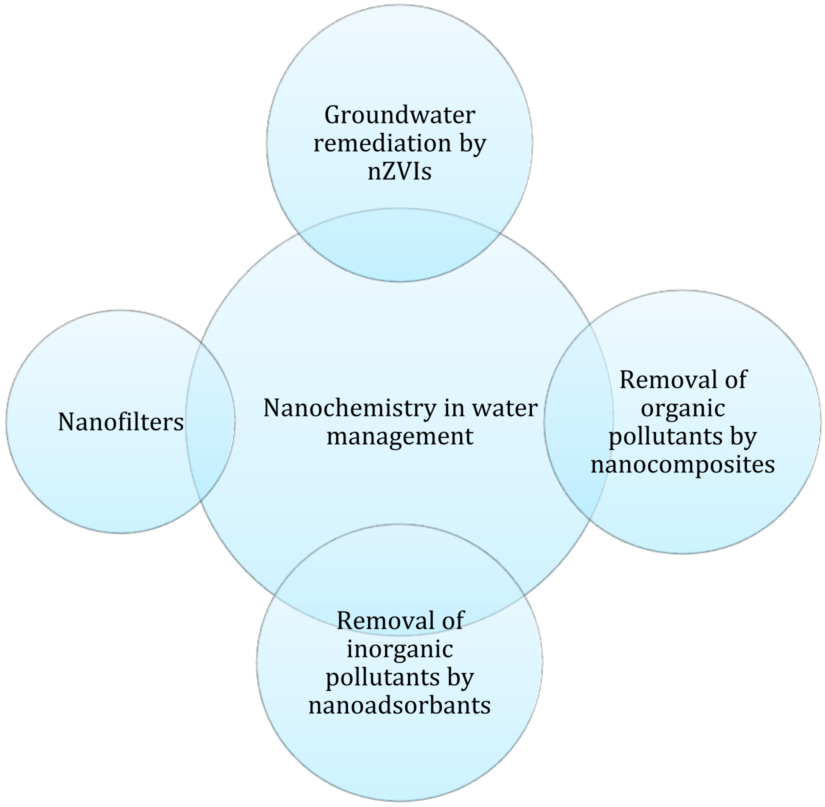

Figure 3: Nanochemistry in Water Management

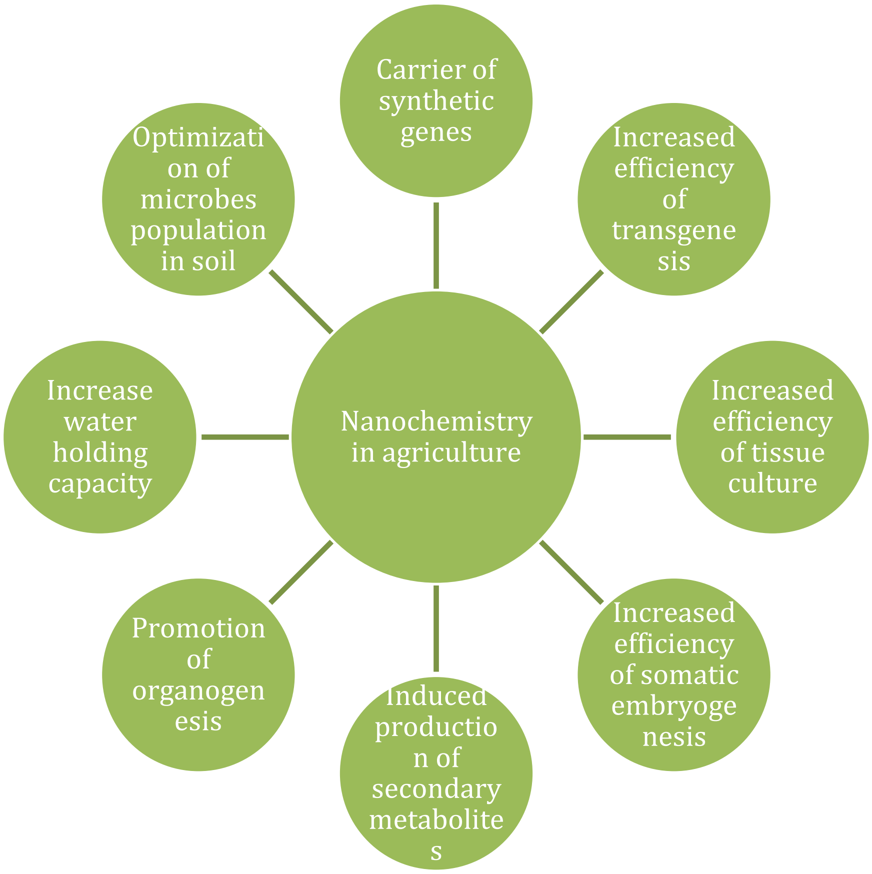

Figure 4: Application of nanochemistry in agriculture

The agricultural wastes also facilitate the green synthesis of nanoparticles. The seeds, skin, pomaces, and stalks of grapes have the capability of producing gold nanoparticles. Silicon nanoparticles extracted from agricultural wastes are widely used in diverse sectors. Carbon nanotubes and activated charcoal are the two most commonly used nanoparticles synthesized from agricultural waste. [5] Biological processing of nanoparticles has become prevalent due to the fabrication of environment-friendly, inexpensive, and balanced novel substances [6]. In spite of being synthesized through an assemblage of standard procedures, the biological methods of processing are more efficacious due to their proficiency in rapid production, cost effectiveness, environment friendliness, optimal toxicity, and control of size attributes. Vascular flora and microbes such as bacteria, fungi, algae, yeasts, actinomycetes, etc. can be used for the biological processing of nanoparticles. [7]. Extracellular excretion of enzymes facilitates the production of nanomaterials of sizes 100–200 nm. It exists in a vaguely pure condition as it makes the nanoparticles free from other cellular proteins, which are also purified further by filtration. Enzymes secreted from the microbes and the phytochemicals present in the plants that have antioxidant properties reduce the metal compounds to their respective nanoparticles. Bacteria are also considered to be an efficient component for the processing of nanomaterials like titanium, titanium dioxide, gold, silver, platinum, magnetite, cadmium sulfide, palladium, etc. [8]. Nanoparticles synthesized from flora, bacteria, and fungi have a wide range of applications in different sectors. [9]. Plants have been shown to be more efficient and time-consuming than bacteria or fungi in the preparation of nanoparticles due to the need for a shorter incubation time for metal ion depletion. The methods, like plant tissue culture (PTC) and downstream depuration approaches facilitate the synthesis of nanoparticles from metals and metal oxides at a wider scale. [10] The use of hyper accumulator-exclusive genes on transgenic plants can improve the plants' phytoremediation abilities. The plant's purification efficiency will be remarkably increased by inheritable modification and other expedient flora-based genetic technologies. Floras are able to remove the metals inherently through particular digestion paths.

