ISBN: 978-93-91768-57-7

Ecology Research

Volume V

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Bhumi Publishing

First Edition: 2022

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Bhumi Publishing

2022

First Edition: September, 2022

ISBN: 978-93-91768-57-7

Published by:

Bhumi Publishing,

Nigave Khalasa, Kolhapur 416207, Maharashtra, India

Website: www.bhumipublishing.com

E-mail: bhumipublishing@gmail.com

Book Available online at:

https://www.bhumipublishing.com/books/

PREFACE

We are delighted to publish our book entitled "Ecology Research Volume V". This book is the compilation of esteemed articles of acknowledged experts in the fields of ecology providing a sufficient depth of the subject to satisfy the need of a level which will be comprehensive and interesting. It is an assemblage of variety of information about advances and developments in ecology. With its application oriented and interdisciplinary approach, we hope that the students, teachers, researchers, scientists and policy makers will find this book much more useful.

The articles in the book have been contributed by eminent scientists, academicians. Our special thanks and appreciation goes to experts and research workers whose contributions have enriched this book. We thank our publisher Bhumi Publishing, India for compilation of such nice data in the form of this book.

Finally, we will always remain a debtor to all our well-wishers for their blessings, without which this book would not have come into existence.

- Editors

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Ecology Research Volume V
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ECOLOGICAL MONITORING FOR THE DEVELOPMENT OF A WETLANDS AT BACKWATER IN PUNASA JANPAD PANCHAYAT, DISTRICT KHANDWA (M.P.) INDIA

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Abstract:

Ecological monitoring for the development of a wetland plants at Backwater in Punasa Janpad Panchayat, Khandwa district (M.P.) India. 37 Species of vascular plants were identified. Many plants are used for edible as well as medicinal purposes. Some plants have tremendous economic value e.g. species of Typha, Hygrophilla, Solanum, Argemone, Datura etc. Backwater impoundment studied with reference to floristic composition.

Keywords: Punasa Janpad, Wetland Plants, Khandwa district.

Introduction:

Wetland is found where the land is wet enough (i.e saturated or flooded) for long enough to be unfavorable to most plants but are favorable to plants adapted to anaerobic soil conditions. As soil becomes increasingly wet, the water starts to, fill the spaces, between the soil particles. When all the spaces are filled with water the soil said to be saturated. In areas which are not wetlands, water drains away quickly and the soil does not remain saturated. Ecological Studies on temporary and permanent wetlands were done by Nazrul - Islam and Kadir (1989), Nazrul – Islam (1991-1993), Islam and Paul (1978) in and around Dhaka and North eastern part of Bangladesh. Wetlands have earned global importance particularly since 1971, when the first International Convention on wetlands was held in Ramsar, Iraq. Wetlands cover about six percent of the total surface. The country has got a large number of temporary wetland, particularly during monsoon period (i.e. May to October). During this period most of the low–lying lands are flooded and support the growth of various wetland species.

The largest backwater impoundment of Khandwa district is a secondary man made, formed after monsoon 2004 under Indira Sagar Project Khandwa District lying between N 21^0 - 31'-00" Latitude and 22^0-25'-00" Longitude and 303.32 MSL. The present study covered a 100 sq. Km. area, 60 km. away from Khandwa, namely Singaji, Pathakhali, Kalimachak, Purni

Ghodapachad in Punasa Janpad Panchayat, were selected for survey of wetland plants. This backwater mainly consist of the catchment area of Chhoti Tawa, the tributary of river Narmada. The river Chhoti Tawa is in turn fed by Kalimachak, Ruparel, Ghodapachhad, Fifrad, Kharkhari nallas etc. small rivers. Indra Sagar Project is a multipurpose project with the largest storage capacity of water in our country, of the total area of 91300 ha. to be submerged is in Khandwa district, After losses due to submergence, the forest will be reduced to 26 percent. The driving forces and mechanism of charges are related to variation in the physical, chemical and biotic environment and to the many possibilities brought about by their mutual interactions, which together affect to growth of hydrophytes and phytoplankton. (Khan, 1993).

Material and Methods:

Macrophytes were collected with flower; special emphasis was given to these wetland because they are rich in biodiversity. The Plant specimens were colleted from these study sites, preserved and identified according to standard taxonomic method and pertinent literature (1 and 6). The families of the concerned plants are enumerated in accordance with Bentham and Hooker's system as for as practicable. Names of the species of the concerned families are arranged alphabetically. The herbaria preserved in the Department of Botany, S.N. Govt. P.G. College, Khandwa, electronic herbaria also prepared.

List of macrophytes occurring in the wetlands:

Dicotyledons

1. Nymphaeceae

   Nymphaea pubescens Willd.

   Emergent, common in backwaters, flowering throughout the year

2. Sterculiaceae

   Melochia corchorifolia L.

   Common in marshy places, flowering from May to September

3. Papaveraceae

   Argemone mexicana L.

   Wasteland of backwaters, flowering throughout the year

4. Fabaceae

   Aeschynomene indica L.

   Emergent, along border of backwaters, flowering from August to September

   Alysicarpus monilifer (L.) DC

Emergent, flowering from August to September.

Desmodium gangeticum (L.) DC.

Common in waste places, flowering from July to April.

Tehprosia purpurea Pers

Common weed of waste lands, flowering from September to November

5. Onagraceae

Ludwigia perennis L.

Emergent common in margin of swamp and backwater impoundment, flowering from August to May

6. Asteraceae

Eclipta prostrata (L.) L.

Emergent as well as submerged, flowering throughout the year

7. Apiaceae

Centala aciatica Linn.

Margine of backwater, flowering from May to January

8. Convolvulaceae

Ipomoea carnea Jacq.

Emergent as well as submerged, flowering throughout the year

Ipomoea aquatica Forssk.

Emergent as well as submerged, flowering throughout the year

9. Solanaceae

Solanum virginianum L.

Common weed of waste lands, flowering throughout the year

Datura metel L.

Common weed of waste lands, flowering throughout the year

10. Scrophulariaceae

Bacopa monnieri (L.) Wettst.

Emergent as well as submerged, flowering from October to January.

Limnophila indica (L.) Druce

Abundant as well as submerged, flowering from March to October

11. Acanthaceae

Hygrophilla polysperma (Roxb.) T.Anderson

Emergent, common in the border of backwater impoundment, flowering from January to September

H. auriculata (Schumach.) Heine.

Emergent, common in the border of backwater impoundment, flowering from September to November

12. Polygonaceae

Polygonum plebelium R.Br.

Emergent in most of the marshes, flowering from September to December

13. Ceratophyllaceae

Ceratophyllum demersum L.

Submerged, flowering from October to January

Monocotyledones

14. Hydrocharitaceae

Hydrilla verticillata (L.*f*.) Royle.

Submerged abundant in backwater impoundment, flowering from December to March

Vallisneria natans (Lour.) Harra

Submerged abundant in backwater impoundment, flowering from December to March

15. Typhaceae

Typha angustifolia L.

Abundant in wetland, flowering throughout the year

16. Lemnaceae

Lemna perpusilla Torr.

Floating, abundant in backwater, flowering from April to October

17. Potamogetonaceae

Potamogeton crispus L.

Submerged as well as free floating abundant in backwater, flowering from January to April

18. Eriocaulaceae

Eriocaulon quinguangulare L.

Emergent, frequent in swamps, flowering from September to April

19. Cyperaceae

Cyperus alopecuroides Rottb.

C. difformis L.

C. compressus L.

C. iria L.

C. polystachyos Rottb.

C. rotundus L.

C. pumilus L.

C. squarrosus L.

C. triceps Endl.

Emergent common in swamps, flowering from June to December

20. Poaceae

Panicum sumatrense Roth.

Emergent, abundant in wetlands, flowering from July to October

Pteridophytes

21. Marsileaceae

Marsilea quadrifoliata L.

Free floating, abundant in swampy places, flowering from July to October

Result and Discussion:

The present work enumerates 37 species of vascular hydrophytes out of which 1 species belonging to 1 genera of Pteridophytes. Angiospermic hydrophytes are represented by 36 species of 26 genera belonging to 20 families. Dicots are represented by 13 families lies 18 genera and 20 species and Monocots by 7 families, 8 genera and 16 species. Among the different types of hydrophytes emergent type has the major contribution. The Cyperaceae is the most prevalent family among Monocots with 9 species. The wetland macrophytes contribute a lot to the productivity of the ecosystem and eventual maintenance of the trophic levels. Constituted by different consumers like annelids, molluscus, anthropods in general and insects in particular, fish, birds rodents and grazing mammls. Many plants are used for edible as well as medicinal purposes. These plants can help to purify waters by removing eutrophying nutrients taking up heavy metals and causing sedimentation of contaminating particles (Nazrul–Islam, 1991). Ecological Monitoring for the Development of a wetland pants at Backwaters in Khandwa is

necessary for further development and establishment of largest backwater impoundment of our country.

Acknowledgement:

The authors are thankful to the Dr. Mukesh Jain, Principal S. N. Govt. P. G. College, Khandwa for providing facilities and encouragement.

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IMPACT OF URBAN-RURAL GRADIENT ON ASSEMBLAGE AND DISTRIBUTION PATTERN OF AVIFAUNA OF KALYAN (W), THANE

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Abstract:

Studies assessing the impact of urbanization on bird assemblage and distribution have been largely carried out in developed countries. Paucity exists in similar kind of studies from India. Compared to other vertebrates, birds are easily observed, identified and monitored by ornithologists, skilled observers or even by bird enthusiasts. These observations can provide a mechanism to explore the impact of different urban designs on the existing and adjacent ecosystem. Diversity, species richness, evenness and distribution of birds in habitats, differently influenced by humans, can be used as a tool to understand anthropogenic impact. During our study, though the Rural site was found to be more diverse (4.4391) than Semi-urban and Urban sites; Richness of avifauna was found to be maximum (19.36) at Rural site and minimum (6.49) at urban. Bird richness varied significantly across the different study sites. Through the present study, we conclude that higher richness and diversity of birds is related to less disturbance and heterogeneity of habitat.

Keywords: Avifauna, urbanization, avifaunal assemblage, Urban-Rural gradient.

Introduction:

Birds is a group of warm-blooded, bipedal vertebrates belonging to class Aves, possessing some unique characters such as body covered by feathers, presence of beak, four-chambered heart, and pneumatic bones. The term avifauna is used to discuss the birds or the kinds of birds of a particular region, period, or environment. Birds have been considered a good ecological indicator, since a long time. The intimate connections between some of the birds and their habitats, climatic condition, vegetation, etc. makes them suitable for evaluating the health of an ecosystem.

Urbanization can be defined as concentrated human presence in residential and industrial settings and their associated affects (Cringan and Horak, 1989, Marzluff, 1997), and for the purposes of ecological studies urban centers have been quantified as containing more than 2500

people (Dumouchel, 1975). It has been globally observed that most metropolitan areas are developing, leading to the expansion of urbanized are into adjacent rural landscapes (Alig and Healy, 1987, UN, 1997, World Resources Institute, 1994). Grimm et al (2000) proposed that with the global increase of urbanization, land cover conversions for urban use will only increase, which will ultimately lead to alter the pre-existing, natural ecosystem patterns and processes.

According to MoHUA, Urban population growth in India was reported at 3.35 % between 2001-2011 and is expected be more than 4% by 2021. As the cities are expanding in naturally species-rich regions, a better understanding of the pattern of species composition along urbanization gradient is necessary for sustainable urban planning and conservation. With the current population trends, urbanization is likely to increase; which is known to adversely impact the avifauna by decreasing natural food availability, resting sites, nesting sites and increasing stress, competition and bioaccumulation of pollutants. Diversity, species richness, evenness and distribution of birds in habitats, differently influenced by humans, can be used as a tool to understand anthropogenic impact. Present study is an attempt to investigate pattern of richness, diversity, and evenness along with feeding habit, occurrence and IUCN status at various urban-rural gradient sites in Kalyan (West), Maharashtra, India.

Study Area:

Kalyan (19.2403° N, 73.1305° E) is a city, encompasses an area of 3650 sq. km, in Thane district of Maharashtra state and is a part of Mumbai Metropolitan Region (MMR), governed by Kalyan-Dombivli Municipal Corporation.

Three sampling sites representing typical form of Urban-Khadakpada (19°15'11.55"N, 73° 8'12.18"E), Urban-Rural-Godrej Hill (19°15'39.58"N, 73° 8'48.93"E) and Rural-natural-Gandhari (19°16'25.85"N, 73° 8'48.19"E) were selected based on density of buildings and decreasing natural vegetation cover. Ulhas river (19°16'4.33"N, 19°16'4.33"N) separates semi urban and rural sites, being a unique habitat, was also investigated for its avifaunal diversity.

Methodology:

Four sites were selected for the study and 500m long transects were marked. Each line transect count lasted for 30 min during which bird species were recorded along with their numbers. Sampling locations were decided according to the visibility and accessibility. Monthly surveys were conducted between September 2019 and February 2020. Visits were made early in the morning and late in the evening as the peak activity of birds is seen during that time. Birds were sampled three times at each point station periodically. Bird species were classified into various dietary guilds viz. carnivore, frugivore, omnivore, insectivore, granivore, piscivore and

nectivore following Ali and Ripley (1987). The species encountered during all sampling point were added cumulatively to determine the total number of species for each sampling sites. Bird richness (Margalef's), diversity (Shannon's diversity) and evenness were calculated using Excel sheet.

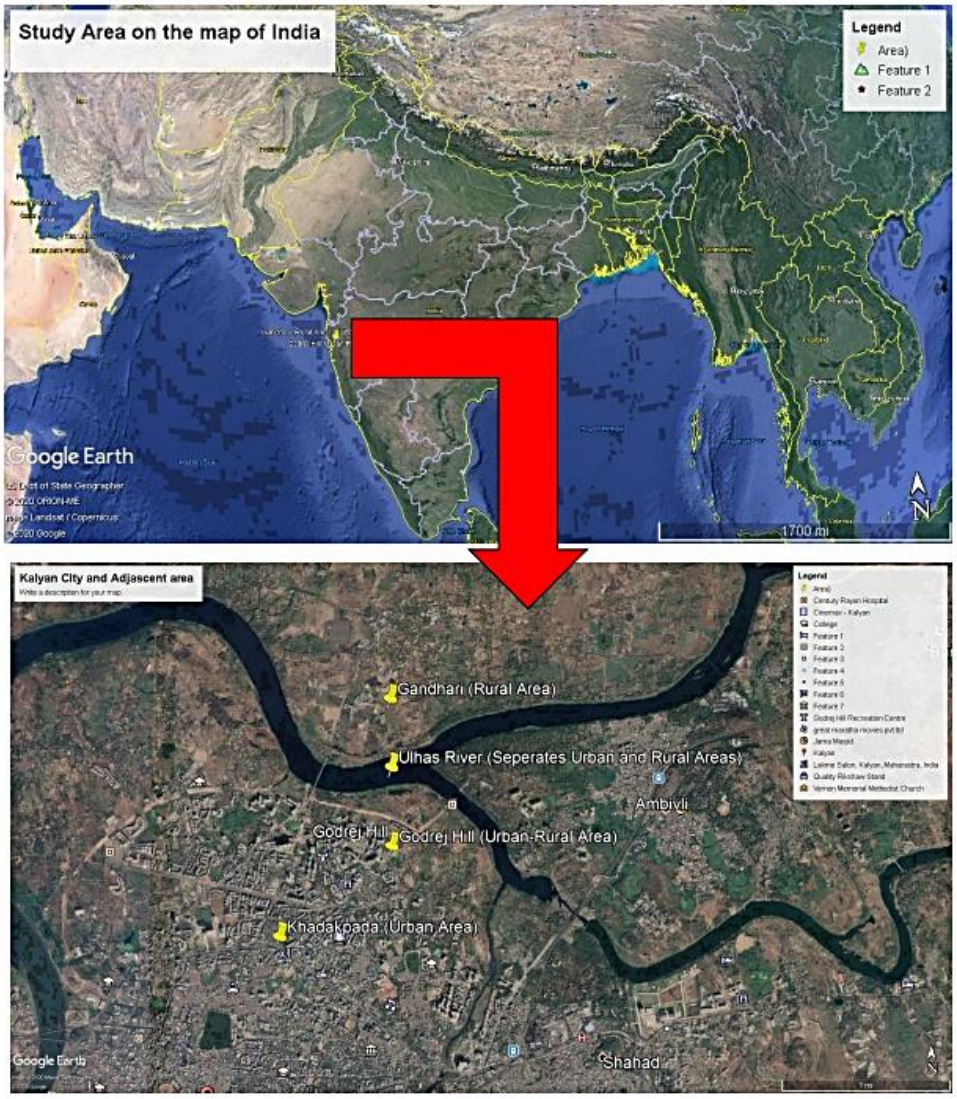

Figure 1: Study area and study sites (Google earth pro imagery)

Results:

A total 7095 individuals of 185 species were observed in the study area, i.e., at all 4 sites representing 57 families.

During present study, 02 endangered (*Clanga clanga* and *Aquila nipalensis*), 03 vulnerable (*Streptopelia tranquebarica*, *Ciconia episcopus* and *Clanga hastata*), 08 near

threatened (*Circus macrourus, Falco jugger*, etc) and with remaining 172 least concern species were reported.

Table 1: Community structure of birds w.r.t. diversity and abundance

Site	Locality	Species Count	Abudance
1	Khadakpada (Urban Area)	43	644
2	Godrej Hills (Urban-Rural Area)	122	3073
3	Ulhas River	60	1063
4	Gandhari (Rural Area)	151	2315

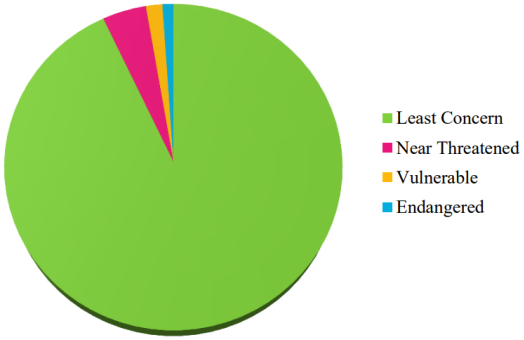

Figure 2: Red list indices of the birds observed during study

Out of 185 species, 51.89 % were migrants while 48.11% were resident birds. Though diversity wise migrant and resident bird shared similar numbers, abundance wise winter migrant species outnumbered resident birds in a ration 2.2:1.