FUTURE PERSPECTIVES

The green synthesis of nanoparticles and advanced nanocomposites through different nanochemical techniques will promote the sustainable synthesis of nanoparticles effectively. The manufacture of Nano fertilizers, nanobioremediators, and nanophytoremediators through nanochemistry mitigates the challenges of environmental degradation. The application of sustainably developed nanochemicals through green synthesis in the industrial sector will reduce the environmental challenges and promote the ecofriendly development of the industrial sector in a sustainable manner. The specially engineered Nano carriers play an important role in successful targeted and non-targeted drug delivery.

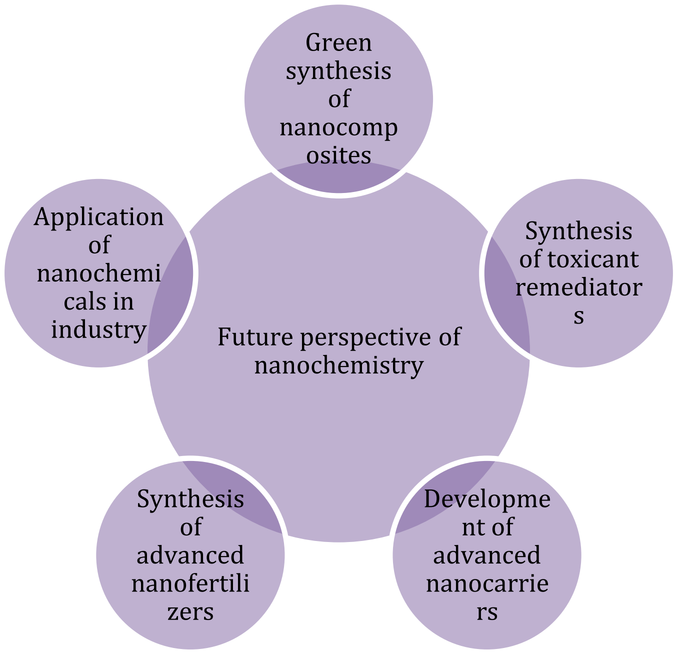

Figure 5: Future perspectives of nanochemistry

CONCLUSION

The development of nanochemistry is still at an infant stage and needs more research for its advancement. On the other hand, nanoparticles such as silicon, silver, iron, copper, aluminium, zinc, zinc oxide, titanium oxide, aluminium oxide, and carbon nanotubes have a wide range of effects in different industries. Because of their proclivity to agglomerate, nanozero-valent iron cannot react effectively with pollutants. Cerium oxide reduced the number of photosynthetic pigments and proteins in plant seeds. The introduction of new technology areas like nanosensors and the advancement of the existing field through extensive research worldwide will enrich the agricultural field and facilitate the achievement of the goal of sustainable agriculture to combat the contemporary problems of environmental degradation and climate change, which broaden the way towards sustainable development goals. The introduction of nanomaterials in the synthesis of fertilizers, pesticides, fungicides, and herbicides will enhance agricultural productivity, leading to the achievement of food security as well as employment security and an increase in the income of the marginalized and economically less empowered sections of the rural population.

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Chapter 15

COMPUTER-AIDED DRUG DESIGNING: A BRIEF REVIEW

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ABSTRACT

The effective development of therapeutic candidates for the treatment of numerous illnesses has been made possible through computer-aided drug design. Drug discovery applications using the CADD methodology are advancing continuously. Recently, there has been a trend in drug design to rationally create effective therapies with multi-targeting effects, better efficacies, and fewer side effects, particularly in terms of toxicity. We've covered computer-aided drug design and its many forms in this chapter. This chapter also discusses the applications and restrictions of CADD.

KEYWORDS: CADD, LB-CADD, SB-CADD, Virtual screening.

INTRODUCTION

Unlike conventional techniques of drug discovery, which focus on matching the apparent effects of chemicals to therapies after testing them on animals or cultured cells. The creative process of developing novel drugs based on the understanding of a biological target is known as drug design, sometimes known as rational drug design [1]. Drug design, in its most basic sense, is creating compounds that interact with and bind to biomolecular targets that are complementary to one another in shape and charge. Target validation, target optimization, lead identification, and lead optimization are all steps in the drug development process. An enzyme, receptor, nucleic acid, ion channel, or transporter is all potential drug targets. In contrast to enzymes and nucleic acids, which are found in the cytoplasm, cell membranes contain receptors, ion channels, and transporters. Gene knockout and RNA interference techniques are used to confirm a target that is crucial to the progression of a disease. The following phase in the drug discovery process is lead identification. A substance from a group of closely similar compounds known as lead contains some of the desired biological activity and may be altered to generate a different molecule with a superior activity profile and fewer adverse effects. Traditionally, libraries of compounds must be assayed for activity and a lot of experimental data must be gathered for experimental high throughput screening. Virtual high throughput screening is used in rational drug design as a complement to experimental high throughput screening. It quickly discovers possible interactions between compounds and targets and chooses the most promising compounds for experimental development. Computer modelling approaches are commonly but not always used in drug design [2]. The term "computer-aided drug design" is frequently used to describe this kind of modelling.

COMPUTER-AIDED DRUG DESIGN (CADD)

The term Computer-aided drug design (CADD) refers to computer resources and techniques for managing, modelling, and analysing molecules. In addition to techniques for systematically evaluating possible lead candidates before their synthesis and testing, it also covers the study of chemical interaction interactions and computer algorithms for generating compounds with intriguing physicochemical properties. Early in the 1970s, the CADD was founded to modify the biological action of insulin through structural biology [3] and direct the manufacture of human haemoglobin ligands [4]. X-ray crystallography proved unworkable for large-scale screening in industrial facilities at the time because it was exceedingly expensive and time-consuming [5]. As new technologies have developed over time, lead design has started to make use of them, such as comparative modelling based on natural structural homologues [6]. These have helped to quickly close the gap between theoretical modelling and medicinal chemistry, together with developments in combinatorial chemistry, high-throughput screening tools, and computer infrastructures. CADD is becoming essential in the discovery of novel molecular entities [7-9]. The current focus includes enhanced design and management of data sources, development of computer programs to produce large libraries of chemical compounds with pharmacological interest, creation of new algorithms to evaluate the potency and selectivity of lead candidates, and design of predictive tools to spot potential ADME liabilities.

Two approaches are adopted in CADD for lead identification;

1. Ligand-based drug designing
2. Structure-based drug designing

LIGAND-BASED DRUG DESIGNING (LB-CADD)

The study of ligands (Figure 1.1) known to interact with a target of interest is a step in the ligand-based computer-aided drug designing (LB-CADD) method. These techniques examine the 2D or 3D structures of chemicals known to interact with the target of interest using a collection of reference structures. The general objective is to characterize these compounds in such a way that the physiochemical characteristics most crucial to their desired interactions are kept and irrelevant data is excluded. Because it does not require understanding the structure of the target of interest, it is regarded as an indirect method of drug discovery. The two fundamental approaches of LB-CADD are

(a) Selection of compounds based on chemical similarity to the known activities using some similarity measure

(b) The construction of a QSAR model that predicts biological activity from chemical structure.