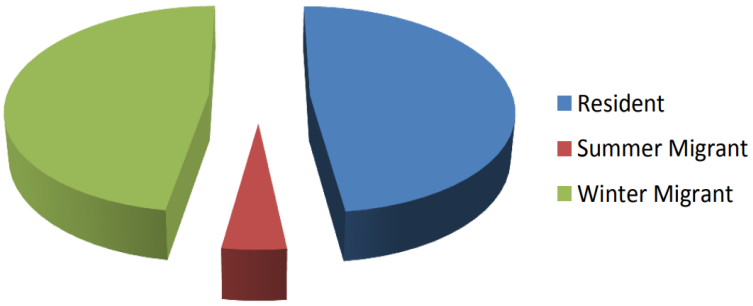

Figure 3: Occurance status of birds

Accipitridae with 15, Scolopacidae with 13 and Ardeidae with 11 species dominated other families.

Rural site was found to be more diverse (4.4391) than Semi-urban and Urban sites. Richness of avifauna was maximum (19.36) at Rural site and minimum (6.49) at urban. Bird richness varied significantly across the study sites.

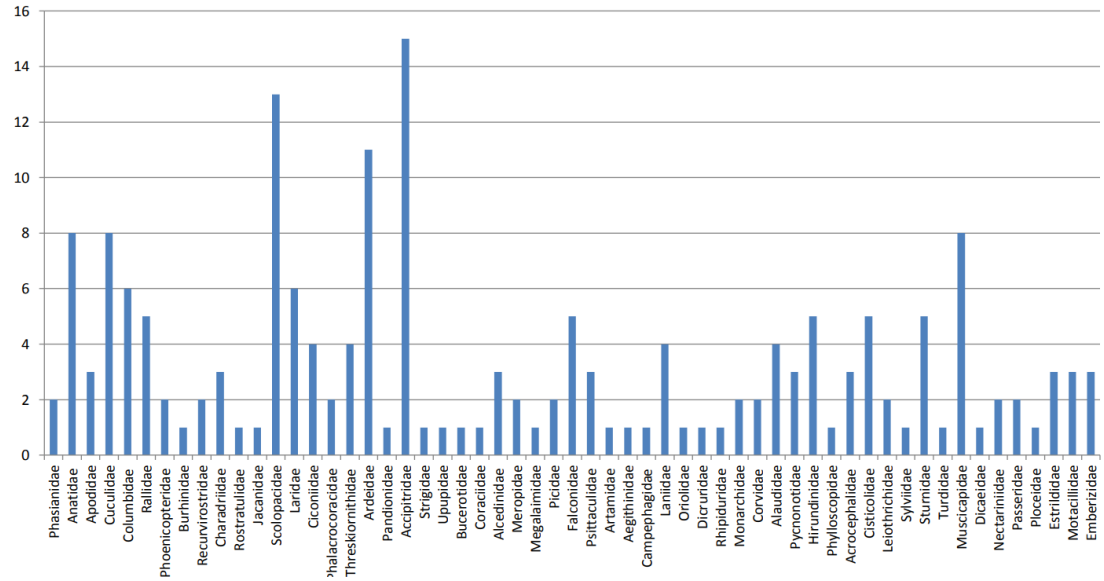

Figure 4: Family wise species diversity

Table 2: Community structure of birds w.r.t. richness, diversity and evenness indices

Site	Locality	Margalef Bird Richness	Shannon Diversity Index	Species Evenness index
1	Khadakpada (Urban Area)	6.49	3.2839	0.873098984
2	Godrej Hills (Urban-Rural Area)	15.06	4.1855	0.871249306
3	Ulhas River	8.47	3.6532	0.892255145
4	Gandhari (Rural Area)	19.36	4.4391	0.88476229

Though the distribution of bird species were more even at Rural site (0.8847) compared with Urban and Semi-urban sites, it was highest (0.8923) at Ulhas river site due to unique aquatic habitat. Though the Rural site showed highest species diversity (151), it was the Semi-urban site who supported highest number of birds (43.31% of total birds). *Motacilla flava* was the most dominant species (220) observed at Semi-urban site followed by *Columba livia* (148) and *Corvus splendens* (122). Numerically, urban site was dominated by omnivore species (48%), which was replaced by insectivorous species (42%) on the periphery, and carnivorous species (39%) in the rural area.

Discussion and Conclusion:

The current study shows that avifaunal richness and diversity are negatively, and evenness is positively influenced by urbanization. The higher diversity of birds in Rural site could be related to higher habitat heterogeneity and less anthropogenic disturbance than the other sites. Though Semi-urban site showed comparatively less diversity, it also showed highest abundance, which can be explained by presence of well-established ground, shrub cover, canopy

cover along with concrete structure to provide the more foraging, nesting and shelter opportunities for a range of species than urban site. Bird species composition was found different among the various urban-rural gradient sites. Carnivorous birds like eagles, harriers and falcons dominated Rural site. Restricted distribution of these species could be related to their habitat association. Ulhas river which borderlines Semi-urban and Rural sites, has influenced avian diversity of both the sites. Current study highlights the importance of Semi-urban and Rural areas in providing suitable habitats for both resident and migrant birds. The present study concludes that higher richness and diversity of birds is related to less disturbance and heterogeneity of habitat.

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Ecology Research Volume V
(ISBN: 978-93-91768-57-7)

PESTICIDES IMPACT ON NON-TARGET ORGANISMS

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Abstract:

Agricultural & related sectors are feeding a growing global population with facing difficulties. One of them is to control the pest by using a pesticide formulation in a different area. It is well-known and documented those pesticides usages shows good and adverse effects on the environment. Many regulatory processes are present for approval of new pesticides with taking care of old pesticides' safe use in the environment. In this review, we are discussing the effect of pesticides on non-target organisms in a different ecosystem.

Introduction:

A pest is any organism that is harmful to humans or human concerns like crops, dairy products, storage facilities of seeds and grains, etc. To overcome this problem different strategies are used since ancient times, like crop rotation, planting different crops in alternate rows, biological control, pesticides, etc.

There are two types of pesticide classification present on basis of usage and by chemical nature. The pesticides are of thirty types; based on the organism, they killed (Akashe *et al.*, 2018). Like herbicides, insecticides, larvicides, molluscicides, etc. Based on chemical composition pesticides are categorized as insecticides, herbicides, molluscicides, rodenticides, etc.

Insecticides are natural or synthetic in origin. According to the United Nations Organization for Food and Agriculture (FAO, 2002) pesticides as any substance or mixture of substances intended for growing, destroying, preventing, or controlling any pest, including vectors of human disease or animal disease, unwanted species of plants or animals that cause damage or otherwise interfering in the production, processing, storage, transport or marketing food, agricultural products, wood and wood products or animal feedstuffs or which may be administered to animals for the control of insects, arachnids or other pests in or on their bodies (FAO, 2002).

Insecticides are broadly classified into two groups: Natural pesticides and chemical pesticides. Natural insecticides are two types of plant-based and mineral oil based. Therefore,

these pesticides are eco-friendly and safe (Mfarrej *et al.,* 2019). Plant-based pesticides are also called green pesticides. These pesticides are having a natural way of defense mechanism against the pest. These pesticides are not only effective but also easily available at a cheap level. They enhance crop production by controlling pests.

Varieties of synthetic insecticides are available in the market. They are broadly grouped into inorganic and organic categories. Organic pesticides are sub-categorized into, organochlorines, organophosphates, carbamates, and pyrethroids (Akashe *et al.,* 2018).

Synthetic pesticides are having an adverse effect on the environment (Aktar *et al.,* 2009). Because they are not natural in origin, their effects on the non-target organism are unpredictable. These synthetic pesticides enter the food chain and get bioaccumulated in the organisms.

There are diverse ways to apply pesticides to the plants, like aerosol, sprinkling, dusting, injection, etc. In certain cases, pesticides are sprayed directly on the infected plant parts to get rid of pests. Only 1% of pesticide reaches the targeted pest and the rest of the 99% of pesticide is entering the environment. The way it is entering in the environment decides the abiotic or biotic factor it will affect. If it is dusted in powder form, it causes air pollution. If it is applied in the dissolved form or liquid form, it causes water pollution. For maximum efficiency extra amount of the pesticide is used by the farmers. These pesticides are still active in the environment for a longer time example DDT (Eskenazi *et al.,* 2009), etc.

Sometimes these pesticides interact with environmental factors and become more toxic. Plants are the producer of the ecosystem. Herbivorous organism feed on plants. Through this food chain, the pesticides enter inside the primary consumers which are herbivores organisms. In this way gradually pesticides are bioaccumulated (Zhang *et al.,* 2011; Ascoli-Morrete *et al.,* 2022) and biomagnified in each tropic level of the ecosystem.

Excess pesticide present in the environment is free to react with soil microbial fauna. Because of the action of pesticides, these microorganisms are going to be affected adversely. The result of this is sterile soil formation (Kaur *et al.,* 2017). Such soil is not suitable for agricultural activities (Joko *et al.,* 2017).

In the rainy season, this excess pesticide enters the nearby water resources like ponds, lakes, rivers, etc. Through the water, it will act on aquatic flora and fauna. In this way, pesticides react with non-target organisms. Water contaminated with pesticides percolated through the soil and contaminate the groundwater. Many studies show that traces of pesticides are seen in the groundwater sample (Bexfield *et al.,* 2020). The residues of pesticides are also seen in the rainwater sample (Kumari *et al.,* 2007).

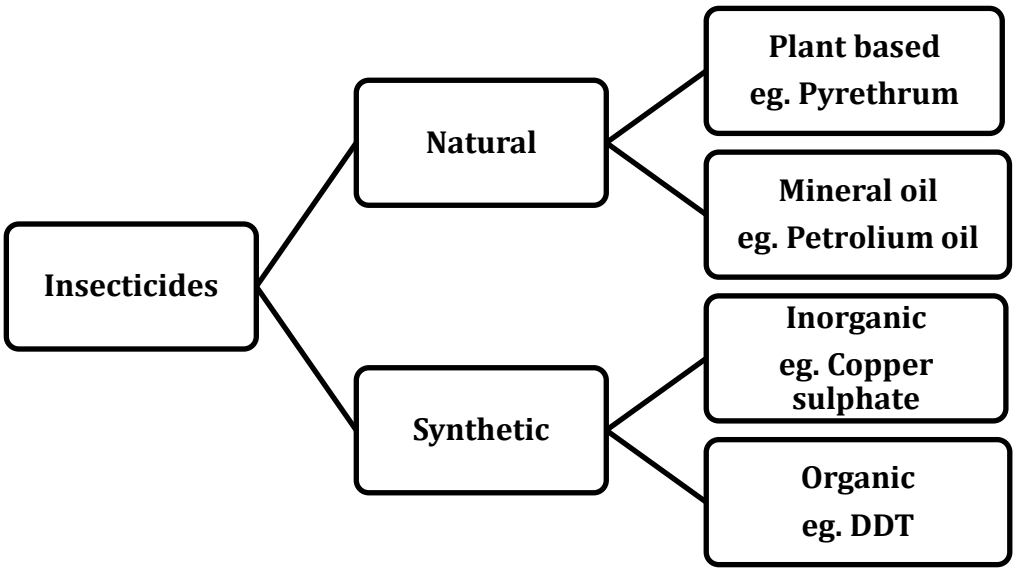

Figure 1: Classification of Insecticides (Akashe *et al.*, 2018)

Agricultural activities take place on the bank of the river and near water storage bodies. Extensive use of these pesticides in agricultural land is also one of the sources of river pollution. After the pesticide application, these utensils may be cleaned at a nearby water reservoir which leads to another way of pesticide pollution.

According to US-EPA (U. S. Environment Protection Agency), herbicides are also toxic to the aquatic environment & its diversity. The acute toxicity of Ron star and Roundup were reported by Folmar *et al.* (1979) and Shafiei and Costa, (1990) respectively. Other herbicides which have glyphosate or glyphosate-containing products cause sub-lethal effects on fish like erratic swimming, and labored breathing caused by gills damage & these fishes was consumed by human beings (Liong *et al.,* 1988). The sockeye salmon i.e., red salmon shows physiological stress responses (McBride *et al.,* 1981) and reduced the food gathering abilities of rainbow trout (Little, 1990) when exposed to 2,4-D herbicides. The earlier studies on dolphins and their prey in the Ganges River, one of the biggest rivers in India, reported concentrations of heavy metals, organochlorine pesticide, and polychlorinated and Butyltuin compounds (Kannan *et al.,* 1993; Kannan *et al.,* 1997).

Synthetic inorganic pesticides have copper sulfate, ferrous sulfate, lime etc. The main classes of synthetic organic pesticides are organochlorines, organophosphates, carbamates, and pyrethroids.

Organochlorines are persistent pesticides. It holds more than five chlorines in each atom. It has a slow rate of degradation (Sparling, 2016). According to Qi *et al.,* (2022) several types of

OCPs, such as dichlorodiphenyltrichloroethane (DDT), methoxychlor (MXC), hexachlorocyclohexane (HCH), endosulfan, chlordane, heptachlorand and hexachlorobenzene (HCB), expounds their effects on women's lactation ability and infant health and supplies a reference for maternal and infant health.

Non-edible parts of the nine plants are evaluated for the organochlorine residues. In some samples, 10 to 50 times higher content of organochlorine than the largest residue limits (MRL 0.01 -0.1 mg/kg) were detected (Chandra *et al.,* 2021).

The person may get exposed at the time of application of organophosphates pesticides in the field. It is a type of occupational exposure to pesticides. Blood pesticide residues and reproductive hormone levels were analyzed in farmer women in one study. Chlorpyrifos, diazinon, malathion, and monocrotophos pesticide residues were detected in the blood samples (Medithi *et al.,* 2022). In this study pesticide-induced alteration in the hormone level was seen.

Behavioral, oxidative stress, and histopathological changes were seen, when *Lamellidens marginalis* is exposed to the monocrotophos (Pandit *et al.,* 2013; Mundhe *et al.,* 2014).

Fishes from the various locations of the Nile River were sampled for organophosphate pesticide residue detection. In this study, chlorpyrifos, malathion, and diazinon pesticides were detected in the fish (Malhat and Nasr, 2011). Organophosphates are also able to induce genotoxicity in non-target organisms (Mundhe *et al.,* 2016).

To know the carbamate contamination in the river, fish were collected from the Chettuva backwater, Thrissur district, Kerala. Fish muscle samples were analyzed with the help of gas chromatography. In total carbamate residues, 65% carbofuran was detected (Sreekala, 2022).

In the human study, prenatal, 3 years old, 7 years old urinary carbofuran phenol concentration was checked. It shows that prenatal and postnatal carbamate exposure may affect the physical developmental process (Zhang *et al.,* 2022).

Pyrethroid insecticides are having excellent biological activity at exceptionally low dose. The chemical properties show low water solubility with strong sorptive properties, which reduces their bioavailability in natural environments (Davies, 1985). Pyrethroid usage leads to adverse effects on non-target aquatic insects and their environment (Tang and Siegfried, 1995; Merivee *et al.,* 2015). Xie *et al.* (2022) observed pyrethroid bioaccumulated in wild fish. Results of this study supply evidence of aquatic pollution. A genotoxic effect of environmental relevant concentration of cypermethrin pyrethroid was seen on *Catla catla* (Sharma *et al.,* 2022).

In conclusion, pesticides are having an irreplaceable role in the agricultural field. There is a need to develop awareness in the farmers while applying them. An effective precise method

should be developed for pesticide application to enhance the effect of pesticide on the target specimen.

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SEED STORES INSECTS AND MANAGEMENT

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Abstract:

The ongoing availability of high-quality seeds is essential for the development of agriculture-based economies across the world. The productivity led growth in agriculture is based on the application of advanced technology, which in turn is dependent on cultivar's access to the seed of desired genetic composition and adequate purity. Among all agricultural inputs, quality seed also provides the best economic and social return. Additionally, it guarantees the best possible use of the other production inputs, such as fertilisers and insecticides etc. Diverse ecological conditions exist across India, leading to the cultivation of a variety of crops. Because of the favourable conditions for the survival and proliferation of insect pests, a huge insect fauna is connected with each of these crops from the point of production to the point of storage. Depending on their feeding habits and life cycles, these arthropods can significantly reduce overall seed output and quality. IPM is a feasible option for controlling insect pests in stores. Additionally, these pests reduce seed recovery, which has a big influence on the regional seed industry's success.

Keywords: Quality seeds, Seed stores, insects, IPM

Introduction:

Stored seeds are ravaged by a number of insect pests. The stored grain pests infest seeds to fulfill their food and shelter requirements resulting in qualitative as well as quantitative losses. The seed loses its germination capacity. Since seeds are often utilised for planting in the next season after an interval of six months or more, it is necessary to preserve seeds. Additionally, a buffer seed stock that may last for two to three years must be maintained. The losses in traditional village shops and warehouses in tropical and subtropical regions are mostly caused by seed damage from biotic (insects, rodents, microorganisms, etc.) and abiotic (temperature, humdity) causes. Of these, moisture, insects, and rodents in storage account for the highest share of avoidable (post-harvest) waste. IPM should be used to save seeds. The basic goal of integrated pest management is to maximise total economic, social, and environmental values, not to maximise pest control. This strategy holds up well across a range of industrial technologies. In

order to maintain insect populations below those causing economic harm, it is crucial to integrate all appropriate strategies and methods of pest suppression in a manner that is as compatible as feasible. Such programmes will need in-depth knowledge of the major pests as well as other minor pests, which will lead to a financial damage threshold; an efficient pest forecasting system; critical knowledge of biological factors regulating the population fluctuations of the pest species in question; and finally, in-depth knowledge of any potential interactions between various control measures.

Damage:

Infestation of insects during storage affects the health of the seeds. It is well knowledge that insect pests found in stored goods are native to the tropics. Insect damage to the endosperm or embryo has an impact on the seed quality. The degree and severity of the damage will determine how vigorous the seedling will be. If the embryo section of the seed is injured, the seed will not germinate. If the endosperm is damaged, the seed may germinate and develop into a seedling. The crop seed and the current ecological circumstances determine the kind, severity, and insect species engaged in the infestation. The safety of the seeds is typically influenced by other factors, such as cleanliness and bulk or bag storage etc.