The distinction between the two methods is that the latter gives weight to chemical structural characteristics in accordance with how they affect the relevant biologic activity, whilst the former does not. This technique is used for the improvement of DMPK/ADMET characteristics, hit-to-lead, and lead-to-drug optimization, and in silico screening for new compounds with the desired biological activity [10]. The methods which are based on ligand-based drug designing are-

(i) QSAR:

(ii) Pharmacophores modelling:

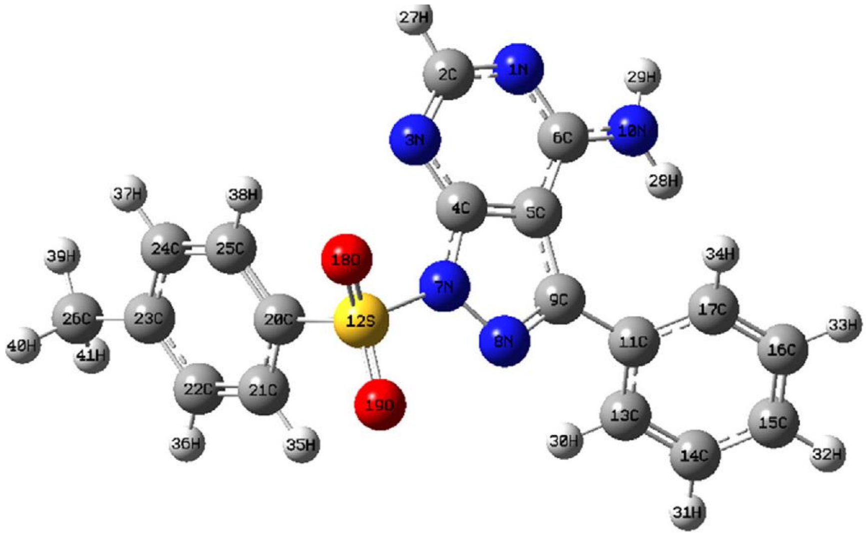

Figure 1: 3-d structure of a ligand

STRUCTURE-BASED DRUG DESIGNING (SB-CADD)

Structure-based computer-aided drug designing (SB-CADD) depends on understanding the structure of the target protein (Figure 1.2) as well as being able to identify and examine the three-dimensional (3D) structures of biological molecules. The essential premise of this strategy is that a molecule's capacity to connect with a specific protein and have the intended physiological impact is dependent upon its capacity to engage positively with a specific binding site on that protein. The beneficial interactions between molecules will have comparable physiological consequences in those molecules. As a result, a thorough examination of a protein's binding site might help reveal new molecules. Every project involving SB-CADD requires structural knowledge of the objective. When there are available high-resolution structural data for the target protein, SB-CADD is often used. Since the early 1980s, researchers have used the structure of a target protein to help in drug development (NIH-structure based). Since that time, SB-CADD has gained popularity as a method for finding new drugs. Numerous 3D structures of human and pathogenic proteins have been revealed via extensive use of biophysical methods including X-ray crystallography and NMR spectroscopy. In the Protein Data Bank, for instance, there are several biological macromolecular structures (www.rcsb.org). The capacity to quickly identify possible binders to the target of biological interest is a need for the drug development process. A chemical that has been successfully used in these techniques will preferably have a co-crystal structure confirmation. The approaches that are based on structure-based drug design are as follows:

i. Homology modeling

ii. Molecular docking

Figure 2: Cartoon representation of a receptor [PDB ID:3BM5]

VIRTUAL SCREENING

Lead compounds are frequently found by virtual screening of chemical libraries made up of synthetic or naturally occurring chemicals. By scanning commercial, open, or proprietary 3-dimensional chemical structure databases, virtual screening is utilized to find novel drug candidates from various chemical scaffolds. Its goal is to condense the chemical space so that lead discovery and optimization can concentrate on more promising options. The objective of virtual screening is to exclude compounds with undesirable features while enriching a group of molecules with desirable properties (active, drug-like, and lead-like) (inactive, reactive, toxic, poor ADMET). Virtual screening employs a variety of CADD methods in a logical order as filters, beginning with characteristics (such as molecular weight, logP, etc.), moving on to topology, 3D-Parmacophore, and concluding with Molecular Docking. With the exception of molecular docking, which is a technique based on structure, all filters are ligand-based. Thus, virtual screening reduces the number of candidate compounds that must be experimentally screened from millions to only a few hundred, improving the likelihood of discovering active molecules at a far lower cost. For ligand-based virtual screening, a number of programmes are available, including Hip Hop, Hypogen, Disco, Gaps, flo, APEX, and ROCS. There are several tools available for structure-based virtual screening, including AUTODOCK, GOLD, GLIDE, FlexX, ICM, FRED, and LigandFit.

APPLICATIONS OF COMPUTER-AIDED DRUG DESIGN

These days, all drug companies' work is influenced by computer-aided drug creation and screening techniques. The importance of computational technologies in boosting the effectiveness of the drug development process will grow as these technologies develop. The evolution of the computational technique will also be influenced by the rapid expansion of structural data on possible therapeutic targets, which is anticipated to occur in the upcoming years. The sheer amount of target-related data that will need to be handled will demand more automation, quicker algorithms, and better information management strategies. Instead of focusing on single targets on a genomic scale, we employ families of related targets. This will greatly increase the amount of knowledge on ligand binding to these families. The task of the molecular modeler will be to efficiently mine this data and convert the available structural data into a format that can be used directly by the bench chemist. As a result of this objective, the interaction between bio and chemoinformatics will grow, advancing our understanding of structural and functional genomics.

LIMITATIONS OF CADD

Despite its successful uses, CADD has its own drawbacks in contemporary drug design. In instance, several of the lead compounds discovered using CADD have not demonstrated the necessary biological activity against biological systems. Before a molecule may be certified as a powerful lead or medicine, a number of requirements must be satisfied and it must also satisfy a number of pharmacological standards. Actually, only around 40% of potential lead or medication candidates successfully complete the various stages of clinical trials and are given the go-ahead for usage in patients [11]. Regular revisions of tools and algorithms are required to overcome constraints and boost accuracy in forecasting potent leads.

CONCLUSION

The use of CADD in drug discovery is crucial because it offers computational tools and algorithms that minimise costs, time, and the chance of identifying unfeasible developing leads. A comprehensive knowledge of the molecular and pathological circumstances brought on by illnesses is necessary for the identification of a novel lead or medication utilizing contemporary CADD paradigms. As new advances are anticipated to result in tools for illness identification and the screening of prospective lead compounds, novel technologies, and computational algorithms are needed to further the CADD method.