When stored in bulk, seeds continually release heat and moisture through respiration, reducing the air flow through the majority of the seeds, which can lead to hot areas and caked seeds. By contaminating the seed with their waste, casteskins, webbing, and body pieces, insects also cause indirect harm. Additionally, heating occurs as a result of some insect pests feeding on it, which promotes the growth of mould. "Weevilized" seeds are not recognised since they may not adhere to certification requirements and because they might contaminate newly opened establishments.

Losses:

The total preventable (postharvest) loss of food grains was 10 per cent of the total production or about 20 million tonnes a year. No such extensive estimate of rejection of seeds due to insect-pests either during seed production or subsequent storage have been made in India. Insect infestation of seeds would assume serious proportions if seeds are produced for marketing abroad because of economic liberalization. In global marketing insects or fungi in seeds during storage and transport greatly affect its quality.

Low levels of insects' infestation can develop into damaging/above minimum permissible certification levels before the seed reaches its final destination. In a study, the data provided by Seed Testing Laboratories, working in diverse ecological conditions, reported that the seed

samples are not assayed for insect damage (ID) in 40 per cent laboratories, as per rules provided in Indian Minimum Seed Certification Standards. In all, 136928 samples (field+revalidated) of 60 crops were analysed for which 3.43 per cent samples were rejected on ID basis. Minimum (0.5%) rejection was reported from West Bengal as against maximum (19.3%) from Orissa. The extent of rejection was maximum in food legumes followed by wheat, maize and sorghum in Andhra Pradesh, Jammu & Kashmir and Uttar Pradesh. Rejection of revalidated samples due to ID was high in oats (23.5%), sorghum (12.5%), fodder (11.6%), barley (11.3%), maize (10.7%) and legumes (5.6%). Rejection of revalidated seed samples as per certification standards do not take into account either the loss of seed yield inflicted by insect pests during production or low seed recovery from raw seed yield after cleaning and grading processes.

In India, both primary and secondary seed feeders infest wheat seed. Lesser grain borer *Rhizopertha dominica* was most prevalent (61.5%) followed by *Sitophilus oryzae* (59.3%) in farmer's saved wheat seed samples. *Trogoderma granarium* - essentially a germ feeder, was recorded from 15.5 per cent samples - mostly from dry zones. On an average, 67.6 per cent samples could not meet the minimum certification standards, maximum damage in a sample was by *T. granarium* in wich 43 per cent szed embryo was eaten by the beetle.

Temperature and seed moisture:

The majority of store pest insects have a short developmental cycle from egg to adult and a fast rate of reproduction. Temperature and moisture are the two abiotic elements that affect these properties. Since seeds may be safely stored in cool, dry environments with temperatures below 20°C, it is believed that needs with moisture levels of less than 10% are pest-free. For the majority of insect species, temperatures between 28 and 32°C are ideal. Temperatures that are lower than ideal may cause them to feed less frequently, delay their maturation, and perhaps result in numerous deaths from famine. Seed degradation is increased at higher temperatures (25–35^{0}C) and humidity because these circumstances encourage insect growth and the development of hot patches in addition to biochemical and nutritional changes in seeds.

The largest single factor causing the loss of seed viability is high seed moisture content. Due to the seeds' own metabolic activity and a rise in insect prevalence, high moisture centres also experience higher deterioration. Every bug species has a different need for moisture. However, they all require greater seed wetness than 10%. Consequently, seeds with less than 10% moisture are safe to store. Storage of seeds with a moisture level more than 16 percent not only reduces their quality but also takes up more space as their bulk grows. At 12 to 14 percent seed moisture, moulds and insects may grow easily, at 18 to 20 percent, heating begins, and at 45

percent seed moisture, germination begins. Insect pests of stores receive water mostly from the seed itself as a result of the procedure, which causes chain reactions that lead to the loss of seed viability. Insects must break down the seed's components or expend their own energy reserves to acquire water if the moisture content of the seed is low, often less than 10%. In these circumstances, fewer insects survive. It is crucial to remember that changes in moisture levels of just 0.5 to 1.0 percent can have a big impact on how quickly and how badly an area becomes infested with insects.

Harvesting conditions:

The harvesters and threshers available in the market are designed for grain and not for seed crops. The primary criterion for grain crops is threshing efficiency, but a seed producer is worried about seed breakage. Low grain moisture content allows for the harvest of grain crops, however with such a moisture level, seed damage would be greater, affecting the seed's capacity to be stored. However, collecting and storing seed with a high moisture content will not only promote rapid insect reproduction but also fungal invasion and growth. However, the presence of broken seeds and dockage in a seed lot promotes the growth of insects. For the store insects that invade the harvested crops in the field. Threshing must be done rapidly to allow for the application of control measures in stores before major damage takes place. It is recommended to harvest and thresh quickly in areas where Sitotroga is present since it helps to prevent infection in the field and in the bin.

Seed residue in processing equipment, in particular conveyers, seed treaters, transport vehicles including trucks and trolleys, harvesters, and threshers, are particularly vulnerable to insects that feed on stored seed and storage fungi. The ideal setting for the development of huge pest populations is one with favourable moisture and temperature conditions. To avoid contaminating recently harvested seed crops, it is thus advised to examine, remove, and treat these seed leftovers.

Seed certification requirements:

Chapter 1 (General Seed Certification Criteria) and subsection 25 of the Indian Minimum Seed Certification Standards provide seed standards for "Insect Damage." According to the rule, "A seed lot under certification shall not, for either the foundation or certified seed classes, have apparent or visible evidence of damage by insects in excess of 1.0 percent for seeds of maize and legumes and 0.5 percent for the seeds other than maize and legumes, unless otherwise prescribed."

Determining the pest infestation of a seed sample before submitting it to the Seed Testing Laboratory is essential. The information obtained is reported to be useful in several ways.

- Insects can because of poor germination and weak seedlings.
- Latent/hidden infestation can lead to increase infestation of a seed lot during transit/storage.
- Spread of insect-pests to newer areas and
- It helps in adoption of proper remedial measures.

For assaying the seed sample from "ID" point of view, it is essential test the sample immediately at the time of its lifting or preserves it in a way so that insects do not multiply.

Seed storage:

A. Requirements of Store:

Farmers in India store the seed in a variety of ways to reduce losses, but they are only partially successful because they use traditional (old) containers like pit-type underground structures, structures made of paddy straw, Kachha kothi earthen pots, oil drums, and Parchhatii and Thekha storage structures, where losses are at their highest. The lack of cracked seeds and other inert material, which, when kept for extended periods and interferes with the normal passage of air through the seeds, not only feeds insects and fills up the gaps between seeds but also compromises seed quality, makes storage more secure. According to a poll conducted in the state of Haryana, the majority of farmers do not distinguish between grain and seed. In fact, the produce is consumed as grain from threshing onwards and the same lot is used as seed for planting in the next season.

Although "Silos" are utilised on a commercial basis, farmers frequently employ "Pusa steel bins" for on-farm storage. Seeds stored in unsuitable containers and dark, wet areas absorb moisture from the earth or the environment, especially during the rainy season. The warm season and high seed moisture content are ideal conditions for insect pest growth, survival, and reproduction rapid. Therefore, the storage structure should contain the following features in order to protect the seeds from insect damage or infection.

- It should be moisture proof.
- It should allow controlled aeration to cool the seeds and thus limit insect development.
- It should be capable of being made sufficiently air tight, for distribution of fumigants and
- It should be easy to clean and inspect and also allow smooth in and out movement of seed.

Besides, it should protect the seed from rodents, birds, objectionable odors, theft etc.

B. Sources of insect infestation:

The temperature and moisture levels in the collected seeds are probably ideal for insect growth. In order to stop the spread of insects, the causes of insect-pest infestation in stores should be investigated before control measures are taken. An infestation of insects can be caused by:

- Leftover seed from bins/stores or spilled seeds under the stacks
- Cleanings of the processing plant
- Old infested stores
- Insect infested trolleys, wagons, trucks etc.
- Storing insect infested seeds with fresh stock or vice-versa
- Old gunny bags
- Entry of insects from neighbouring stores and
- Carryover of field infestation

C. Seed inspection during storage:

The most crucial aspects of pest control in seed storage are routine inspections and ongoing monitoring. Flour stains on gunny sacks, foul odours, or dockage are typical signs of infestation foci. In bulk seed, small plastic traps with or without pheromone bait have been employed to successfully scout for insects.

To assess the development of an insect population, a seed store must undergo appropriate inspections, including those of its exterior. When searching for indications of their potential presence, it is important to consider the insect's behaviour. The inspections must be carried out by staff that is well-equipped and trained, who should search for the raw seed as well as any equipment used for processing, cleaning, or shipping, among other things, and who keeps a thorough record of pest control. To find a beginning insect infestation or heating, seed storage must undergo routine checks on a regular basis. These examinations are especially crucial during the monsoon or in coastal areas when the ecological setting and seed dampness encourage fast insect proliferation.

Inspections of possible insect infestation in stored seeds have become pivotal with shift towards integrated pest management. In fact, inspections are now a standard component of every successful pest management programme. As far as feasible, inspections should be scheduled in advance, and the necessary instruments and equipment should be ready. Everywhere throughout

the inspection, including all stationary locations and equipment, should be checked. Reports should be presented in a clear and straightforward manner. To distinguish between damaged seeds and insects, we require a seed probe and seed physical purity boards for examination.

The development of the pest population varies depending on the storage's ambient temperature and moisture content. Therefore, it is advised to verify the stores/bins every three to four weeks. Inspecting should be done every two weeks in coastal locations and during the rainy season. Systematically taken seed samples should be examined for pest population, seed damage, and dockage. Be on the lookout for odours, cakeing, and crushing throughout the examination since these are telltale signs of bug and moisture issues.

Insect pests of seed stores:

Secondary seed feeders attack the already damaged seed where testa is cracked, holed or broken either due to mechanical damage during harvesting, threshing and processing or by too rapid seed drying or by prior feeding damage by primary seed feeders. These bugs are the main pests of flour and processed goods. The larvae of Ephestia, Plodia, and the beetles of Oryzaephilus, Cryptolests, Tribolium, and other Tenebrionidae are the most prevalent secondary pests on seeds. Trogoderma is a major pest in warm, dry climates, but Sitophilus and Rhizopertha are found in damp, fairly warm climates. In seed storage, insects fall into one of two categories:

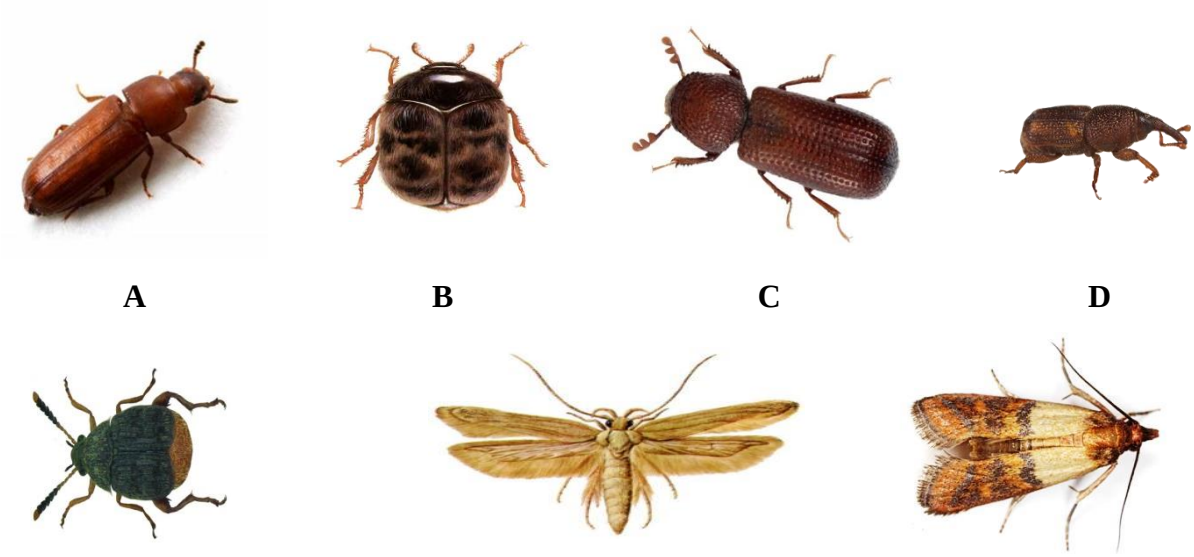
Group-1: Insects that infest the seed in the field and do not multiply in transit/ store e.g. pink boll worm in cotton, midges in millets etc. The number of seeds damaged in field remains constant. Pests are transmitted through these infested seeds from place to place and year to year. They resume their life activity in field or other media under favourable conditions.

Group-II: Insects that infest the seed in field/store or any other place where seed is handled. These arthropod pests continue life-cycle in ambient conditions. Number of damaged seeds as well as insects continue to increase with the passage of time e.g, weevils, beetles, moths etc. Thus, after lifting a seed sample containing such insects, it should immediately be tested.

Proper pest control is predicated on knowing what we are trying to control. Thus, identification of insect pest species is important. Knowing the insect species in a potential problem can help us decide what the risks are, what actions are indicated and how prompt these actions need to be adopted.

Table 1: Insect pests of seed stores

Common name	Local name	Scientific name	Seed attacked	Mode of damage	Optimal climatic requirements
Rust Red Flour Beetle	Sursi	*Tribolium castaneum*	All already damaged seeds	Secondry feeder; Adults & larvae feed on seeds already damaged	30-35^{0}c RH>70% Seed m.c. 11-16%
Khapra beetle	Pai, Khapra	*Trogoderma granarium*	All seeds	Primary feeder; larvae feed on germ portion and reduce seed into frass	34-37^{0}c RH>50% Seed m.c. 11.5%
Lesser grain	Ghun	*Rhizopertha dominica*	All seeds	Primary feeder; adults & larvae feed on seed and reduce them to mere shells with many irregular holes	33-36^{0}c RH> 60% Seed m.c. 11.14%
Rice weevil	Sundwali sursi	*Sitophilus oryzae*	Cereals	Primary feeder; larvae feed and pupate inside seeds. Seedling vigour is adversely affected	26-30^{0}c RH> 70% Seed m.c. 14%
Pulse beetle	Dhora	*Callosobruchus chinensis*	Pulses	Primary feeder; larvae feed and pupate inside the seed. Seed quality is adversely affected	30-35^{0}c RH> 50% Seed m.c. 12-14%
Grain moth	Patanga	*Sitotroga cerealella*	Cereals	Larvae feed seed from inside which partly gets filled with the excreta. Damaged endosperm results in reduced seedling vigour	30^{0}c RH> 70% Seed m.c. 14-16%
Indian meal moth	Patanga	*Plodia interpunctella*	Cereals & Dried fruits	Primary feeder; larvae feed inside seed making a silken web.	29^{0}c RH> 70% Seed m.c. 14-16%



A **B** **C** **D**

E **F** **G**

Figure A. Rust Red Flour Beetle, B. Khapra beetle, C. Lesser grain, D. Rice weevil, E. Pulse beetle, F. Grain moth G. Indian meal moth

Management:

Since the viability of the seeds must be kept in addition to controlling insect pests, a well-defined management approach is necessary for the management of insect pests in a seed store. According to a previous research, there are five essential procedures to controlling insects in a seed store or processing facility, listed in chronological order: a barrier, etc.

1. Have an inspection or surveillance system for the storage which would yield prompt awareness of a possible problem
2. Determine the extent and nature of the possible problem - what species, how many and when
3. Device a plan for the control of the problem. Make use of your own basic knowledge and information. Consult experts, literature etc. or whatever combination is required
4. Implement the device plan being willing to modify it as indicated and
5. Monitor the results of the effort.

The strategy of insect pest management must keep into consideration the following key aspects of insect control:

A. Prevention:

1. Keep facility clean (sanitation)
2. Do not bring the insects into the processing plant
   - check conveyances

- check raw seed including packaging supplies
- maintain building tightness

3. Have clearly defined inspection programme for early detection
    - use check list(s) of where to look
    - use traps as monitoring devices

B. Presence noted - assessment of problem:

1. Species definitely identified
2. Determine behaviour/habits -think like an insect
3. Determine source(s) or origin(s) of infestation

C. Plan of Management:

1. Define magnitude of "problem" species, number/locations etc.
2. Select control treatment(s) based on:
    - seed damage in bulk or bag
    - potential for contamination
    - physical facilities
    - risk to operator & others
    - cost (control measures, possible loss of seed or seed quality etc.)

Avoidance, physical store modification, and eventually poisonous chemicals are used to manage insects in seed shops. In tropical and subtropical areas of the world, choosing the right kind of storage structure is essential for keeping seeds free of insects during on-farm storage. The control measures are often divided into (i) curative and (ii) preventative measures. Chemical and non-chemical curative techniques are separated into several categories. Chemical techniques for pest control include fumigating stores, spraying store surfaces and bags, and combining insecticidal dust with seeds. Biological control, host tolerance to pests, changed atmospheric systems, temperature manipulations, radiation, physical barriers, etc. are examples of non-chemical techniques.

Preventive:

- Prompt harvest, drying and thorough cleaning of the seed help prevent entry of insects into the seed stores.
- Good sanitation in the processing plant and harvest machinery is crucial, since seed pests often breed in small remenent deposits of old seeds in inaccessible places viz., conveyer belts, screens, lift, hoppers etc.
- Hard to reach spots should be disinfested by fumigation.

- Destroy (burn or burry deep) the sweepings, clear trash, litter from outside the store/processing hall and remove the spilled seeds from under the stacks.
- Remove all the leftover seeds from store/bin; sweep down the walls, ceilings, sills, ledges and floor etc.
- Make necessary repairs of crack and crevices.
- Use new gunny bags for fresh harvest. However, if old bags are to be used dip them in 0.1% malathion 50 EC (1part malathion 50EC+ 500 parts of water).
- Drying, followed by cooling and ventilation of bulk stored seed, as well as temperature monitoring is important for long term storage.
- Bagged seeds must be kept at distance from walls to allow inspections, fumigation and avoiding the seed to absorb moisture from moist surfaces.
- To disinfest the stores, spray 0.5% malathion 50EC (1:100) on floor, wall and ceiling or fumigate with aluminium phosphide tablets (3 g each) @ 7-10 tablets or 10.0 L EDCT per 1000 cubic feet.
- To avoid insect damage to store seed, mixing of malathion 5D @ 250 g/qt or deltamathrin 2.8 EC @ 4 ml/qtl. seed is recommended. This treatment besides checking the insect infestation in serds do not have any delatarius effect on its quality.
- Spray inside and outside surfaces of the store atler cleaning with the following Insecticides to kill any insect that has remained in the store or insects that may crawl across these areas to damage the stored seed:
    1. 0.1% malathion 50EC (1 part of insecticide +500 parts water) or
    2. 2 0.1% fenvelrate 20EC (1 part of insecticide 200 parts water) or
    3. 0.1% cypermathrin 25EC (1 part of insecticide + 2500 parts water.