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Chapter
16

A MINI REVIEW ON WATER MEDIATED KNOEVENAGEL CONDENSATION REACTIONS

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ABSTRACT

Water plays an essential role in life processes; however water has emerged as a versatile solvent for organic chemistry particularly in Knoevenagel reaction in recent years. Despite the fact that it is the low-priced, innocuous and most nontoxic solvent in the world. The utilization of water as solvent in organic synthesis is one of the most influential tools of green chemistry as it diminishes emission of toxic chemicals in the environment thereby falling pollution. The synthesis can be done under gentle circumstances limiting synthetic waste with modest work up procedure empowering recycling of the catalyst. This review momentarily features a few significant responses did in water.

KEYWORDS: Water, organic synthesis, green solvent.

INTRODUCTION

The Knoevenagel condensation reaction is a type of chemical reaction named after German chemist Emil Knoevenagel in organic chemistry.[1] it is a very useful reaction in organic chemistry known for its synthetic utility in carbon carbon bond formation from the condensation of an active hydrogen compound to a carbonyl group. It the most important routes repeated in the synthetic organic chemistry and allow the production of various active pharmaceutical molecules. Also, Knoevenagel condensation is extensively employed in the fine chemicals industry, remarkably for the preparation of coumarins and their derivatives which are imperative intermediates in the manufacture of cosmetics, perfumes, and pharmaceuticals as well as in the synthesis of carbocyclic and heterocyclic compounds with various biological activities. [2]

Chemists have been attentive in organic synthesis using water as a solvent for a long time. Water is the nature's solvent and has recognized physical and chemical properties. It displays strong hydrogen bonding and wide temperature reach to stay in fluid state. As of late, many organic transformations have been done in water.[3] Benzene, methanol, and toluene are just a few examples of the many organic solvents that are carcinogenic, harmful to human health, and pose a threat to the environment by polluting the atmosphere. One of the main goals of green chemistry is to replace volatile organic solvents in organic reactions.[4]

As of late, numerous heterocyclic molecules are synthesized utilizing green synthetic protocols. It is of impressive interest to look further into changed green innovation stages, which have been used for the union of significant heterocyclic scaffold. These green techniques have undergone regular assessment because they are a significant and expanding area of research. The current endeavour is to survey momentarily water intervened organic reactions, bringing about the combination of different heterocyclic compounds works and to feature the importance as well as utility of water as a green solvent.

Takashi Murase et al.[5] have reported a cationic coordination cage dramatically accelerates the Knoevenagel condensation of aromatic aldehydes in water under neutral conditions. The addition of a nucleophile and aldehyde to generate anionic intermediates seems to be simplified by the cationic environment of the cavity (Figure 1).

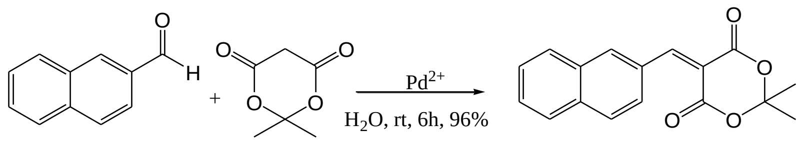

Figure 1: Knoevenagel condensation of aromatic aldehydes

Gupta *et al.*, have developed a rapid, economic and environment-friendly method for the preparation of cinnamic acids by Knoevenagel condensation between aldehydes or ketones and malonic acid in the presence of TBAB, K_2CO_3 and distilled water in excellent yield (65-90% (Figure 2).

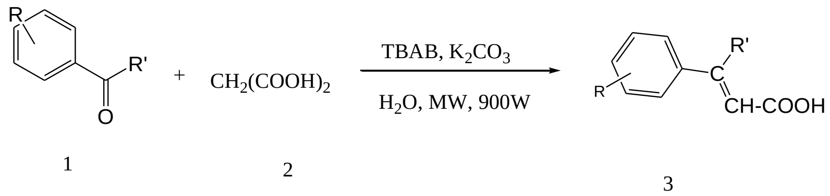

Figure 2: Knoevenagel condensation between aldehydes or ketones and malonic acid in the presence of TBAB

An efficient and green procedure for the synthesis of 2, 2-dimethyl-5- [(4-oxo4H-chromen-3-yl) methylene]-1, 3-dioxane-4, 6-dione from the condensation of substituted 4-oxo-4Hbenzopyran-3-carbaldehyde with Meldrum's acid in the presence of boric acid in water at room temperature in good yields has been developed by Jadhao et al[7] (Figure 3).

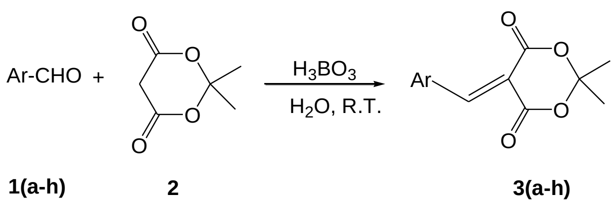

Figure 3: Synthesis of 2, 2-dimethyl-5- [(4-oxo4H-chromen-3-yl) methylene]-1, 3-dioxane-4, 6-dione

Shelke et al.[8] have described a simple, efficient, and cleaner methodology for the synthesis of 5-arylidene-2,4-thiazolidinedione derivatives by Knoevenagel condensation of different aromatic aldehydes with 2,4-thiazolidinedione in presence of alum in water at 90^{0}C (Figure 4).

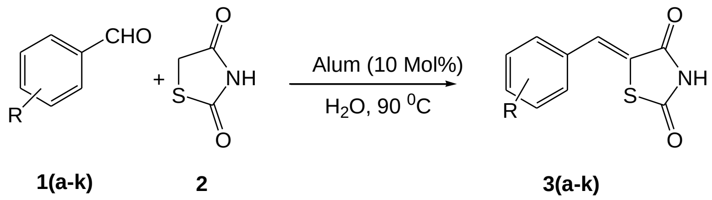

Figure 4: Synthesis of 5- arylidene-2, 4-thiazolidinedione

Neeraj Pathak *et al.*, [9] have proposed an efficient and quick method for Knoevenagel condensation has been developed by using sodium bicarbonate as an inorgano-green catalyst in water. A wide range of aldehydes (aromatic/heteroaromatic/α, β unsaturated aldehyde, ferrocenecarboxaldehyde), cyclic and acyclic ketones easily undergo condensation with active methylene compounds (malononitrile and ethyl cyanoacetate) and affords the corresponding substituted electrophilic alkenes in excellent yields. (Figure 5).