Care must be taken to treat all the cracks, crevices and areas around doorways and other places where insects could enter from outside.

Note:

- Always look for the expiry date on the label of the insecticide container: use as directed on the label; do not use spray material that have sat overnight after being mixed with water.
- To keep pulses free from the bruchid infestation, keep a 7.0 cm layer of sand at the top of seed stored in bulk.
- Where empty godown is infested with *Trogoderma*, it must be fumigated with EDCT or aluminium phosphide before use.

Fumigation:

The use of fumigants in seed storage or the application of insecticides to protect seed from insect ravages are justified in tropical and subtropical climates due to insufficient seed storage techniques and high risk factors for insect infestation. As they are inexpensive, effective, and simple to apply against target pests, fumigants are frequently used for curing or preventing action because they may penetrate into areas where other control approaches are impractical or impossible.

A chemical compound known as a fumigant exists in gaseous form at specific temperatures and pressures and has a sufficient concentration to be harmful to pest organisms. In addition to other qualities, a fumigant should not impair seed viability and be very diffuse, non-persistent, and non-corrosive. The most popular fumigants used for fumigation are aluminium phosphide, methyl bromide, ethyl dibromide, and EDCT. Many cereal and legume crops have been observed to have reduced seed germination when treated with EDB. Although there have been no unfavourable impacts of aluminium phosphide fumigation, there have been variations in wheat, rice, green gramme, and broad beans for germination and other quality indicators. Onion seeds have been observed to completely lose viability, produce mutagenic elects, and exhibit chromosomal abnormalities at greater seed moisture contents and phosphine dosages. In rice, high phosphine doses led to reduced respiratory enzymes, increased dehydrogenase activity, and electrolytes in seed leachate. Most crops' germination and vigour are negatively impacted by high seed moisture contents, excessive fumigation dosages, and prolonged exposure times. Consequently, even fumigation has consequences when seed batches are revalidated.

Due to the fact that phosphine gas reacts differently with seeds of crops with various moisture levels, aluminium phosphide should be handled cautiously in seed stores. The seed quality is reportedly impacted if phosphine fumigation is carried out at more than 12% seed moisture content, thus the storage facilities should be reliable to prevent moisture from moving throughout the store.

Curative:

- Fumigate with aluminium phosphate a 7 tablets (3 g each) or EDCT mixture (3:1) per 1000 cubic feet space with exposure period of at least 7 days.
- Never keep the fumigant at the bottom of the floor/bin as the gas is heavier than air and travel downwards. Since the gas can penetrate downwards upto feet, the fumigant should be placed accordingly.

- Spray the stores with DDVP @ 0.25% (1:300). For 100m area. 3 lines of spray material is required. Spray on all the walls, ceiling and floor of the dore. Spray other surfaces/structures (see check list) where presence of invest is suspected.
- Surface of the bags should be sprayed with Malathion 50 EC (1 mil malathion in 100 ml water) after 3 or 4 weeks.

Precaution:

- Fumigations are to be done cautiously by trained persons under technical guidance.
- It should be ensured that the fumigated structures are air tight.
- Never use EDB in seed stores as it would affect seed quality.
- Never mix BHC or DDT with seeds.

Non chemical methods:

Biological Control:

A variety of parasites and predators that have some natural control target stored product insects. When using traditional methods of management is not acceptable, enhancing or manipulating these natural enemies gives new ways to manage pests in storage. To control the populations of *Cadra cautella* and *Plodia interpunctella*, a parasitic wasp called *Bracon hebetor* kills their late stage larvae. This approach's potential is still untapped in retail settings.

Pheromones:

Synthetic pheromones have been product for the almond moth.red and confused flour beetles. Other insect species include the khapra and smaller grain borer. Pheromone traps may effectively find concealed infestations, according to research.

Host resistance to insect-pest:

Although plant breeders have worked hard to create resistant strains of many different crops, little study has been done to create strains whose grains or seeds are resistant to assault by insects that feed on stored goods.

Temperature manipulation:

Applying hot or low temperatures provides a non-chemical method of cleaning stored goods of pests. Sublethal temperatures can have an impact on locomotion, eating, growth, development, and reproduction. However, temperature must not have an impact on the viability of the seed population.

Controlled or modified atmospheres:

It has long been recognized that killing insects using a changed environment of oxygen, carbon dioxide, and nitrogen is possible. According to laboratory tests, all life stages of the main bug species that infest shops may be effectively controlled by oxygen-deficient atmospheres. For

instance, Sitophilus weevils will suffocate in air with only 2% oxygen. Additionally, the continued storage of wheat, rice, barley, malt, and almonds in this environment for up to a year did not negatively influence their germination: Additional research is required to examine the economic viability of chemical control techniques and changed atmospheres. Additionally, fundamental knowledge on the development and population increase of surviving insects under these circumstances is required.

Radiation:

Gamma radiation's effects in reducing bug infestations in shops have been well studied. Its impact on seed viability, however, has not been thoroughly investigated**.**

Physical barriers:

The usage of physical barriers built around the product is one of the proven non-chemical techniques for the management of pests found in stored goods. To safeguard the seeds, for instance, a multi-wall paper bag has been devised. The packing material also acts as a physical barrier to keep insects out of the bags containing the seeds. The following packaging materials have been shown to be insect-resistant: polyester, polyvinyl chloride, polypropylene, and polycarbonate. Ethylene tetrafluoroethylene is another option. Additionally, insecticides have been added to packing materials to make them resistant to insects. A high tensile strength plastic sheet is also being tested as a barrier against insect invasion. Additionally, it has been noted that physical disruption or turning of seeds, vacuum transportation, and Entoleters can only diminish the number of external feeding insects. Inert dusts derived from the shells of diatoms are being used to mix with seeds. However, seed moisture must be kept in mind while using these dusts.

Integrated pest management:

IPM is now a feasible option for controlling insect pests in retailers. The adoption of the control strategy and the suggested control method(s) are predicted using computer models. The best management strategies are based on these models' utilisation of historical store data and understanding of insect ecology. IPM necessitates thorough knowledge of the species, monitoring, biology, behaviour, and response to various control measures of insect pests. Reduced pesticide use in IPM promotes physical and biological pest management techniques while also lowering the risk of insecticide resistance. The most crucial element of such management programmes is frequent sampling.

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ANTINUTRITIONAL FACTORS IN FOOD

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Abstract:

This book chapter (review) focuses on the anti-nutritional factors in plant metabolism and how they are helpful and harmful to animals in addition feasible processing methods that can be used to decrease the level of these factors in foods. The anti-nutritional factors can be defined as those substances generated in natural food substances by the normal metabolism of species and by different mechanisms e.g. inactivation of some nutrients, diminution of the digestive process or metabolic utilization of feed, which exert effects contrary to optimum nutrition. Anti-nutritional factors are natural or synthetic compounds that interferes the absorption and metabolism of nutrients. Nutrition studies focus on these antinutrients commonly found in food sources and beverages e.g. polyphenols, oxalic acid, oxalates, glucosinolates, amylase inhibitor, lipase inhibitor, protease inhibitors and phytic acid etc.

Keywords: Anti-nutritional factors, polyphenols, phytic acid.

Introduction:

Antinutritional factors (ANFs) are components of natural and synthetic origin which interfere with the absorption of nutrients, which leads to impaired gastrointestinal functions and metabolic performance. Lectins, tannins, saponins, β-glucans, and protease inhibitors are a few important ANFs found in plants.

Several bodies such as the National Research Council in the United States and World Health Organisation directed their attention to nutrients and foods that have positive role in maintaining health and delaying age related disorders.

Plants for their own defense primarily use antinutrients such chemical compounds can be evidently advantageous to human kind when consumed wisely. A number of so called antinutrients have been shown to possess anticancer, antimicrobial properties which also vary according to their level in the diet. Brief reference to such effects are also included because a

pressing challenge to scientists is to identify optimal levels for maximizing the benefit to risk ratio. Plants commonly synthesize a range of secondary metabolites as part of their protection against attack by herbivorous, insects and pathogens or as means to survive in adverse growing conditions (Bora, 2014). Such compounds are of increasing interest in the fields of biochemistry, medicine, pharmacology and nutrition (Akande *et al.,* 2010).

Science has added knowledge about the disease preventing phytonutrients present in food stuffs. The major phytonutrients identified to have nutraceutical properties include terpens, phytosterols, thiols etc. Numerous ANFs have been reported for commonly used plant protein feedstuffs. Soybean meal contains protease inhibitors, lectins, phytic acid, saponins, phytoestrogens, antivitamins, and allergens. While many of the same ANFs are found in other plant protein sources, glucosinolates (rapeseed meal, mustard oil cake), tannins (pea seed meal, mustard oil cake), cyanogens (pea seed meal), alkaloids (lupin seed meal), arginase inhibitor (sunflower oil cake), gossypol (cottonseed meal), cyclopropenoic acid (cottonseed meal), and mimosine (Leucaena leaf meal) may also be present (Francis *et al.,* 2001).

Broad classifications of ANFs proposed by Francis *et al.* (2001) include (1) factors affecting protein utilization and digestion, such as protease inhibitors, tannins, and lectins; (2) factors affecting mineral utilization, which include phytates, gossypol, and glucosinolates; (3) antivitamins; and (4) miscellaneous substances such as mycotoxins, mimosine, cyanogens, alkaloids, phytoestrogens, and saponins. Across the groupings, several ANFs irritate the intestinal epithelia or otherwise cause excess mucus production, thus impairing the function of the intestine and altering cellular and chemical signaling.

Antinutrients in plant-based foods:

Antinutritional factors (ANFs) are compounds in foods that tend to reduce the availability of nutrients. Besides from providing protein, carbohydrates, vitamins, and minerals, pulses are also rich in ANFs. ANF in pulses includes amylose inhibitor, trypsin inhibitor, saponins, agglutinins, etc. Among these inhibitors, trypsin inhibitor is of major concern as it reduces the availability of proteins by reducing the digestibility of specific amino acids. To reduce ANF in pulses, generally, pulses are heat-treated or cooked with water. In a study, cold plasma was used for reducing the ANF–trypsin inhibitor activity in soybean (Li et al., 2017). DBD plasma at 2 kV power reduced the trypsin inhibitor in soymilk by 86.1% in 21 min treatment time. The mechanism behind this property of cold plasma is its ability to change the conformation of the ANF. After treatment, the hydrophobicity of the Kunitz type trypsin inhibitor decreased with a significant increase in the sulfhydryl group. The large extent of decrement in the trypsin inhibitor

and phytic acid about 39.23%, and 52% were observed in cold plasma–treated mung beans at 60^0C for 20 min on comparison with germinated seeds. The cold plasma treatment increases the enzymatic activity of amylase, protease, and phytase, which results in the reduction of antinutrients in improving the bioavailability of the essential nutrients present in the mung beans (Sadhu *et al.,* 2017).

Table 1: Anti nutritional factors present in some feed stuffs

Feed stuffs	Anti nutritional factors
Peas	Lectins, tannins and oligosacharides
Soybean meal	Lectins, Oligosacharides,trypsin inhibitors
Wheat	Tannins, saponins, phytic acid, polyphenols.
Barley	Glucans.

Major ant nutrients found in plant based food are phytates, tannins, lectins, oxalates etc. Oxalates are found in raw spinach, kale, broccoli, and soyabeans prevents calcium being absorbed in the body.

Tannins are associated with green tea, wine, grapes, generally inhibit protein absorption and also interferes with the protein digestion and interferes with iron absorption.

Lectins are water soluble carbohydrate binding proteins. Lectins prevent cell damage caused by free radicals also slow down digestion and absorption of carbohydrates.

Saponins non volatile secondary metabolites. Saponins are steroids contains sugar moiety in their structure. It should be noted that the low levels of saponins in legumes may not be injurious to health but could become toxic when consumed in high concentration in the diet (Jansman *et al.,* 1998).

Goitrogens found in vegetables like cabbage, broccoli, cauliflower, kale interfere with the iodine uptake that interferes with thyroid function. The consumption of cruciferous vegetables causes hypothyroidism by altering the levels of T_3 and T_4.

Disabling antinutrients:

Several processing techniques and methods such as soaking, germination, autoclaving, fermentation etc can be used to reduce antinutrient contents in foods. By using various methods alone or in combination is possible to reduce antinutrients in foods. However it should be borne in mind that processing can also introduce undesirable compound, for example volatile aldehydes and ketones and peroxides as a direct result of lipid oxidation or reduce levels of desirable compounds e.g. protein and essential minerals.

Sprouting is one of the most effective methods for the reduction of antinutrients especially phytate levels, it leads to increased nutritional and decreased antinutrient content of plant based foods. Fermentation with fermenting assorted grain flour with *L.acidophilus* at 37ºC for 2 hours led to reduction of polyphenols, phytic acid content from cowpea flour. Cooking whole grains beans and vegetables can reduce certain antinutrient such as phytic acid, tannins and oxalates. Protease inhibitors are easily denatured by heat treatment due to their protein nature. Autoclaving for 120^0c for 15-30 minutes can also considerably reduce the contents of phytates, tannins and trypsin inhibitors. (Inuwal *et al.*, 2011).

Soaking*:*

Soaking can be seen as one of the easiest physical processes to remove soluble antinutritional factors. Soaking decreased the total protein, soluble sugar and tannins, in soybean flour [9]. However, lectin is not affected by this method of deactivation.

Conclusion:

In this book chapter paper we have discussed the basically the antinutritional factors that are usually consumed by humans animals as their diets. In diets we take cereals mostly pulses and some leafy vegetables they contain so many antinutritional factors. These antinutritional factors have so many harmful effects on humans as well as animals and also converted in their derivatives. . Antinutrients may induce their undesirable effects when consumed above their upper limit.

In existing situation our life and body have so many complications due our diet so we should aware about cereals and pulses harmful constituents basically anitnutritional factors. These are not possible to detoxify so we can reduce a lot of quantity during processing of various stages by physical and biochemical processes. Extensive research is still needed to explore elimination methods for heat stable, antinutrient present in various food without altering the nutritional value of food. Deeper knowledge of the chemical structure of the antinutrients involved can help to devise technological strategies in order to obtain toxin free products.

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ROLE OF INTEGRATED PEST MANAGEMENT IN AGRICULTURE AND ENVIRONMENT SUSTAINABILITY

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Abstract:

Different types of the pests destroyed a large amount of the agricultural product. Therefore it is essential to control pest population. Integrated Pest Management (IPM) is the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations. It combines biological, chemical, physical and crop specific (cultural) management strategies and practices to grow healthy crops and minimize the use of pesticides, reducing or minimizing risks posed by pesticides to human health and the environment for sustainable pest management.

Keywords: IPM, pest, agriculture, environment, etc.

Introduction:

The population of the world has multiplied during the past century and will continue to grow in the near future. Future demands for food and water will increase due to the growing global population. Many governments continue to prioritize food security, with developing nations receiving special attention. Concern over the world's future food supply and demand is growing. Unprecedented demands are combining on the world food system, and these forces may get worse in the future.

Greater inputs of land, water, and energy, or a combination of these inputs, will be needed to produce more food. Thus, the need to produce more food will raise competition for land, water, and energy. Global agriculture is changing as a result of human demand for food, technological advancements, and climate change.

Application of various fertilizers can boost productivity, but when different types of pests attack the crop, all of the work of fertilizer on plant growth is wasted. Weeds reduce crop output, particularly because they compete with organic fertilizers (Boote *et al.,* 1983). In order to avoid

and reduce crop losses caused by pests in the field (pre-harvest losses) and during storage, crop protection has been created (post-harvest losses).

The evaluation of agricultural losses is crucial for identifying future action areas, as well as for government and farmer decision-making. High-yielding cultivars, better water and soil management, fertilization, and other cultivation methods can all boost crop productivity in many places.

Crops with higher yield potential, however, are frequently more susceptible to pest attack, which results in larger absolute losses and loss rates (Oerke *et al.*, 1994). Pests that attack crops before harvest cause yields to drop by 35% on average worldwide (Oerke, 2005). Besides reducing crop losses brought on by pests, preventing waste throughout the entire food chain is essential (Popp, 2011). In addition to this decreased productivity, pesticide attack reduces productivity yield by roughly 50%.

Entomologists refer to this increased reliance on chemical pesticides as the "pesticide treadmill" (Bosch, 1978). Two responses to pesticide resistance play a significant role in the "pesticide treadmill." The first is to apply more of the less effective pesticide, which usually results in increasing levels of pest resistance as well as harm to the environment and natural enemies. The second course of action is to create and market a new insecticide. The treadmill theory postulates that this two-step process will continue until the insect encounters a pesticide that is resistant to it or until the supply of new, highly effective pesticides runs out. Extreme evolutionary responses occur in pest populations when control tactics have a bigger impact on those populations.

Although using pesticides boosts crop productivity, it is important to consider their negative consequences on the ecosystem. Therefore, biotechnology, organic farming, IPM, biological control and cultural practices etc. are some methods to reduce overuse of pesticides.

However, the use of pesticides globally has mainly continued unabated, with detrimental effects on farmer livelihoods, biodiversity preservation, and the right of people to food. A good example of how crop protection has changed over the past 60 years is integrated pest management (IPM). Throughout this time, IPM has worked to advance environmentally friendly agricultural practices, achieve significant decreases in the use of synthetic pesticides, and consequently address a wide range of socioeconomic, environmental, and health issues.

What is Integrated Pest Management (IPM)?

IPM is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation,

modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment.

The IPM approach can be applied to both agricultural and non-agricultural settings, such as the home, garden, and workplace. IPM takes advantage of all appropriate pest management options including, but not limited to, the judicious use of pesticides. In contrast, *organic* food production applies many of the same concepts as IPM but limits the use of pesticides to those that are produced from natural sources, as opposed to synthetic chemicals.

The IPM method is based on scientific research surrounding pests and pest management. A pest is considered to be any organism that interferes with desirable plants in an agricultural setting, damages homes or other structures, or impacts human or animal health and well being. Pests can be plants, animals, insects, or a bacteria, virus or fungus causing disease. IPM focuses on long term prevention. By researching the environmental factors affecting a pest, the management strategy can be tailored to create unfavorable conditions and reduce the possibility of future outbreaks.

Steps of Integrated Pest Management:

IPM is a form of pest control that combines techniques to lower dangers to people and the environment while preserving business profitability. By focusing on all available pest management techniques and only employing chemical control as a last resort, IPM practices reduce the need for chemical control. Both conventional and natural pest control are covered under IPM.

There are four basic steps involved in IPM: (1) set action thresholds, (2) monitor and identify pests, (3) prevention, and (4) control.

1. **Set action thresholds:** The point at which pest management action must be taken to prevent financial or aesthetic damage is known as the set action threshold. Not every time a pest is in merit action. Action levels are based on the degree of damage by the pest as well as factors like the impact on the economy, human health, safety, and aesthetics.
2. **Monitor and identify pests:** Pest life stages, population increase, damage, and the presence of beneficial species can be detected by regularly checking for the existence of organisms. Simple visual inspection of plants for insects, symptoms of illness, or stress is sufficient for monitoring. For more sophisticated monitoring, tools like hand lenses and

bug traps are available. Finding pests or plant issues can assist choose the best pest control strategy and prevent using the incorrect sort of pesticide or using it when it is not essential. Some pests are hardly dangerous and could even be helpful.

3. **Prevention:** Often, insect damage can be effectively reduced through prevention, eliminating the need for chemical application. Preventative approaches can be effective and affordable, hurt people and the environment only minimally, and lead to long-term control of pest problems. By destroying the conditions that make pests thrive, preventive measures discourage the establishment of pests. Key components of insect avoidance are fostering plant health and diversity in your garden. Culture-based pest management is one method of prevention. The elimination of pest overwintering locations, crop rotation, sanitation, appropriate watering, mulching, the use of physical insect barriers, and the selection of pest-resistant and disease-resistant plant types are all examples of cultural management techniques. Mechanical pest control uses hands-on methods like hand or mechanical weeding, cutting and removing heavily infested branches or leaves, trapping, and insect removal to reduce pest load.
4. **Control:** When preventive methods fail and pest control is required based on action thresholds, integrated pest management advises using chemical control as a last resort. When non-chemical methods are no longer working, chemical application is necessary.

Main strategies of IPM:

Selection and application of chemicals to reduce risk is the main strategy of integrated pest management (Muntz *et al.*, 2016). This includes mainly four steps:

1. Use selective pesticides: While many pesticides help keep unwanted organisms under control, many of them also harm other beneficial organisms. Selective pesticides target-specific pest species, causing little harm to non-target organisms.
2. Use of non-persistent pesticides: Pesticides that are non-persistent degrade quickly in the environment. Pesticides with a half-life of 30 days or less are regarded as non-persistent and often degrade before leaching into ground water. Half-life is the period of time it takes for half of a chemical to decompose.
3. Spot treat: When applying pesticides, treat only that areas where the pests are a problem.
4. Schedule Application timings: Apply pesticides early in the morning or late at night when pollinators are less active.

Pest management:

To achieve the necessary control, it is also crucial to comprehend the inherent and prospective interconnections among different management options. The following are typical control methods that can be applied to prevent, lessen, or treat pest infestations at various phases of crop production. Although each of them may offer some degree of control, their combined effect may be quite effective in reducing yield losses.

1. **Host plant resistance:** A tactic involving the utilization of cultivars created through conventional breeding or genetic engineering that is both pest-resistant and pest-tolerant (Kennedy, 2008; Douglas, 2018; Nelson *et al.,* 2018). These cultivars have physical, morphological, or biochemical traits that make them less appealing to pests or less conducive to their growth, development, or effective reproduction.
2. **Cultural control:** Cultural control is the use of effective agronomic techniques to prevent or minimize pest infestations and harm. To reduce the likelihood of introducing pests at the very beginning of crop production, it is essential to select clean seed or plant material. By changing the planting dates, farmers can prevent the occurrence of pests or avoid their most vulnerable periods. Pest infestations will also be impacted by plant density or row spacing. The pest's soil-dwelling stages can be controlled by destroying agricultural leftovers and cultivating the soil thoroughly. Sanitation procedures to eliminate diseased or infested plant debris, routine field equipment cleaning, and avoiding unintentional contamination of healthy fields by human activities are all crucial for halting the spread of pests. In order to eliminate crop leftovers and reveal the soil-dwelling stages of numerous vegetable pests, lowing is another crucial control method (Kunjwal and Srivastava, 2018). In many crop growing systems, the management of weeds, diseases, and insects has been accomplished through crop rotation (Curl, 1963; Wright, 1984; Liebman and Dyck, 1993; Mohler and Johnson, 2009). Other cultural management techniques used in IPM include intercropping pest-repelling or non-host plants, utilizing trap crops to keep pests away from the main crop, and using pesticides (Pretty and Bharucha, 2015; Nielsen *et al.,* 2016).
3. **Biological control:** Natural enemies such as predatory arthropods and parasitic wasps can be very effective in causing significant reductions in pest populations in certain circumstances (Hajek and Eilenberg, 2018). Periodical releases of commercially available natural enemies or conserving natural enemy populations by providing refuges or avoiding practices that harm them are some of the common practices to control endemic

pests. Biological control has been successfully used in greenhouses (Van Lenteren, 1988) and specialty crops such as strawberries grown in the field (Zalom *et al.,* 2018). To address invasive pest issues, classical biological control approach is typically used where natural enemies from the native region of the invasive pest are imported, multiplied, and released in the new habitat of the pest (Kenis *et al.,* 2017; Heimpel and Cock, 2018). The release of irradiated, sterile insects is another biological control technique that has been effectively used against a number of pests (Klassen and Curtis, 2005).

4. **Behavioral control:** Baits, traps, and mating disruption tactics can be used to take advantage of the pest's behavior for monitoring and control (Heinz *et al.,* 1992; Shorey and Gerber, 1996; Foster and Harris, 1997; Vladés *et al.,* 2005; El-Sayed *et al.,* 2009; Morrison *et al.,* 2016). When applied to the ground or put in traps, deadly baits will draw the pests in and kill them. Pests are drawn to particular hues, luminosities, and pheromone or attractant scents. Pests can be drawn to, captured, or killed by devices that utilize one or more of these. Pheromone smell confuses adult insects, prevent them from mating, which reduces the number of offspring they can produce.
5. **Physical or Mechanical control:** Using a range of physical or mechanical methods, such as exclusion, trapping (which is sometimes comparable to behavioral management), removal, or killing of pests, is referred to as this strategy (Webb and Linda, 1992; Gamliel and Katan, 2012; Gogo *et al.,* 2014; Dara *et al.,* 2018). Examples of physical or mechanical control include pest exclusion with netting or row covers, handpicking or vacuuming to remove pests, mechanical weed-control tools, traps for rodent pests, altering environmental factors like heat or humidity in greenhouses, steam sterilization or solarization, and visual or physical bird deterrents like reflective material or sonic devices.
6. **Microbial control:** Microbial control mainly refers to the use of entomopathogenic bacteria, fungi, microsporidia, nematodes, or viruses against arthropod pests, plant parasitic nematodes, and plant pathogens (Mankau 1981, Paulitz and Bélanger 2001, Dong and Zhang 2006, Lacey 2017).
7. **Chemical control:** Chemical pesticides are the most common type of control used nowadays (Pimental, 2009). Technically speaking, chemical control should, however, encompass both synthetic and chemicals derived from microbial or plant sources. Even though they are classified as biologicals (Lasota and Dybas, 1991; Sarfraz *et al.,* 2005; Dodia *et al.,* 2010), microbe-derived toxic metabolites like avermectin and spinosad and

botanical extracts like azadirachtin and pyrethrins are still chemical molecules and carry many of the same risks for human and environmental safety as chemical pesticides. Rotating chemicals from diverse mode of action groups is advised to lessen the possibility of resistance development as chemical pesticides are divided into many groups based on their modes of action (Sparks and Nauen, 2015). Government regulations limit the use of specific chemical pesticides and their dosage, reducing the risks that come with them. The use of double-stranded RNA, a novel method of ribonucleic acid interference (RNAi), to silence particular genes in the target insect is referred to as a bio pesticide (Gordon and Waterhouse, 2007). Although they are applied as amendments and do not make any claims for the prevention or treatment of pests or diseases, some bio stimulants based on minerals, microscopic organisms, plant extracts, seaweed, or algae confer induced systemic resistance to pests, diseases, and abiotic stressors. (Larkin, 2008; Vleesschauwer and Höfte, 2009; Sharma *et al.,* 2014; López- Bucio *et al.,* 2015; Dara 2018). These new items or technologies may fit into one or more of the pest management categories outlined above.

Organic insecticides, microbial insecticides, horticultural oils, insectidial soaps, some minerals etc. are some commonly used alternatives to conventional synthetic pesticides (Muntz *et al.,* 2016). Examples of some common organic pesticides are listed in Table 1.

Table 1: Examples of some common pesticides used in IPM

Pesticide	Type	Acute Toxicity to Humans	Use and Target Pests
Horticulture oil	Oils	Not toxic	Fungicide, Insecticide, Miticide
Neem oil	Bacterial	Not toxic	Insecticide, Fungicide, and Bactericide
Pyrethrin	Botanical	Slightly toxic	Insecticide- wide variety of insects
Spinosad	Microbial-Botanical	Slightly toxic	Insecticide- codling moth, cheery fruit fly, earwigs, thrips, and caterpillars
Bacillus thuringiensis (Bt)	Microbial-Bacterial	No rating	Insecticide-caterpillars
Insecticidal Soap	Soap	Not toxic	Fungicide, Insecticide, Miticide
Copper sulfate	Mineral	Moderately toxic	Fungicide, Algaecide, Root Killer, Herbicide
Bordeaux mixture	Mineral	Moderately toxic	Fungicide

Advantages of IPM:

1) **Lower cost intervention**
   - Traditionally, the use of the pesticides to control the pest invasion would account to lots of cost.
   - Also, these pesticides need to be imported as well.
   - The application of IPM would lessen the financial burden.
   - Moreover, different techniques involved in IPM are more sustainable with long lasting benefits.
2) **Benefits to the environment**
   - Uses of the pesticides are often linked degradation of the environment causing some more additional problems.
   - IPM is an eco-friendly approach and the effects on the environment are always considered before the application of any interventions.
   - Less use of pesticides won't affect the fertility of soil.
3) **Minimizes residue hazards of pesticides**
   - It is obvious that in an IPM schedule the use of pesticides will be considerably reduced; hence the pesticide residue hazards will also get automatically minimized.
4) **Anti-resistance**
   - The IPM model in itself is the anti-resistant mode for pest control.
   - It discourages the use of chemicals and thus creates less cases of anti-resistance.
   - Pesticides are used only when the other alternatives are not satisfying.
5) **Useful and best intervention for the general public**
   - Assurance of safe, reliable and low-cost pest control.
   - The pest control will not affect the crops.
   - Moreover, it is safe and affordable for the general public as well.

The benefits of using IPM are summarizes below:

- Promotes sound structures and healthy plants
- Protects non-target species through reduced impact of pest management activities.
- Maintains or increases the cost-effectiveness of a pest management program
- Promotes sustainable bio-based pest management alternatives.
- Reduces environmental risk associated with pest management by encouraging the adoption of more ecologically benign control tactics

- Reduces the need for pesticides by using several pest management methods
- Reduces the potential for air and ground water contamination
- Decreases worker, tenant and public exposure to pesticides
- Reduces or eliminates issues related to pesticide residue
- Reduces or eliminates re-entry interval restrictions
- Alleviates public concern about pest and pesticide-related practices

Disadvantages (limitation) of IPM

1) More involvement in the technicalities of the method

- IPM needs to be planned.
- IPM demands more attention and dedication.
- Requires expertise of various fields.
- All those involved in the IPM needs to be educated and trained which often requires much time.

2) Time and energy consuming

- Application of IPM takes time.
- Much time is needed in planning itself.
- As IPM strategies differ from region to region, a separate plan is required for each region.
- The expected results of intervention may take long time to be achieved.
- Adoption of IPM strategies provides economic benefits due to sustained development, increased productivity and reduced pest damage. The options that IPM can offer make sole reliance upon synthetic pesticides a thing of the past. In the long-term, everyone benefits through a healthier environment.

Conclusion:

Since the days of the world's earliest inhabitants, pests and humans have co-existed. However, methods of keeping pests in their place have varied widely and evolved over time. Now more than ever, it is critical to make thoughtful and appropriate changes and sustain positive outcomes. Constructing a multidisciplinary, sustainable pest management program requires an integrated operational approach. Continued success of the IPM program requires effective and efficient management, continued adoption of best practices and synergies with other sustainable development projects. Benchmark surveys, regular inspections and monitoring,

interoperable and immediately accessible digital information are critical to rapidly address pest issues in a sustainable way.

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GREEN LEAFY VEGETABLES USED BY THE TRIBAL PEOPLES OF JHARIGAON BLOCK OF NABARANGPUR DISTRICT, ODISHA, INDIA

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Abstract:

A total of 44 plant species, belonging to 35 genera and 27 families were recorded as green leafy vegetables by the tribal peoples of Jharigaon Block of Nabarangpur district, Odisha, India. In this present study, the dominant families were Amaranthaceae and Brassicaceae contributing five species (11%) each. The Fabaceae family contributed four species (9%), the Cucurbitaceae family contributed three species (7%), and four families Apiaceae, Chenopodiaceae, Portulacaceae and Tiliaceae contributed two species each respectively. The rest of the 19 families contributed one species each. The leafy vegetables consumed by these two tribes include 31 nos. (71 %) of herbs, 05 nos. (11%) of trees, and 04 nos. (9%) of each climber and shrub respectively. Leafy green vegetables like *Acalypha indica* L., *Amaranthus oleraceous* L., *A. viridis* L., *Basella alba* L., *Coriandrum sativum* L., *Cucurbita maxima* Duchesne., *Ipomoea aquatic* Forssk., *Marsilea minuta* L., *Moringa oleifera* Lam., *Murraya koenigii* (L.) Spreng. and *Spinacia oleifera* L. were used more commonly. Documentation of leafy green vegetables not only improves the economic condition of the tribal people but will also aid in the conservation of biodiversity, sustainability, and food security.

Keywords: Green leafy vegetables, Jharigaon block, Nabarangpur district, Odisha.

Introduction:

In India, more than 53 million tribal people depend on natural resources for their daily needs (Bharucha and Preety, 2010). Further, wild vegetables are a key constituent of traditional food systems around the world (Turner *et al.*, 2011). The Indian lifestyle is speedily altering into a developed way of life, the habit of intake the wild plants and plant parts as food has not been eliminated. In addition, people grow a few crops and also collect wild edible plants to meet their daily needs. The human diet is dominated by a single staple food and less amount of other food substances, ensuring in high risk of poor consumption of both macro and micronutrients in many

developing countries. Rice and wheat are the staple diet in India. In India, parboiled rice is the staple food and other food substances like vegetables, fish, pulses, fruit and animal products constitute less amount of diet. Vegetables mainly leafy green vegetables are major sources of nutrition, being rich in carbohydrates, proteins, and oils and are the crucial in diet as they contain β-carotene, folic acid, ascorbic acid, antioxidant, phenols and minerals (Aberoumand, 2009; Aberounmand and Deokule, 2009; Mishra and Mishra, 2013). To protect against diet-related chronic diseases, the WHO (World Health Organization) endorses a daily intake of >400 gm of fruit and vegetables per person per day (WHO, 2013). In the last few decades, the traditional leafy vegetables are being progressively substituted by incorporating high-yielding varieties, thereby intimating the survival of many precious characters existing in the rural areas of India. In addition, there is a rapid decay of traditional information about wild edible leafy vegetables and increased dependence on processed food. Thus, documentation and assessment of the traditional knowledge associated with the diversity, practice, and status of leafy green vegetables are very crucial for the sustainability and conservation of wild leafy vegetables. In this background, reports from Nabarangpur district of Odisha are insignificant; however, the poor rural people of the district depend on a wide variety of wild leafy vegetables for their source of revenue. Therefore the present study has been carried out in the interior pockets of Nabarangpur district of Odisha, India with the objectives to collect oral traditions on the assortment of leafy vegetables and to keep it through documentation not only for the potential economic importance but also its cultural significance.

Materials and Methods:

Study site

Nabarangpur district lies between 19° 23' North latitude and 82° 55' East longitudes and has 5,294 Sq Km of geographical area, most of the area is covered with dense forest. Nabarangpur district is a tribal-dominated district having a population of 12,20,946 (Census of India 2011). The population density of this district is 230 inhabitants per square K.M. It has a sex ratio of 1018 females for every 1000 males and the literacy rate is 48.2%. The Scheduled Castes and Scheduled Tribes are 14.53% and 55.79 % of the population respectively. This district is well known for its tribal culture. Some of the largest tribes are the Bhottadas and Gond, they have their language, customs and folk dances. The river Indravati forms the boundary between Nabarangpur and Koraput districts.

Data collection

Before starting fieldwork, a literature survey of similar work in Odisha was carried out (Mishra and Mishra, 2013; Mallick *et al.*, 2017; Sahu and Sahu, 2019; Parida and Mahalik, 2020; Sahu and Ekka, 2021). The study area was frequently visited and close interaction was made with the tribal peoples of Jharigaon Block. Plant specimens were collected and identified with local flora (Saxena and Brahmam, 1994-96). The local names of the collected species were crosschecked by using earlier reports by various authors (Sahu *et al.*, 2010; Mishra and Mishra, 2013; Sahu *et al.*, 2013; Mallick *et al.*, 2017; Sahu *et al.*, 2019; Parida and Mahalik, 2020; Sahu and Ekka, 2021; Sahu *et al.*, 2021). The knowledge regarding the use of leafy green vegetables is passed from one generation to other. At present decades people not much depend on the use of wild leafy green vegetables, they generally prefer modern food. Hence, the knowledge regarding the use of wild leafy green vegetables become vanishes after a few decades. Keep these things in mind present study was conducted to document the use of leafy green vegetables by the tribal of Jharigaon Block, Odisha, India. The collected leafy green vegetables are kept on a table having the botanical name, followed by the local name in Odia, its family and habit. All the statistical analysis was carried out using MS Excel 2010.