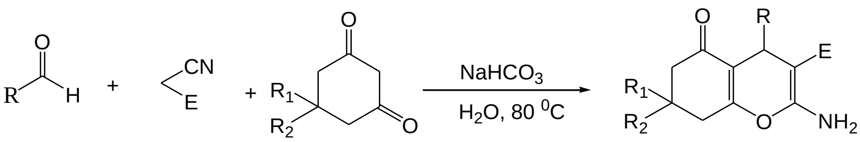

Figure 5: Knoevenagel condensation has been developed by using sodium bicarbonate

Prabakaran Kaliyan *et al.*, [10] have described useful method for Knoevenagel condensation has been developed from the reaction between active methylene compound and aldehyde using the water extract of onion as a green catalyst. This method is suitable for variety of aldehydes including, substituted aromatic, aliphatic, α, β-unsaturated, and heterocyclic with malononitrile or ethyl cyanoacetate, and affords the α-cyanoacrylonitriles and α-cyanoacrylatesin excellent yields (Up to 98%). The products are isolated without column chromatography. The use of water extract of onion has several advantages such as low price, easy handling, simple work up procedure and environmentally benign. (Figure 6)

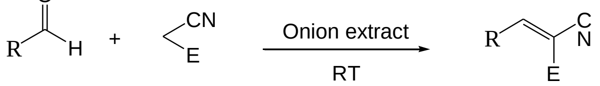

Figure 6: Synthesis of α-cyanoacrylonitriles

CONCLUSION

In this mini review, we have concentrated on some aqueous mediated Knoevenagel condensation reactions which will certainly help researchers and scientists across the globe to create innovative low-cost, eco-friendly, and efficient methods for performing Knoevenagel condensation reactions and organic synthesis.

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Chapter **17**

LIPINSKI'S RULE AND ITS CHEMICAL AND BIOPHARMACEUTICAL APPLICATIONS

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ABSTRACT

Mathematical models show qualitative and quantitative dependencies between the structure, physico-chemical properties and activities of the investigated compounds. The Lipinski rule is one of the well-known in spite of the several formulas for predicting high bioavailability. The rule relates to the molecular characteristics that are crucial for a drug's pharmacokinetics-that is, how it behaves in the body-namely, absorption, distribution, metabolism and excretion. Other combinations of factors that are significant permeability predictors have been identified in response toward the Lipinski rule. Veber suggested the insertion of another rule. Using molecular flexibility, he also compared the compound's permeability and oral bioavailability.

KEYWORDS: Absorption, Acceptors, Biological response, Benefactors, Exemptions lipophilicity, polar area, hydrogen bonding and charge.

INTRODUCTION

Furthermost the scientific studies are currently attentive on the discovery and synthesis of therapeutic compounds, the study of their action, efficiency and possible toxicity to the environment. Earlier a novel bioactive molecule is synthesized, several mathematical models are applied to define the qualitative and quantitative relationships between its structure, physico-chemical characteristics, and activities in order to save time and money.

Lipophilicity is the molecular characteristic that is most frequently utilized to forecast if a molecule has the potential to be bioactive. According to IUPAC, lipophilicity refers to a molecule's or a molecule's component's affinity for a lipophilic environment. In addition to lipophilicity, the theory of biological activity of substances is evaluated using the principles of excellent bioavailability, among which the Lipinski rule is the most well-known (Apostolov and Vastag, 2017).

The pathways of biologically active substances in the body are dictated by their absorption, distribution, metabolism, excretion, and toxicity (ADMET). Understanding the pharmacokinetics of a bioactive molecule is crucial to assess and improve its action and efficacy. Human effective permeability in the jejunum is a pharmacokinetic predictor that may show the degree of intestinal absorption because the majority of bioactive compounds are not delivered intravenously. The amount of permeability is directly conditioned by the lipophilicity of the molecules since molecules with greater lipophilicity have better permeability through the phospholipid bilayer of enterocytes.

The compound's ability to cross the blood-brain barrier affects how it reacts in the central nervous system. The blood-brain barrier (BBB) is a defense system that prevents chemicals from the blood from entering the cerebrospinal fluid and, ultimately, the brain and spinal cord. The value of the pharmacokinetic parameter log BBB shows if a chemical has the potential to be used as a neuroactive agent. A biologically active substance must be studied for its environmental effects in the early phases of contemporary design, which is frequently reflected in the evaluation of its risk to various test species (Apostolov and Vastag, 2017).

LIPINSKI RULE

Large efforts are being made to assess the comparable "drug-like" qualities of compounds in the beginning stages of the discovery-research process in order to advance the research and development of novel medications. There are other ways to address this issue, Chris Lipinski and Pfizer colleagues created the simplest and most popular solution, which is known as the Lipinski Rules or the Rule of Five (ROF-5) (Petit *et al.*, 2012).

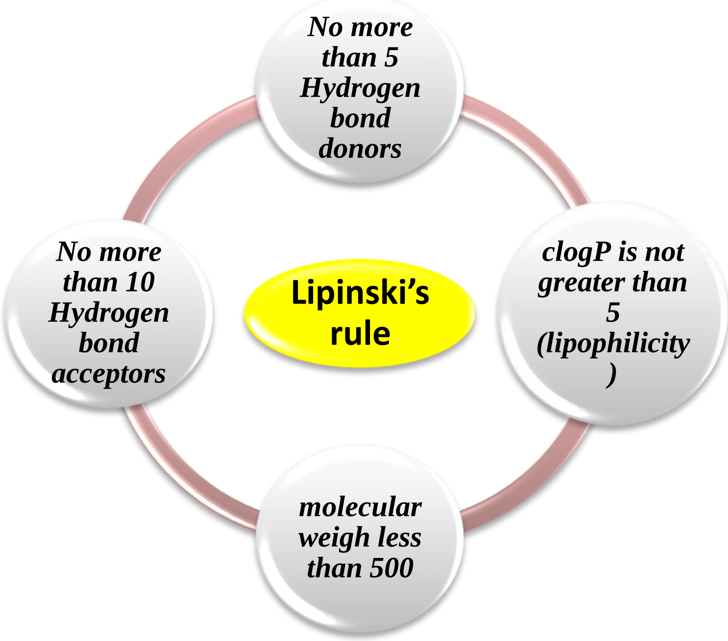

Figure 1: Schematic representation of Lipinski Rule Requirements

The rule of five (ROF-5) is a broad recommendation used to examine if a chemical molecule has properties that would make it likely to be a medication in humans or to determine how similar it is to a type of drug (Lipinski *et al.*, 1997).

To possibly be employed as an oral medication, the biologically active chemical needs to meet five requirements. The likelihood of poor absorption or penetration is highest, when

- Molar mass >500,
- Number of H-bond acceptors >10,
- Number of H-bond donors > 5,
- LogP> 5 (or mLogP>4.15) (Lipinski *et al.,* 1997).

A potential medicine alone has more than one infringement of the disclosed criteria if it has an orally active pharmaceutical rating of between "0" and "4" based on the ROF. Lipinski notes that even though many medications do not follow rule of five, such compounds shouldn't be entirely disregarded for further analysis (Petit *et al.,* 2012).

Although the Lipinski rule has many applications, but it has certain drawbacks. The equal weight assigned to each rule and the distinct line that delineates when a rule has been broken is the two main flaws. The fact that this restriction excludes organic and biological components is another drawback. Metabolic-related criteria are not included in ROF.

LIPOPHILICITY

A physicochemical feature called lipophilicity, which describes a molecule's capacity to partition into octanol or water, is frequently thought to be extremely important to the rate of absorption. The logarithm of the drug's partitioning into the organic phase to that into the aqueous phase, or LogP, is used to determine lipophilicity.