Results:

During the study as many as 44 plants belonging to 35 genera and 27 families have been reported as leafy green vegetables (Table 1). Both the families Amaranthaceae and Brassicaceae are contributing five species each; followed by the family Fabaceae (4); Cucurbitaceae (3); four families namely Apiaceae, Chenopodiaceae, Portulacaceae and Tiliaceae (2); the rest 19 families contribute one species each (Table 1, Figure 1). Most of the green leafy vegetables used by the tribals were herbs (71%), followed by trees (11%), and both climbers and shrubs contributed 9% each (Figure 2). The leafy green vegetables like *Acalypha indica* L., *Amaranthus oleraceous* L., *A. viridis* L., *Basella alba* L., *Coriandrum sativum* L., *Cucurbita maxima* Duchesne., *Ipomoea aquatic* Forssk., *Marsilea minuta* L., *Moringa oleifera* Lam., *Murraya koenigii* (L.) Spreng. and *Spinacia oleifera* L. were used more commonly. Most of the tribal people depend on wild leafy green vegetables more than cultivated ones.

Table 1: List of plat species used as green leafy vegetables by the tribal peoples of Jharigaon block of Nabarangpur district, Odisha

Botanical Name	Local Name	Family	Habit
Acalypha indica L.	Kaphgajri	Euphorbiaceae	Herb
Allium cepa L.	Ueil	Amaryllidaceae	Herb
Alternanthera sessilis L. R. Br.	Madrangasaag	Amaranthaceae	Herb
Amaranthus oleraceous L.	Bhaji	Amaranthaceae	Herb
Amaranthus spinosus L.	Kanta Leutia	Amaranthaceae	Herb
Amaranthus tricolour L.	Lal khada	Amaranthaceae	Herb
Amaranthus viridis L.	Khada	Amaranthaceae	Herb
Azadira chtaindica A. Juss.	Lim	Meliaceae	Tree
Bacopa monnieri (L.) Pennell	Bramhi	Scrophulariaceae	Herb
Basella alba L.	Poi	Bassillaceae	Herb
Bauhinia purpura L.	Kuler	Casaloiniaceae	Tree
Boerhavia diffusa L.	Gadhapurnisaag	Nyctaginaceae	Herb
Brassica napus L. Var. Glauca (Roxb.) Schul	Sursoo	Brassicaceae	Herb
Brassica oleracea L. Var. Gongylodes L.	Gaintkobi	Brassicaceae	Shrub
Brassica oleracea Var. *botrytis* L.	Phulakobi	Brassicaceae	Herb
Brassica oleracea Var. *capitata* L.	Bandhakobi	Brassicaceae	Herb
Bryophyllum pinnatum (Lam.) Pers.	Patargaja	Crassulaceae	Herb
Capsicum annuum L.	Mircha	Solanaceae	Herb
Chenopodium album L.	Batha	Chenopodiaceae	Herb
Cicer arientinum L.	Chana saag	Fabaceae	Herb
Cinnamomum tamela Nees.	Tejpatar	Lauraceae	Tree
Colocasia esculenta (L.) Schott	Saru	Araceae	Herb
Commelina benghalensis L.	Kenasaag	Commelinaceae	Herb
Corchorus capsularis L.	Nalta	Tiliaceae	Herb
Corchorus trilocularis L.	Lalbhaji	Tiliaceae	Herb
Cordia oblique Willd	Bahal	Boraginaceae	Tree
Coriandrum sativum L.	Dhania	Apiaceae	Herb
Cuculligo orchiodes Gaertn	Kanjher	Hypoxidaceae	Herb
Cucurbita maxima Duchesne	Makha	Cucurbitaceae	Climber

Ipomoea aquatica Forssk	Kalama saag	Convolvulaceae	Herb
Lablab purpureus (L.) Sweet	Simba	Fabaceae	Climber
Marsilea minuta L.	Sunsuniasaag	Marsileaceae	Shrub
Mentha spicata L. emend. Nathh.	Podina	Lamiaceae	Herb
Momordica charantia L.	Karla	Cucurbitaceae	Climber
Momordica dioica Roxb.	Kankdo	Cucurbitaceae	Climber
Moringa oleifera Lam.	Munga	Moraginaceae	Tree
Murraya koenigii L. Spreng	Lesinga	Rutaceae	Shrub
Portulaca oleraceae L.	Chantisaag	Portulaceae	Herb
Portulaca quadrifid L.	Nunisaag	Portulaceae	Herb
Raphanus sativus L.	Mula	Brassicaceae	Herb
Sesbania grandiflora L.	Agasti	Fabaceae	Shrub
Spinacia oleraceae L.	Palangsaag	Chenopodiaceae	Herb
Trachyspermum ammi L.	Juani	Apiaceae	Herb
Trigonella foenum-graecum L.	Methi	Fabaceae	Herb

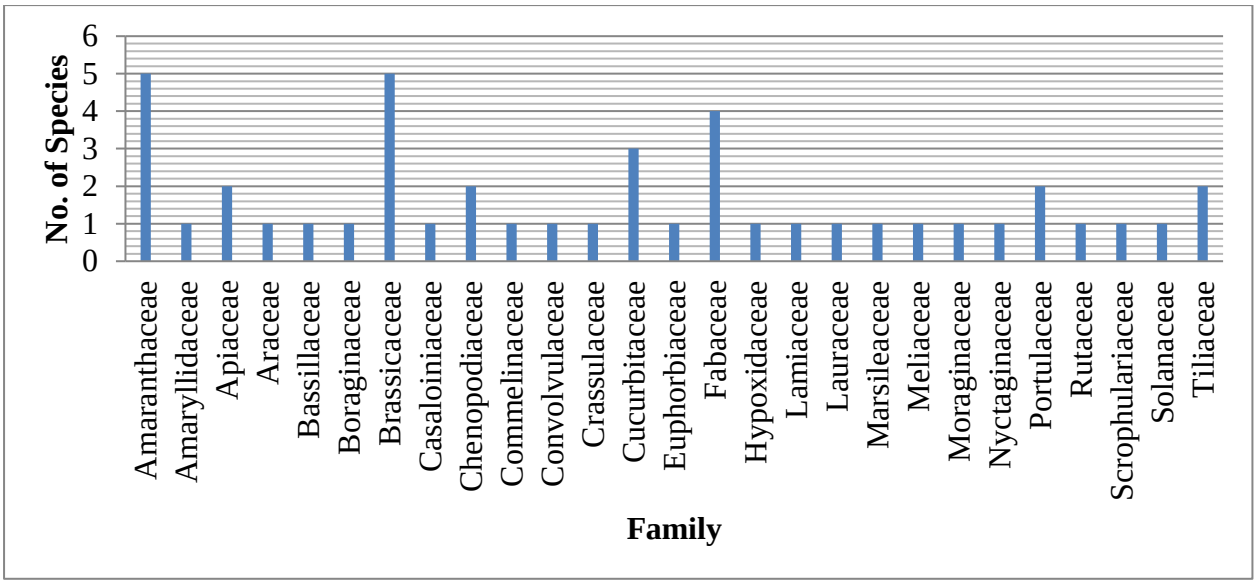

Figure 1: Family-wise distribution of green leafy vegetables used by the tribal peoples of Jharigaon block of Nabarangpur district, Odisha

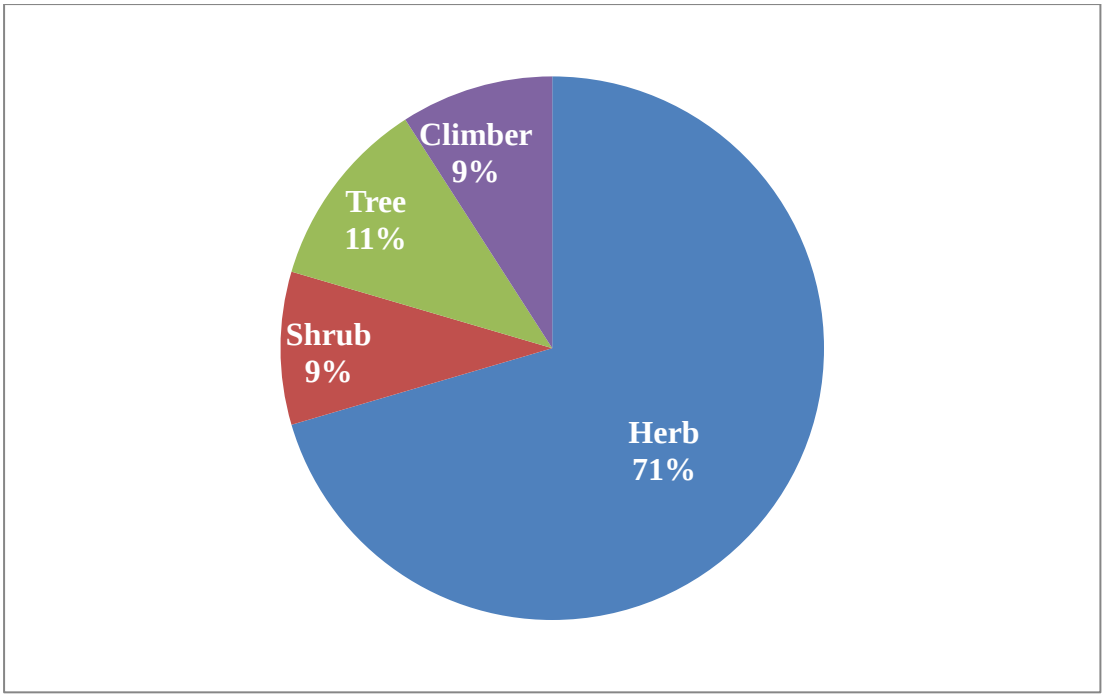

Figure 2: Diversity of used plant species by habit

Discussion:

Since ancient times tribal peoples have been using many types of wild leafy green vegetables generally as part of their daily food which are having both high nutritional values and medicinal importance. A few of them are also dried and preserved for use during the nutrition stress period. As many as 44 leafy green vegetables from 27 families were used by the tribal of Jharigaon block as food. Species like *Amaranthus oleraceous* L., *A. viridis* L., *Basella alba* L., *Ipomoea aquatic* Forssk., *Moringa oleifera* Lam. are used as life-supporting species in some remote areas. These species are consumed by the tribal as their main staple diet or utilize as supplementary foods or emergency foods. This study represented that the degree of consumption depends upon their eating habits which were also matched with the works information of Dansi *et al.* (2008), Mishra and Mishra (2013), Parida and Mahalik (2020), and Sahu and Ekka (2021). Dansi *et al.* (2008) reported the use of 187 traditional leafy vegetables in the Benin Republic. Mishra and Mishra (2013) reported on the use of 106 leafy vegetable plants in South Odisha, India. Parida and Mahalik (2020) reported about the use of 48 green leafy vegetables used by seven tribes of Odisha, India. Sahu and Ekka (2021) reported on the use of 39 leafy vegetables by the native of Bargarh district, Western Odisha, India. Due to the loss of biodiversity and fragmentation of habitat few species are now available in less quantity in some areas of this block. The traditional knowledge on the use of leafy green vegetables is also lost with the loss of

biodiversity. This present study is a humble effort to document various uses of leafy green vegetables by the tribes of the Jharigaon block of Nabarangpur district, Odisha. Further investigation provides more about the nutritional and medicinal importance of leafy green vegetables available in their locality, which will also ensure food and nutritional security for them.

Acknowledgement:

Both authors are thankful to the tribal peoples of the Jharigaon block of Nabarangpur district, Odisha for their cooperation and voluntarily sharing their valuable knowledge regarding the use of leafy vegetables in their communities. The author ARS is especially thankful to the Principal, The Directors and The Chairman of Vikash Group of Institutions, Bargarh for providing necessary facilities, moral support and encouragement during the study. Likewise, both authors highly acknowledge their son Nehan Sahu for giving a pleasant atmosphere and their family members for constant support and encouragement.

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GOMPHONEMACEAE AT MEHEKARI WATER RESERVOIR

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Abstract:

The algae from Mehekari water reservoir were investigated from October 2017 to January 2019. Algal samples were collected from various locations of the water reservoir. Present paper reports the unlikeness of diatoms from the water reservoir. The observed species were belongs to family Gomphonemaceae. Two species of diatoms belonging to *Gomphonema* have been reported from the study area.

Keywords: Gomphonemaceae, *Gomphonema*, Mehekari, Water Reservoir

Introduction:

Mehekari Lake is constructed on the Seena River in Beed district of Maharashtra. The study was carried out to explore the presence the diversity of diatoms of the water reservoir.

Diatoms are extensively found in salt waters as well as in fresh waters. They occur in all aquatic habitats forming an important part of the vegetation. Although diatoms are mostly unicellular, colonial species are also represented by them. These are most fascinating and offer us a sight of pleasure when viewed under a microscope, because of the very fine sculptured cell wall.

A survey of the algae was carried out at different locations of Mehekari water reservoir, during the years 2017-2019. The diatoms observed during the investigation are described in this paper.

Materials and Methods:

The studies on algae from different locations of Mehekari Lake (Ashti) in Beed District of Maharashtra were undertaken for the present study. The samples were collected at monthly intervals during October 2017 to January 2019 from the different locations of water reservoir. The Samples were collected in collections bottles then taken to the laboratory and preserved in 4% formalin for further taxonomic investigations. Temporary Mounts of algal specimen were prepared with suitable stains and observed under compound microscope.

Identification of taxa was carried out by using Gandhi (1956), Sarode and Kamat (1984), Rai (2005), Rath and Adhikary (2005), Sambamurty (2006), Chowdhary and Pal (2008), Rashmi *et al*. (2011), Mahajan (2012), Sirmour *et al*., (2012), Dwivedi and Misra (2014) and other relevant literature.

Results and Discussion:

During present investigation *Gomphonema* species were observed which are described as under.

Family: Gomphonemaceae

Genus: *Gomphonema* Ag.

Cells solitary and free floating, usually epiphytic on the ends of dichotomously branched gelatinous stalks, sometimes sessile, transversely asymmetric in the both girdle and valve views, cuneate in girdle view, girdles without intercalary bands; valves clavate, lanceolate or nearly straight with a straight raphe; striations strictly transverse or somewhat radial; central area sometimes extending to the margins with an asymmetrically placed dot.

1) *Gomphonema aequatoriale* Hustedt.

Sarode and Kamat, 1984, p 182, pl 21, f 486

Valves 55 µ long, 10 µ broad, clavate in the middle inflated with broadly rounded apex and narrowly produced rounded base; raphe thick; axial area narrow; central area widened; striae 9-10 in middle and 11 in 10 µ, towards the ends, clearly punctate.

2) *G. gracile* Ehr. var. ***major*** Grun.

Sarode and Kamat, 1984, p 187, pl 22, f 502

Valves 67.5 µ long, 10 µ broad, narrowly lanceolate, turgid in the middle and gradually tapering towards the rounded apex and base; raphe thin and straight; axial area narrow; central area with an isolated stigma on the opposite side; striae 10-12 in 10 µ slightly radial and finely punctate.

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HORMONAL COMBINATIONS *INVITRO* PRODUCTION OF SOMATIC EMBRYOGENESIS FROM LEAF EXPLANTS OF *MENTHA ARVENSIS*

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Abstract:

In Somatic embryogenesis the embryo regenerate from somatic cells, tissues or organs either de novo or directly from tissues which in the opposite of zygotic or sexual embryogenesis. Various terms for non-zygotic embryos have been reported in literature such as adventive embryo Somatic embryos arising directly from other organs or embryos partheno genetic embryos (Ugender and Venkatershwarlu, 2019). Those formed by the unfertilized egg. Andro genetic embryos (Formed by the male gametophyte. However in general context Somatic embryos are those which are formed from the somatic tissue in culture, i.e. in vitro conditions. In sexual embryogenesis the act of fertilization triggers the egg cell to develop into an embryo however it is not the monopoly of the egg to form an embryo, any cell of the gametophytic (embryo-sac) or sporophytic tissue around the embryo-sac may give rise to an embryo, cells of the nucellus or linear integument of members of Rutaceae family may develop into embryos.Somatic embryo genesis offers great potential in plant multiplication and crop improvement for efficient cloning and genetic transformation (Ammiratio 1987, Roberts *et al.*, 1995; Ugender *et al.*, 2019, 2012). It is an alternative and efficient method for plant propagation over regeneration via organogenesis.

Keywords: *In-vitro*, Embryogenesis, Somatic embryo Hormonal Combinations

Introduction:

Thus Somatic embryogenesis always appeared to be dependent on the types of auxin/cytokinin/auxin+cytokinin and their concentration in the medium. The type of phytohormone and its concentration also varies from genotype to genotype. High concentration of auxin in combination with less concentration of cytokinin induced the somatic embryogenesis and maturation of Somatic embryos .The peppermint *Mantha arvensis* is cultivated on a large scale in the states of Oregan, Indiana, Idaho, Ohio and Michigan. Whereas spearmint cultivation is localized in Indiana and Michigan. Spearmint is also cultivated in France, the United

Kingdom, Italy, Yugoslavia, Hungary, Bulgaria, Russia, South Africa, Thailand and Vietnam. Bergamot mint is commercially cultivated in China, Taiwan and India, and menthol or Japanese mint in India**.** Somatic embryos are believed to originate from single cell while organogenesis is through collective organization of cell. Therefore the plants derived from somatic embryos tend to be genetically alike, in addition somatic embryos are bipolar structures with root and shoot apices they can easily be developed into a complete plantlets.

Embryos formed in cultures have been variously regenerated as accessory embryos, adventive embryos, embryoids and supernumerary embryos (Kohlenbach, 1978) has proposed the following classification of embryos.

1. Zygotic embryos- those formed by fertilized egg or the zygote.
2. Non- Zygotic embryos- those formed by cells other than the zygote.

i) Somatic embryos- those formed by the sporophytic cells (except zygote) either in vitro or in vivo. Such somatic embryos arising directly from other embryos or organs (stem embryos in carrot and butter cup) are termed adventive embryos.

ii) Parthenogenetic embryos - those formed by unfertilized egg.

iii) Andorogenic embryos- those formed by the male gametophyte (microspore pollen grains).

Somatic embryogenesis is the process of a single cell a group of a cells initiating the developmental pathway that leads to reproducibleregeneration of non-zygotic embryos capable of germinating to form complete plants. Under natural conditions this pathway is not normally followed, but from tissue cultures somatic embryogenesis occurs most frequently and as an alter native to organogenesis for regeneration of whole plants. According to Sharp *et al.* (1982). Somatic embryogenesis is initiated either by Pre-Embryogenic Determined Cells (PEDCS) or by "Induced Embryogenic Determined Cells (IEDC'S). In PEDCS the Embryogenic path way is predetermined and the cells appear to only wait for the synthesis of an inducer (or removal of an inhibitor) to resume independent mitotic divisions in order to express their potential. Such cells are found in embryonic tissues (including scutelum of cereals).

There are examples of embryos arising from endospermal cells also. However occurrence of a sexual embryogenesis is generally restricted to intra ovular tissues, what is particularly striking about embryo genesis in plant cultures in the development of embryosfrom somatic cell (epidermis, Parenchymatous cells of petioles or secondary root phloem) in addition to their formation from unfertilized genetic cells and tissues typically associated with in vivo sexual embryogenesis (eg. nucellus).

Methodology:

Plant material

Seeds of Mentha arvensis were collected. From CIMAP (Central Institute of Medicinal Aromatic Plant) Uppal. Hyderabad. Seeds which were initially soaked over night and then washed with running tap water for 30 min to remove adherent particles, thoroughly washed seeds were then immensed in 5% (v/v) Teepol for 10 min and then rinsed 3 times with sterile double distilled waster. This was followed by the surface sterilization with 05 % (m/v) HgCl, under the sterile conditions for 5 min. these were rinsed 5 times in sterile double distilled water to remove all traces of HgCl2 the sterilized seeds were then placed on to the basal Murashige and Skoog (1962) medium for germination.

Culture media and culture conditions

Leaf (4 weeks old) explants from axenic seedlings were placed on MS medium supplemented with 30 gm/L sucrose along with different combinations of NAA (1.0-2.0 mg/L) + 2.0 mg/L BAP respectively. The pH of medium was adjusted to 5.8 prior to autoclaving 121° C for 15 -20 min.

All the cultures were incubated under 16/8 h light / dark photo period at 25+2° C. a light intensity of 40 µ mol m^2s^1 was provided by cool- white fluorescent tubes. The cultures were transferred to fresh medium after an interval of 4 weeks.

For germination and plantlet formation somatic embryos were transferred to MS medium supplemented with 1.0 mg/L. IAA + 1.0-3.0 mg/L BAP and incubated under the same culture conditions.

Results:

Results In somatic embryogenesis in M. arvensis are presented inTable –I . leaves cultured on various concentrations of NAA in combination with 0.5 mg/L BAP become swollen, and generally dedifferentiated and developed friable callus after 8-10 days of culture within 15-20 days of culture globular embryos had formed directly on the surface of callus (Plate -I Fig-1,2,3).when the explants of somatic embryos were cut into fragments and cultured on the same induction medium secondly somatic embryos were induced within 4 weeks.

Encapsulation of somatic embryos

The propagation in its natural habitat is a rare phenomenon evidenced by close field observation. In an attempt of vegetative propagation, the stem cuttings of the plants failed to root with the application of different hormones.Encapsulation of the somatic embryos was done using 1, 2 and 3 % sodium alginate gel. Somatic embryos with sodium alginate dipping into 5%

calcium nitrate solution. Drops seed propagation. The major ones are variations in edaphic and climatic factors, low percentage of seed set and seasonal dormancy. The propagation in its natural habitat is a rare phenomenon evidenced by close field observation. In an attempt of vegetative propagation, the stem cuttings of the plants failed to root with the application of different hormones. The above mentioned causes prompted us to find an alternate method of rapid micropropagation of this species. Clonal mass propagation can be widely applied to shorten the long sexual cycle and other problems like limited seed availability and problems of seed physiology. It is difficult to collect the seed as they are dispersed I wind on attaining maturity in this system. So in view of medicinal importance, there is an urgent need to conserve this species ex situ through in vitro methods. Reports on propagation are limited so, in this study we are giving efficient and reproducible protocol for somatic embryogenesis in *Mentha arvensis*

Discussion:

Somatic embryogenesis is an important step in any successful plant transformation scheme. Stable transformation required that a single cell gives rise to a plant. The ideal transformation scheme is that via somatic embryogenesis, because from callus each transformed cell has the potential to produce a plant. Somatic embryogenesis and subsequent plant regeneration has been reported in most of the major crop species (Evans and Sharp, 1981). Soybean and cotton proved to be the most difficult to regenerate (Matsuoka and Hinata, 1979; Gleddle *et. al.,* 1983; Scowcroft, 1984) also observed a stimulatory effect of NAA on embryogenesis in egg plant hypocotyls explants and in leaf explants with carrot hypocotyls explant on the other hand somatic embryos formed in response to a wide range of auxins including (IAA: NOA, NAA, 2,4-D, 2,4,5-T.

The sugars which supported callus proliferation on cotyledon explant i.e. sucrose, fructose, glucose were also supported embryogenesis, Somatic embryogenesis in NAA treated leaf explants was inhibited by cytokinins were also observed cytokinins induced of embryogenesis in egg plant hypocotyls cultures, ethylene also typically inhibits somatic embryogenesis (Ammirato, 1983b). The molecular aspects of embryogenesis, embryo specificproteins in carrot have been studied. In rice (Chen and Luthe, 1987) Embryo specific proteins in somatic embryogenesis has been studied in alfaalfa (Stuat *et. al.,* 1985). These developmental regulated genes are now being isolated (Choi *et. al.,* 1987). BAP has been used for shoot induction of melon (Kathal *et al.,* 1986; Suesmatsu *et. al.,* 1986; Dirks and Buggenum, 1989). The effect of BAP on somatic embryogenesis was tested by Oridate and Oosawa (1986) and the most efficient embryo formation was obtained at a concentration of 0.1 mg/L. The

adventitious shoot formation and somatic embryogenesis in melon can be controlled by the ratio of auxins and cytokinin in the medium. In Coffeaarabica also somatic embryos developed only when a callus grown on 2,4-D containing medium in transferred to 2,4-D free medium (Sondal and Sharp, 1977) and in pumpkin, NAA and IBA favoured embryogenesis (Jelaska, 1974). In nucellus cultures of vitis embryo formation occurred in the presence of NAA and BAP (Molling and Srinivasan, 1976).

Table 1: Effect of various concentrations of NAA and 0.5 mg/L BAP on somatic embryo genensis in leaf explants of *Mentha arvensis*

Growth regulators (mg/L)	% Leaf explants of culture responded	Number of shoots/explants (S.E)*
IAA+BAP		
1.0 + 0.5	50	2.6 ±0.66
2.0 + 1.0	55	3.0 ± 0.44
3.0 + 1.5	60	3.2 ± 0.45
4.0 + 2.0	62	3.8 ± 0.43
5.0 +2.5	67	4.0 ± 0.32
2.0 + 3.0	70	6.0 ± 0.34
3.0 + 3.5	65	3.6 ± 0.34
4.0 + 4.5	50	2.5 ± 0.45
5.0 + 5.0	45	2.0 ± 0.43

1 **2** **3**

Plate 1: Somatic embryo genesis from leaf explant cultures of Mentha arvensis after 4 weeks

Figure 1: leaf explant

Figure 2: Green embryogenic callus induced on MS + 1.0 mg/L NAA + 0.5 mg/L BAP

Figure 3: Green embryogenic callus formed on MS + 3.0 mg/L NAA + 0.5 mg/L BAP

Conclusion:

The embryogenic potential is markedly dependent on genotype isolated embryogenic callus from Mentha arvensis.The embryogenesis action of NAA in explants also different in another aspect from the role of auxin in embryogenesis in other species in explant induction and maturation of Somatic embryos to the cotyledon stage was achieved on the same medium. The removal of NAA was only required for further development of embryos to plant lets, cotyledon explants grown on NAA embryos were observed in globular shaped heart shaped and torpedo shaped stages.

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ANTIBIOTIC RESISTANCE: ALARM OF EMERGING "SUPERBUG"

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Abstract:

Antibiotic resistance is now global problem. In the middle 1940s of the twentieth century important revolution of medicine started. Over the year there is tremendous use in human, animal as well as agriculture infection prophylaxis. This is agent overall used in treatment of bacterial, fungal, parasitic, viral infections and is applied on human, animal. As result of massive use of antibiotic there is combination of genome and community dynamic wide spread in water, soil, wildlife, in human food chain such poultry, livestock, aquaculture .Hence evolutionary changes of bacteria into antibiotic resistance represent life threatening to human. This review represents aspects of antibiotic resistance, multifaceted improvement in healthcare sector practices, pharmaceutical industry and food sector.

Keywords: Antibiotic resistance, regulatory issues, awareness, superbug

Introduction:

Discovery of antibiotics in the clinical world was no doubt the most significant medical achievement of the 20th century. Penicillin was the first antibiotic discovered by Alexander Fleming in 1928 (Golkar *et al*., 2014). Dorothy Hodgkin solved the beta-lactam structure of penicillin in 1945. Antibiosis between microbes was described before the discovery of penicillin, including by Louis Pasteur, who proposed that microbes could secrete material to kill other bacteria. It was used widely during World War II (Sengupta *et al*., 2013). In the 1930 sulphonamides were the first antibiotic class used in medical sector. Selman Waksman started study of microbes as producers of antimicrobial compounds in the late 1930s. In the word of Waksman, an antibiotic is a compound produced by a microbe to destroy other microbes and actinomycetes are factory of antibiotic. Waksman discovered numerous antibiotics made by soil-dwelling, including and, the first agent active against tuberculosis. Antibiotic resistance is a loss of susceptibility of to the killing or growth-inhibiting properties. Antibiotic resistance is stage in which bacteria are able to proliferate in the presence of one or more antibiotics.

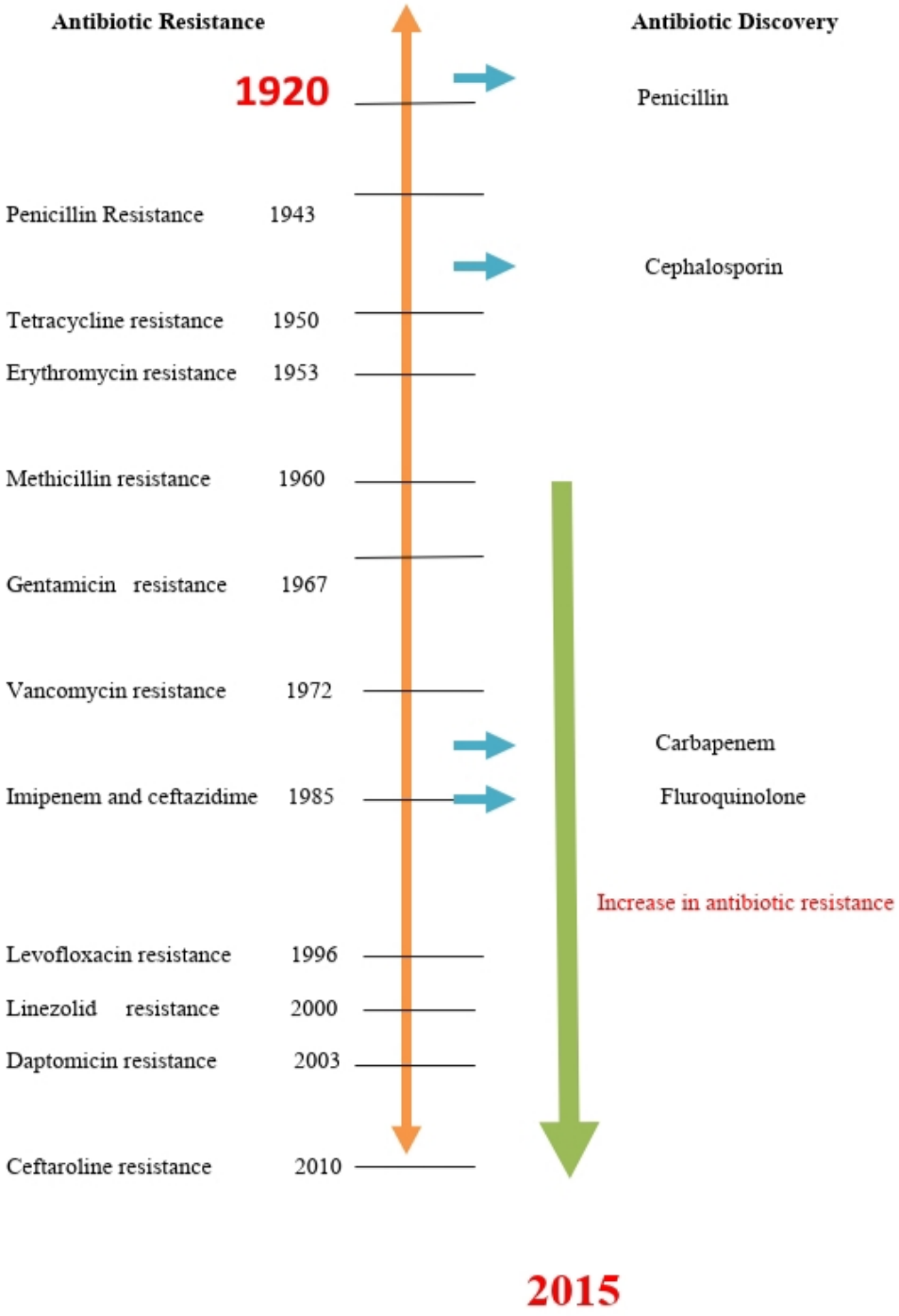

Figure 1: Journey of Antibiotic resistance with time

The reoccurrence of resistance typically exists in nature. Due to the ample use of antibiotics, bacteria frequently exposes to antibiotics and antibiotic resistance rate elevated day by day. Antibiotics are drugs used to address bacterial infections. Antibiotics function in several ways. Penicillin, for examples, inhibits the growth of bacteria by indirectly causing their cell

walls to weaken and rupture. Tetracyclines, on the contrary side, prohibit bacteria from producing proteins, preventing them from growing and instead inhibiting their growth. While certain antibiotics are effective against a variety of infections, others are only effective against infections brought on by certain bacterial species. These include β-lactams (inhibit cell wall synthesis), aminoglycosides (protein synthesis), macrolides (protein synthesis), tetracyclines (protein synthesis), daptomycin (cell membrane function), platensimycin (fatty acid biosynthesis), and glycopeptides (cell wall synthesis). A person's medical history, including any antibiotic allergies, the type of infection, and frequently laboratory tests that can identify the bacterium causing the disease and which antibiotic will work best are all factors that healthcare professionals consider when selecting an antibiotic to treat an infection. In order to properly treat their diseases and help to stop the emergence of antibiotic-resistant bacteria, patients must carefully follow directions when taking antibiotics.

Mechanisms of resistance:

Bacteria can develop antibiotic resistance in various different ways. It is possible to slow but not stop the natural process of selective pressure. Additionally, bacteria can develop resistance when they exchange genetic material with other bacteria. Bacterial DNA fragments known as plasmids can be exchanged between bacteria. Some plasmids allow bacteria to manufacture an enzyme that renders antibiotics ineffective. It is simple for antibiotic resistance to propagate when the plasmid is incorporated into other bacteria. The rate at which bacteria mutate in the case of mutation determines how quickly resistance arises. A mutation is an irreversible alteration to the genetic code of an organism. Bacteria are especially prone to mutation because their genome consists of a single. They have a high rate of replication. When cells divide, mutations happen naturally. As a result of their DNA-based genome, bacteria are particularly susceptible to mutation. The more replications a cell undergoes, the higher the chance it has to mutate. Bacteria can develop multiple types of resistance through various ways throughout time. This may result in "superbugs" that are resistant to many types of antibiotics. A person to person transmission of antibiotic-resistant bacteria can lead to the spread of an infection that cannot be treated e.g. MDR M. tuberculosis is a serious infection that affects both underdeveloped and industrialised countries. Microbes with heightened mortality and morbidity as a result of several mutations are referred to as "superbugs." Medical procedures including organ transplants, chemotherapy, and major surgeries become riskier when there are no effective anti-infection treatments available. Infections that are difficult to treat or incurable can be brought on by antibiotic-resistant bacteria, including gonorrhoea, gonorrhoea-related sexually

transmitted diseases, pneumonia, wound and skin infections, and tuberculosis. Everyone is susceptible to resistant bacterial infections; however some populations are more at risk than others. These include chemotherapy, intricate procedures, dialysis for end-stage renal illness, immunosuppressive medications, and organ transplants**.**

1) **Limiting drug uptake:** In those bacteria with large outer membranes, substances often enter the cell through porin channels. The porin channels in gram negative bacteria generally allow access to hydrophilic molecules. In porin mutation can change selectivity of porin channel and can limit drug uptake .e.g: *Enterobacteriaceae, E. aerogenes, Neisseria gonorrhoeae*
2) **Modification of drug target:** Transpeptidases called PBPs (penicillin-binding proteins) are involved in the synthesis of peptidoglycan in the cell wall. An increase in PBPs with a decreased capacity for drug binding. If a structure is altered, such as PBP2a in *S. aureus* after the mecA gene is acquired, this may reduce the drug's capacity to bind.
3) **Drug inactivation:** Drugs are rendered inactive by bacteria either through drug breakdown or through the addition of a chemical group. A very wide set of enzymes that hydrolyze drugs are known as β -lactamases. Tetracycline is hydrolyzed and rendered inactive by the tetX gene. Transferring acetyl, phosphoryl, and adenyl groups causes the medication to become inactive. Streptogramins, chloramphenicol, aminoglycosides, and fluoroquinolones are the main targets of acetylation-based defences.
4) **β- lactamases:** The β- lactam medication class is the most commonly used class of antibacterial agent. There are three ways that β-lactam medications can be resistant to them: (1) blocking the interaction between the drug and the target PBP, typically by altering the drug's capacity to bind to the PBP (3) the drug's breakdown by β-lactamase enzymes; (2) the presence of efflux pumps that can expel β -lactam medications. e.g The ampC gene on the chromosome encodes the first β-lactamase to be identified, which is from the bacteria *E. coli.*
5) **Drug efflux:** Most bacteria have a wide variety of efflux pumps. The ATP-binding cassette (ABC) family, the multidrug and toxic compound extrusion (MATE) family, the small multidrug resistance (SMR) family, the major facilitator superfamily (MFS), and the resistance-nodulation-cell division (RND) family are the five main families of efflux pumps in bacteria, which are categorised based on structure and energy source. e.g. EmrB, a component of the MFS, functions as a tripartite pump (EmrAB-TolC) in *E. coli* to expel nalidixic acid.