Although this feature may be physically measured in some kind of ways, there are multiple techniques to compute LogP, each of which has benefits and drawbacks of its own. For instance, the cLogP technique calculates the lipophilicity of a molecule by adding the LogP values of the individual pieces that make up the molecule. These fragmented values, which include contain correction factors for electronic and steric effects, were produced via least-squares fitting to a training set. The cLogP technique performs effectively for molecules with functional groups that are typically found in drugs as well as for fragments that are closely connected toward the training dataset. The atomic contributions of each atom in the molecule are used in an atomic-based LogP prediction (AlogP, MlogP), which is additionally fitted to a training set using partition coefficients that were found through experimentation.

MLOG P: LOG P BY THE METHOD OF MORIGUCHI

All carbons and halogens are counted as lipophilic atoms with a multiplier factor applied to normalize their contributions and hydrophilic atom (all N and O atoms) earlier beginning the Moriguchi method's computation of log P. The Moriguchi approach uses eleven correction variables, four of which describe hydrophobicity and seven of which define lipophilicity (Lipinski *et al.,* 1997).

The correction factors that describe hydrophobicity are:

1. UB (The number of bonds, excluding those in nitro groups that are unsaturated).
2. AMP (the correction factor for amphoteric compounds): And α amino acid structure adds 1.0 to the AMP parameter, while each amino-benzoic acid and each pyridine carboxylic acid adds 0.5.
3. RNG: If the molecule has any rings other than benzene-based, hetero-aromatic, or

hydrocarbon rings, it has a value of 1.0.

4. QN (how many quaternary nitrogen atoms there are).
5. The seven modifying variables for lipophilicity.
6. PRX (a topologically close-to-one-another proximity adjustment factor for the nitrogen and oxygen atoms):

   6.1) 2.0 is added for every pair of atoms that are joined directly as well as every pair that are connected via a carbon, Sulphur, or phosphorus atom,

   6.2) unless one of the two bonds joining the two atoms is a double bond, the addition of 1.0;

   6.3) each carboxamide group gets an extra 1.0, and each sulfonamide group gets an extra 2.0.
7. HB: 1.0 if there are structural features that will make an internal hydrogen bond.
8. POL (the number of carbon atoms associated to two or more heteroatoms that are likewise joined to an aromatic ring by a single bond, or the number of heteroatoms connected to an aromatic ring by only one bond).
9. ALK: 1.0 if the molecule contains only carbon and hydrogen atoms and not more than one double bond.
10. NO2 (the number of nitro groups).
11. NCS: 1.0 for each isothiocyanate group and 0.5 for each thiocyanate group.
12. BLM: 1.0 if there is a β-lactam ring in the molecule (Lipinski *et al.*, 1997).

HYDROGEN-BOND DONORS

Large amounts of hydrogen-bond donor groups in a compound might lessen a molecule's capacity to penetrate a membrane bilayer in addition to high molecular weight and lipophilicity. In contrast to the lipophilic environment seen in a biological membrane, compounds with a lot of hydrogen-bond donors will partition into a highly hydrogen-bonding solvent (like water). By simply accounting for the N-H and O-H bonds in a molecule, one may determine the functional groups capacity for hydrogen bonding (Lipinski *et al.*, 1997).

HYDROGEN-BOND ACCEPTORS

Hydrogen-bond acceptors influence permeability by reacting positively with a highly hydrogen bonding solvent, such as water, for the same reason that hydrogen-bond donors diminish the permeability of molecules into lipophilic environments. Once more, despite the fact that hydrogen-bonding characteristics can be calculated, Lipinski and colleagues found that merely adding the molecule's nitrogen and oxygen atom counts acts as a decent substitution for correlating to oral bioavailability (Lipinski *et al.*, 1997).

Variations of the rule of five

Others have observed different combinations of factors that are significant predictors of permeability, differentiating the utility of certain retrospective evaluations of drug candidates as initially carried out and defined by Lipinski. Veber proposed an additional rule. He contrasted the substance's oral bioavailability with its permeability and with its molecular flexibility, which may be characterized in regards to the number of rotatable bonds. Correlation of permeability qualities is possible without taking into account molecular weight thanks to estimation of the amount of rotatable bonds. It has been determined that the permeability of compounds with much more than 10 rotatable bonds is often low. Veber also came to the conclusion that the increased polar surface area influences the decrease in permeability (Pollastri *et al.,* 2010).

The rule of five is supplemented by Veber's flexibility rules:

- There can be no more than five hydrogen bond donor sites in the compound,
- No more than 10 hydrogen bond acceptor sites are allowed,
- Its molecular weight must to be under 500 Daltons,
- 20 to 70 atoms must be present in each of its molecules (a median of 50),
- It must have a polar surface area that is less than 140 $Å^2$.
- These aspects can estimate a product's intestinal absorption and capacity to cross the blood-brain barrier.

Ajay suggested relating computed molecular descriptors to central nervous system (CNS) permeability (Ivanović *et al.,* 2002). Computed parameters, such as molecular weight, molecular branching, hydrogen bonds, aromatic density, and LogP, were assessed and contrasted against lists of medications for which information on CNS activity was available. The strongest association between CNS permeability and molecular weight, degree of branching, number of rotatable bonds, and number of hydrogen bonds was found. Such that if these values are increased, CNS exposure is decreased. Similarly, increasing aromatic density, numbers of H-bond donors, or cLogP values predicted compounds are with higher CNS permeability (Pollastri, 2010).

A variation of ROF known as rule three, is used to display small fragments and for screening set design, that desirable fragments possess a:

- molecular weight <300
- Less than 3 hydrogen bond acceptors and donors
- cLogP ≤ 3

The rule three also contains a variation of the Veber's criterion, so that the desirable fragments have three or less rotating bonds and a polar surface area ≤ 60 $Å^2$. These results indicate that the rule of three may be helpful for building fragment libraries for effective lead discovery (Congreve *et al.,* 2003).

THE RULE OF FIVE EXCEPTIONS

A distribution of computed qualities among thousands of medications forms the basis of the "rule of 5". Thus, certain medications will by definition fall beyond the rule's parameter cutoffs. Most of USAN (United States Adopted Name) medications having qualities outside the Lipinski criteria fall into a very limited number of therapeutic groups.

These groups of orally active medications are:

- Antibiotics,

- Antifungals,
- Vitamins,
- Cardiac Glycosides.

The structural characteristics of these molecules make it possible for the medications to serve as substrates for naturally existing transporters. If such classes are excluded from the USAN library, there are very few examples of compounds remaining that violate the ROF (Lipinski *et al.,* 2001).

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Chapter
18

HYDROGEL OF POLY VINYL ALCOHOL AS WOUND DRESSING MATERIAL

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ABSTRACT
Hydrogels are nano materials which are capable of retaining a large amount of water in them, thus their name is so given. In early days these hydrogels are extensively explored and got a lot of attention as they have many useful properties like biocompatibility with the biological tissues, water sorption properties, high healing power of wounds, excellent drug releasing properties etc. Thus there is a lot of scope of hydrogels being used in many ways. One of the ways is to use them as wound dressing materials. The hydrogels which are Poly vinyl alcohol based with crosslinking agent like gelatin and glutaraldehyde are generally used as wound dressing materials as such hydrogels are capable of healing the wounds in small time; having high capacity to heal the wounds. When such hydrogels are impregnated with silver nano particles then their antibacterial activity increases making the suitable hydrogel for dressing material. This chapter highlights this capacity of hydrogels of PVA for healing the wounds.
KEYWORDS: Hydrogels, PVA (poly vinyl alcohol), nano silver particles, smart hydrogels, glutaraldehyde.

INTRODUCTION

Hydrogels are three-dimensional polymer networks that can retain a large amount of water in their swollen state.[1-3] Due to their high-water content, the properties of hydrogels resemble those of biological tissues, resulting in excellent biocompatibility. Furthermore, their soft and rubbery nature minimizes inflammatory reactions of the surrounding cells, making them an ideal candidate for biomedical applications.

The interactions responsible for the water sorption include capillary, osmotic, and hydration forces, which are counterbalanced by the forces exerted by the crosslinking in polymer chains that resist the expansion. This cross-linking is done chemically by forming covalent bonds, physically employing noncovalent interactions, or combining both.[1-3] Moreover, the equilibrium swollen state depends on the magnitudes of these opposing forces and determines the properties (such as internal transport and diffusion characteristics and mechanical strength) of hydrogels to a large extent.

After their discovery in the 1960s by Wichterle and Lim, hydrogels were first successfully applied as contact lenses. Later, hydrogels were frequently used as systems for the controlled delivery of biologically active agents. These hydrogels facilitate the localized and sustained release of a drug, thereby decreasing the number of administrations, preventing damage to the drug, and allowing for relatively low doses.

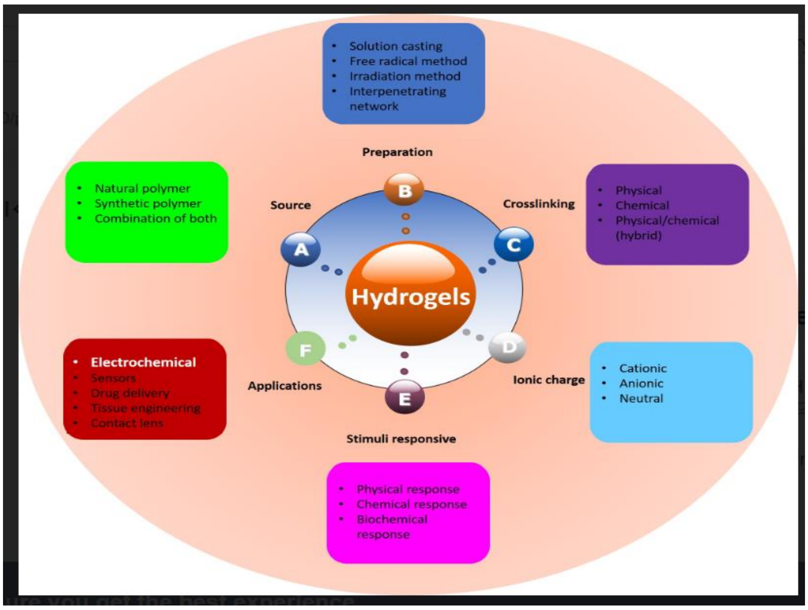

Figure 1: Source – Bashir S. *et al.* (2020) : Fundamental Concepts of Hydrogels-Synthesis, properties and their applications

TYPES OF HYDROGELS

FIRST GENERATION HYDROGELS

Around 1900, the term 'hydrogel' first appeared in scientific literature when it was used to describe a colloidal gel of inorganic salts. In 1960, Wichterle and Lim were the first to report on hydrogels as we know them nowadays, e.g. as water-swollen cross-linked macromolecular networks, in their landmark paper about poly (2-hydroxyethyl methacrylate) (pHEMA) gels for use as soft contact lenses.

SECOND GENERATION HYDROGELS

In the 1950s and 1960s on the possibility of transferring chemical energy into mechanical work, in the beginning of the 1970s the hydrogel research focus shifted from relatively simple, water-swollen macromolecular networks to hydrogels capable of responding to a change in environmental conditions such as pH, temperature or concentration of biomolecules.

THIRD GENERATION HYDROGELS

The temperature- and pH-responsive physical hydrogels discussed in the previous chapter are mainly cross-linked via hydrophobic and ionic interactions, respectively. In the mid-1990s, other physical interactions were recognized and exploited as crosslinking methods that offered the possibility to enhance and finely tune the mechanical, thermal and degradation properties of hydrogels.

SMART HYDROGELS

Smart hydrogels, or stimuli-responsive hydrogels, are three-dimensional networks composed of cross-linked hydrophilic polymer chains that are able to dramatically change their volume and other properties in response to environmental stimuli such as temperature, pH, and certain chemicals.[20] Rapid and significant responses to environmental stimuli and high elasticity are critical for the versatility of such smart hydrogels. Recent literature reports the synthesis of rapidly responsive, highly swellable, and stretchable smart hydrogels by constructing a nano-structured architecture with activated nanogels as nano cross-linkers.[37] These nano-structured smart hydrogels show very significant and rapid stimuli-responsive characteristics, as well as highly elastic properties to sustain high compressions, resist slicing, and withstand a high level of deformation, such as bending, twisting, and extensive stretching.[42] Because of the concurrent rapid and significant stimuli-response and high elasticity, these nano-structured smart hydrogels may expand the scope of hydrogel applications, and provide enhanced performance in their applications.

How do different hydrogels work?

Chemical cross-linking methods are more common in preparing PVA hydrogels. Reagents used for cross-linking include formaldehyde, epichlorohydrin, carbonized diimine, transglutaminase, maleic anhydride, and genipin, all possessing high cytotoxicity and complicated hydrogel preparation. Intriguingly, physical cross-linking that depends primarily on forming intermolecular and intramolecular hydrogen bonds overcomes the drawbacks of chemical cross-linking significantly.

Polyvinyl alcohol (PVA) is one of the most versatile synthetic polymers for hydrogel synthesis. It is also a promising cutaneous dressing for wound healing due to its high biocompatibility and biodegradability. Ag NPs (Silver Nanoparticles) dispersed in PVA hydrogels act as antimicrobial agents. Further improvement of tissue regeneration and wound recovery abilities have been achieved by mixing or crosslinking it with polymers such as gelatin and hyaluronic acid in order to mimic the microenvironment of native tissues. Gelatin is an animal protein obtained by hydrolysis of fibrous insoluble collagen that is used in synthesizing hydrogels, capsules, and microspheres for different biomedical applications, including drug delivery systems, wound dressings, and regenerative scaffolds. This is because gelatin has proven helpful in exudate absorption and in providing a moist environment that accelerates wound healing by promoting cell adhesion, differentiation, and proliferation mainly due to the presence of arginine-glycine-aspartate (RGD) active motif domains sequences. Hyaluronic acid is a linear polysaccharide found in the extracellular matrix of connective tissues. Additionally, it has viscoelastic, biocompatibility, biodegradability properties, and the capacity to retain a high amount of water. This makes it unique for promoting healing and helping induce relevant cell signalling for tissue regeneration. The hydrogel's mechanical properties and physical stability are typically assured by chemical or physical crosslinking. Another polymer often incorporated into topical and cosmetic formulations is poly (acrylic acid), commercially known as Carbopol.[34]

This polymer is also very biocompatible, has been well accepted by patients and shows compatibility with the most active ingredients. These hydrogels have been used as wound dressing materials.

Initiatives in the area of stimulus responsive hydrogels, particularly those that respond to temperature and pH and their applications in drug delivery are progressive in Biomedical Fields.

Nanosilver (NS) is a new generation of Nano product in biomedical applications. NS, comprising silver nanoparticles, is attracting interest in various biomedical applications owing to its potent antibacterial activity. It has recently been demonstrated that NS has useful anti-inflammatory effects and improves wound healing, which could be exploited in developing better dressings for wounds and burns. The key to its broad-acting and potent antibacterial activity is the multifaceted mechanism by which NS acts on microbes. This is currently utilized in antibacterial coatings on medical devices to reduce nosocomial infection rates.

All macromolecular microspheres have been utilized as building blocks or covalent cross-linkers to form either rapidly responsive hydrogels or highly elastic hydrogels. The nanocomposite hydrogels with clay cross linkers are very elastic and have much better stimuli-responsive properties than normal hydrogels. However, their thermo-responsive equilibrium swelling ratio is still limited.

An amorphous gel formulation containing silver nanoparticles (SNPs) and Carboxymethylcellulose (CMC) was reported to be prepared in one step by the reduction of silver nitrate insitu. Spectrophotometric and microscopic analysis revealed that the SNPs were 7–21 nm in diameter. In simulated wound experiments, SNP–CMC gel was found to absorb 80.48 ± 4.69% w/w of saline and donate 17.43 ± 0.76% w/w of moisture within 24 h, indicating its dual fluid affinity. The antimicrobial activity studies showed that SNP–CMC containing 50 ppm of SNPs was effective against the growth of both Gram-negative and Gram-positive strains, including methicillin-resistant Staphylococcusaureus (MRSA). These results indicate that SNP–CMC could be ideal for the treatment of deep infected wounds.

Fabrication of Silver Nanoparticles in Hydrogel Networks was demonstrated and it has been reported that the hydrogel network structure determines the size and shape of the nanoparticles. These particles are more stable in the gel networks compared to other reduction methods.[5] the hydrogel/silver nanohybrids are well characterized by XRD, UV-vis spectrometry, scanning electron microscopy and transmission electron microscopy.

The use of Hydrogel membranes that incorporated AgNPs had a stimulatory action on wound healing, as evidenced by the high intensity of fibroblasts and neovascularization in the tissue, which promoted a faster healing process when compared to untreated wounds.

Hydrogels impregnated with silver nano particles have a porous three-dimensional reticulum structure and high mechanical properties. Also, the hydrogels possessed outstanding antibacterial properties and good biocompatibilities. More importantly, it effectively repaired wound defects in mice models, and wound healing reached 97.89% within 15 days, far exceeding other groups, and indicated its potential for use in wound treatment applications.

Injectable hydrogels have recently attracted the significant attention of researchers as they offer several benefits, including cytocompatibility, non-invasive administration, tunable mechanical properties, high permeability, controllable degradability, and injectability, and these hydrogels can be used as scaffolds or as carriers of therapeutic agents such as drugs, cells, and proteins. However, several essential challenges still need to be overcome to use these injectable hydrogels successfully. Two important properties for the effective application of injectable hydrogels are strength and degradation. Although researchers are now producing high-strength hydrogels, the balance of strength with degradation is crucial for hydrogels. The degradation rate of hydrogels should be well adjusted with cell adhesion and proliferation. Also, developing advanced controllable electro-sensitive hydrogels with a faster response rate for smart drug delivery is another area to explore further in depth.

Antigen or antibody-responsive hydrogels are outstanding smart materials for many uses in biomedical diagnostics. They exhibit unique swelling-deswelling transitions responsive either to antibodies or antigens. However, the fabrication of smart hydrogels responsive to antigen-antibody interaction has not been reported. Therefore, this point is attractive for future research. Besides, many investigations declared the functionality of antibody-conjugated hydrogels. However, the fabrication of smart, responsive hydrogels with antibodies in their backbone structure is still a question for future research.

Smart hydrogels are also used as wound dressing materials. Polyacrylic acid and polyvinyl alcohol are used by many researchers for the synthesis of hydrogels which are impregnated with different metal oxides, including silver oxide, zinc oxide, iron oxide, and many more. Recently, NASA has also started working on synthesizing hydrogels that Astronauts may use for healing unpredictable wounds. They are also working with different polymers including polyvinyl alcohol.

Hydrogels are compound materials capable of absorbing and holding large amounts of water. However, certain advanced hydrogels have the additional capability to absorb moisture from the air, store it, and release it in controlled ways.

METHODS OF SYNTHESIS AND CHARACTERIZATION

Different types of stimuli-sensitive systems have been synthesized through methods such as group transfer polymerization, atom transfer radical polymerization and reversible addition-fragmentation chain transfer polymerization.

The swelling ratio of the hydrogel was found to be influenced by varying the chemical architecture of the hydrogel, i.e., by changing the proportions of PEG, HEMA, and acrylamide and crosslinking agent in the feed mixture of the hydrogel. The degree of water sorption was studied as a function of the experimental conditions, such as the pH and temperature of the swelling medium and presence of salt ions in the outer solution.

The hydrogels show enormous swelling in aqueous medium and displayed swelling characteristics, which were highly dependent on the chemical composition of the hydrogels and the pH of the swelling medium.

Porous biocompatible spongy hydrogels of polyvinyl alcohol and gelatin are prepared by the freezing–thawing method and characterized by infrared and differential scanning calorimetry.

CONCLUSION

Hydrogels of which are PVA based are very useful as wound dressing material. These are smart also as these are stimuli responsive. They can adjust to the external environment and react accordingly. These are pH and temperature sensitive which doesn't mean they are incapable of healing the wound but these are adjustable to such changes. Thus, there is a lot of scope of such hydrogels. These hydrogels can be made with the help of different kinds of cross linker like glutaraldehyde, gelatin, cellulose, etc. These are then impregnated with different nano particles which have different pharmaceutical activities. There are many methods which can be used to characterize these hydrogels which include FTIR, TEM, SEM, DLS, and XRD etc. The only difficulty in using hydrogels as wound dressing material is their cost. These are not cost effective thus it is needed to make them cost effective so that they could be easily available in the market.

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