6) **ABC transporter family:** The transport systems in the ABC efflux family, which utilise ATP hydrolysis-derived energy, include both uptake and efflux transport systems. These pumps function in pairs, either as homodimers or heterodimers, in the membrane and work cooperatively with cytoplasmic ATPases to transport amino acids, drugs, ions, polysaccharides, proteins, and sugars. For example, the ABC pump, which is found in Vibrio cholerae (VcaM), can transport tetracycline and fluoroquinolones.
7) **MATE transporter family:** These individuals use the efflux of fluoroquinolone aminoglycosides, cationic dyes, and a Na+ gradient as their energy source. The NorM pump from the chromosomal DNA of Vibrio parahaemolyticus, along with *Neisseria gonorrhoeae* and *Neisseria meningitides*, was the first to be characterised.
8) **SMR transporter family:** The proton-motive force (H+) invigorates the SMR efflux family, which is hydrophobic and predominantly effluxes lipophilic cations. The genes for these pumps have been detected in transposable elements, plasmids, and chromosomal DNA. These pumps confer resistance to certain aminoglycosides and β-lactams. *Staphylococcus epidermidis,* for instance, has an SMR pump that transports the antibiotics ampicillin, erythromycin, and tetracycline. *Escherichia coli* also have an SMR pump (the EmeR pump which transports vancomycin, erythromycin, and tetracycline).
9) **MFS transporter family:** Using solute/cation (H+ or Na+) symport or solute/H+ antiport, the MFS efflux family catalyses transport. They assist in the transportation of carbohydrates, metabolites, anions, and medications. Although the MFS pumps individually tend to be substrate selective, as a group they have the widest range of substrates. Examples of this substrate specificity include *Escherichia coli* having distinct MFS pumps for macrolides (MefB), fluoroquinolones (QepA), and trimethoprim, and *Acinetobacter baumannii* having distinct MFS pumps for erythromycin (SmvA), chloramphenicol (CraA and CmlA), and erythromycin (SmvA) and chloramphenicol (CraA and (Fsr). Nearly 50% of the efflux pumps in *E. coli* are MFS pumps, and the majority of MFS pumps have been discovered on bacterial chromosomes.
10) **RND transporter family:** Many gram negative bacteria have members of the RND efflux family, which catalyse substrate efflux via a substrate/H+ antiport mechanism. All of them are multi-drug transporters; hence they are involved in the efflux of antibiotics, as well as detergents, dyes, heavy metals, solvents, and a variety of other substrates. Some of our pumps are tailored to a certain drug or drug class (Tet pump—tetracycline; Mef pump—macrolides). Others, like the MexAB-OprM pump in *Pseudomonas*

aeruginosa, can transport a variety of medications and impart intrinsic resistance to β - lactams, chloramphenicol, tetracycline, trimethoprim, sulfamethoxazole, and certain fluoroquinolones. e.g: The *Escherichia coli* AcrAB-TolC pump, which confers resistance to penicillins, chloramphenicol, macrolides, fluoroquinolones, and tetracycline, is a well-known RND pump. Two binding pockets on the AcrB pump protein enable the binding of substrates of various sizes.

Example of antibiotic resistant bacteria:

The bacterium that causes tuberculosis (TB):

TB is a fatal airborne bacterial disease. Although TB typically affects the lungs, it can also affect a variety of other body organs. Usually, a combination of numerous medications is taken for six months to two years to treat it. Multidrug-resistant tuberculosis is the term for it (MDR TB).

Clostridium difficile

After receiving antibiotic treatment, patients' colons get infected with the bacterium *C. difficile*. In most cases, the populations of bacteria that ordinarily inhabit the gut inhibit *C. difficile* colonisation and reduce *C. difficile*-associated illness. Treatment with antibiotics can change the microbiota, promoting the growth of the naturally resistant *C. difficile* bacterium and resulting in colon inflammation.

Vancomycin-resistant *Enterococc*i (VRE)

The female vaginal tract and the human digestive tract frequently harbour *Enterococci*, which are bacteria. People who are in hospitals or other medical facilities are more likely to get VRE infections. Additionally, they frequently happen in persons who are at risk for infection because of underlying health issues or the use of specific catheters or other devices. Vancomycin, a common antibiotic used by medical professionals to treat Enterococcal infections, is ineffective against VRE.

Methicillin-resistant Staphylococcus aureus (MRSA)

Methicillin-resistant *Staphylococcus aureus*, or MRSA, has changed over the past 40 years from a manageable annoyance to a significant public health threat. One of the most prevalent illnesses picked up in hospitals is MRSA. Nevertheless, strains that can lead to life-threatening diseases are increasingly spreading throughout the community.

Neisseria gonorrhoea

The second most frequently reported infection in the United States is gonorrhoea, a sexually transmitted disease. Sexual, racial, and ethnic minorities are disproportionately affected,

and if left untreated, it can result in serious reproductive issues. Controlling gonorrhoea depends on quickly identifying and treating affected people as well as their sex partners. The CDC recently revised its treatment recommendations for gonorrhoea in an effort to decrease the development of drug resistance as some medications lose their efficacy in treating the disease. Gonorrhea is a widespread issue. Action taken in the United States alone is unlikely to stop the emergence of resistance, although prompt identification and efficient treatment of individuals and their partners might contain its growth.

Carbapenem-resistant *Enterobacteriaceae* (CRE)

Escherichia coli and *Klebsiella* species are members of the extremely resistant bacterium family known as CRE *(E. coli*). Hospital patients and people with weakened immune systems are the main populations affected by CRE. Through medical devices like ventilators or catheters, the germs can enter the body. Some CRE infections can be fatal since they are resistant to the majority of current medications.

Spread of resistant bacteria

There are several ways that resistant bacteria propagate throughout the environment:

- Person to person transmission: whether or not the other person exhibits symptoms, sick individuals can pass resistant bacteria to them. Direct contact, coughing, using a keyboard, or a doorknob can all cause this. Regular hand washing helps stop the spread of bacterial resistance.
- Animal to person: Resistant bacteria that are spread from animal to person are frequently found in the intestines and excrement of animals and these germs can be transmitted to humans, including farmers and veterinarians. Recently, molecular detection techniques have shown those farm animals harbour resistant germs that can spread to humans through meat products (Bartlett *et al.,* 2013)
- Food contamination: the injudicious use of antimicrobial agents to increase the productivity of farmed seafood can serve as an emerging source of environmental AMR.
- In hospitals:the proliferation of resistant germs in healthcare environments is a particular worry. Antibiotic use is high and there are many sick patients around, which fosters the growth of resistant bacteria. Crowding and poor cleanliness raise the risk. When sick patients are moved within or between healthcare institutions, resistant bacteria can also spread. Urinary tract infections brought on by catheters, pneumonia brought on by ventilators, and infections in post-operative wounds are some examples of typical healthcare-associated infections.

- Travelling: when foreign visitors go to areas where resistance is high, they may come into touch with resistant bacteria and spread them to other areas. The spread of resistant bacteria is also a problem for patients who are hospitalised while travelling**.**
- AMR in contaminated water: In the effluent of one of the Indian pharmaceutical plants, the levels of ciprofloxacin were found to be 28 and 31 mg/l on two consecutive days (Larsson DG *et al.*,2007) While the former constitute an ever-growing pool of AMR, the latter indicates recent contamination of wastewater. The adequate treatment of this wastewater in developed countries decreases the overall associated risk while the lack of optimal wastewater treatment increases its overall risk in India.
- Municipal waste water: With 30-90 per cent fraction of all antimicrobials being excreted unchanged *via* human faeces and urine, municipal waste water becomes an important dumping ground of resistant organisms or genes. It is estimated that only 20-30 per cent of municipal waste water is treated in treatment plants and that too is not effective enough to eliminate the resistant organisms (Lundborg CS, Tamhankar AJ., 2017).
- Heavy metals: Metals can have mechanisms of resistance as that of antimicrobials like decreased membrane permeability, efflux pumps, target alterations, intracellular sequestration and the presence on the same plasmid.(Baker-Austin C *et al.*,2006)Bacteria carrying metal-resistance genes are more likely to drug-resistance genes.
- Hospital effluent: Hospitals and all other healthcare sector are important sources of antimicrobial waste indirectly by patient or directly as unused discarded medicines.

Detection of resistant bacteria

For locating resistant bacteria, a range of laboratory techniques are utilised. These consist of:

- Bacterial cultured from the site of infection, identified, then exposed to antibiotics to learn which are most effective. Test results are used to choose the best drug for treatment and to monitor how resistance may change over time.
- Molecular analysis and whole genome sequencing of bacterial DNA are two methods that quickly reveal certain bacterial genes. The examinations are used to identify infections.
- Carbapenemase production test- This test uses a culture to determine if microbes produce an enzyme called a carbapenemase that can destroy carbapenem antibiotics. If the bacteria produce the enzyme, then carbapenem antibiotics will be ineffective.
- Colonization screening is a technique used in medical facilities to identify carriers.

Regulatory issues related to antibiotic resistance:

India has been referred to as 'the AMR capital of the world' (Chaudhry and Tomar, 2017). International management guidelines for daily antibiotic practices are yet unavailable. Since the beginning of the industrial revolution; we have dumped increase amounts of organic and inorganic toxins into streams, rivers, oceans, land, and air. In the personal care industry, there are insufficient guidelines for monitoring the home hygiene products which are likely to cause more risk for resistance because these products contain a high concentration of antibacterial ingredients. The development of antibiotic resistance in bacteria is a natural process that can't be stopped but can be slowed. Resistance is currently developing at an alarming rate because of unnecessary antibiotic use in healthcare settings includes using antibiotics when they are not needed for treatment, prescribing the wrong type of antibiotic for treatment, and prescribing antibiotics for an inappropriate duration. In food animals, antibiotics are sometimes added to livestock food and water to promote growth and prevent disease. Animal excreta can contaminate the environment directly with resistant organisms or indirectly with antimicrobials (Wichmann *et al*., 2014). More than half of antibiotics currently made are used to enhance livestock growth. This contributes to bacteria becoming resistant to drugs important for human health. With an abundance of evidence, there is no scope to ignore global antibiotic resistance. Antibiotic resistance can be more prevalent where antibiotic consumption is found to be higher. Lack of regulation and control in using antibiotics is prominent and needs to be targeted at a global capacity. Developing nations are at the greatest risk. Low cost, easy access and excessive use of antibiotics is adding to the burdens on developing nations.

The current problem of in India is as follows: In India wherein rising rate of antibiotic resistance in all sectors from the past decades (Kahn, 2017).

a) **AMR in Human:** According to the scoping report on antimicrobial resistance in India, among Gram-negative bacteria, more than 70% of isolates of *Escherichia coli, Klebsiella pneumoniae*, and *Acinetobacter baumannii*, as well as close to 50% of all Pseudomonas aeruginosa, were resistant to fluoroquinolones and third generation cephalosporins (2017). Colistin resistance has also been observed in India. Although the rate of colistin resistance was only 1%, with the exception of 4.1% (Gandra *et al.,* 2016), colistin-resistant K. pneumonia was associated with a high mortality of 70%.

b) **AMR in food animals:** India was the world's top producer of milk and fish, respectively, according to a 2015 statistics report. Antimicrobial drugs are utilised widely to boost productivity in the food animal industry due to its enormous potential. In West Bengal, 48.8% of the Gram-negative bacilli found in cow and buffalo milk produced extended-spectrum β-lactamases (ESBLs), while in Gujarat, 47.5% of them were resistant to the antibiotic oxytetracycline (Das *et al.*, 2017). With all isolates in Bihar and West Bengal being completely resistant to ciprofloxacin, gentamicin, and tetracycline (Gandra *et al.*, 2017).

c) **AMR in environment:** The main sources are hospital effluents and pharmaceutical waste fluids, which are dumped into the adjacent water resources without being properly treated. When domestic water, domestic waste, hospital effluent, and hospital effluent were the inflow to the treatment facility in India, the rates of separation of E. coli resistant to third generation cephalosporin were 25, 70, and 95% (Akiba *et al.*, 2015).

Conclusion:

Antibiotic resistance is elevating at an alarming rate and is now is global issue that requires urgent attention. We are all affected by this multi-faceted public health issue. An all-encompassing problem that doesn't just affect to clinical personnel and microbiologists, but service personnel, industry , specialists and the general public. We have to take necessary action towards this complicated challenge. The high economic burden in the healthcare sector has become a challenge, due to extended hospital stays, isolation wards, stringent infection control measures and treatment failures. The public health leaders should establish a pan surveillance system coordinated at national and international levels, ongoing analysis and a mandatory reporting system for antibiotic resistance. Both domestic and global policies need to be conventional and adhered-to to stop the overuse and misuse of antibiotics. Application of modern technology can help the patient to take the antibiotic timely.

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HORMONAL IMBALANCE AND IT'S LEADING PROBLEMS IN WOMEN

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Introduction:

"Hormones are chemical messengers synthesized and produced by the specialized endocrine glands to control and regulate the activity of certain cells and organs". Hormonal balance is having appropriate amount of hormones at a specific time in the body. Hormonal Imbalance occur when there is too much or too little of hormones production in body, even small Imbalance in hormones production create many Health issues. Diet and are important, but they aren't the whole story.

Underneath all the meal suggestions, exercise programs, and everything else in the dietary lexicon are little messengers within your body, your hormones carry messages from your brain to your body and from your body to your brain. When you eat certain foods, some hormones kick in telling you whether you want more food, where that food will go, what effect it will have on the body and on the brain. When you exercise hormones go to work, directing the body to move energy stores here, consume energy stores there boost this part of the body shut down that part. And it's very easy to throw off. if one of your glands the places in your body that produce hormones shuts down, becomes overactive or develops a tumor ; if your consumption of a particular food throws off your body chemistry if depression pregnancy any kind of emotional, psychological or physical turmoil occurs the body goes a little haywire. UhHormone balancing is an important health issue for women today. It adversely affects every woman somewhere within their lifetime. Hormones fill us with the vitality of music in our lives. With the proper levels of hormones and Nutrition we fill great and have a full amount of energy to live our life abundantly. On the other hand, when our hormones decline and reproductive ability ceases we become less useful in our livelihood. We need our hormones for many reasons in order to a life vibrantly. Our hormones serve as a regulator in our body. The hormones are important for regulating the activity of cells and tissues in various organs in the body (Leparski, 2019).

This chapter will discuss the importance of hormones, types of female sex hormones, the effects of hormonal Imbalance, Foods causing Hormonal Imbalance, our physical activities.

Types of female sex hormones:

Female sex hormones include Estrogen, Progesterone, and small quantities of Testosterone.

Estrogen

Estrogen is produced by ovaries, it plays a major role in reproduction processes. It helps to stimulate growth of egg follicle in ovaries, then it keeps the thickness of vaginal wall, it also plays a vital role in the formation of breast tissue (Hannah, 2020).

Progesterone

Progesterone is Hormone produced by ovaries, it has a major role in maintaining pregnancy, and progesterone helps in implantation of fertilized egg in the uterus. It helps the body to prepare for conception and regulates the monthly periods. Too much of progesterone levels would likely to cause premenstrual syndrome, such as bloating, Mood swings, abdominal cramps (Payne, 2017).

Testosterone

Testosterone is a male hormone. In the female body lower levels of testosterone is produced in ovaries, it is necessary for normal reproductive functioning, Testosterone helps in sex hormone development, vaginal lubrication but higher levels of progesterone has negative impact in vaginal health, also leads to PCOS, ovarian cyst, infertility, skin problems (Weiss, 2021).

Foods that causes hormonal imbalance:

Hormonal imbalance in women usually happen during puberty, menstruation, and pregnancy. There are various reasons for its cause, these reasons could be due to increased stress, medication, blood sugar levels and certain foods that tend to consume in high amounts (Gupta, 2020).

Dairy and dairy products:

Milk and other dairy products contain a hormone known as insulin-like Growth Factor 1. It promotes the production of androgen hormones such as testosterone, which can worsen hormonal Imbalances. Besides, to meet the excessive demand for milk, cows are being pumped with external hormones and antibiotics. When we consume that milk those hormones find their way into our bloodstream and further disrupt our natural hormonal balance (Kukreja, 2021).

Red meat: Red meat consumption merely increases the production of estrogen levels and that badly leads to hormonal imbalance, Red meat is high in saturated and hydrogenated fats these fats adversely effects health and disrupt the hormonal balance (Gupta, 2020).

Processed foods: Processed and refined foods have been linked to various health issues. Regular consumption of processed food brings hormonal imbalance in our body by increasing cortisol levels and decreasing estrogen levels because these foods have high amounts of salt, sugar and preservatives that leads to inflammation in body (Roy, 2021).

Coffee: Coffee habit could be putting the blood sugar levels on roller coaster.'As too much of caffeine interfers hormonal balance itself can cause the body to produce extra cortisol (Dubey, 2018).

Healthy balance diet for balancing hormone:

The most effective approach to balancing hormones is through diet. Focus on dressing each meal with lots of fresh organic green vegetables with healthy oils like Olive, Avocado, flax, coconut. The leafy greens are full of oxygen, nutrients, proteins, and Antioxidants which your cells need to optimally function.

Healthy fats noted in the oils above help with the digest off food and deliverance of nutrients into the cells. Compliment with small beans like lentils, moong beans and ancient whole grains. Beans are rich in protein and easy to digest when the dry beans are soaked overnight in water and then cooked slowly on the stovetop. Stick with grains which are not genetically modified since they are not recognised as safe by our body's immune system, and often sprayed heavily with pesticides (Bhandari, 2019).

The Best tolerated grains are Quinoa, Amaranth, Millet, and Oats. The combination of vegetable, beans, and Ancient grains mixed with good oils allows these foods to be easily digested and blood sugar to be easily delivered to the cells. Hormones such as GLP-1, cholecystokinin, and pancreatic polypeptide (PPY) remain in balance causing a feeling of satiety and fullness.

On the other hand, Trans fats in processed food and saturated fats in all Animal protein like Dairy products, poultry, red meat, eggs negatively affect health. They immediately cause Insulin resistance and along with increased appetite and mood shifts (Bhandari, 2019).

Higher protein diets sourced from excess animal protein and soy consumption cause major hormone imbalance and eventual liver and kidney failure. People only require 16% of their daily food intake to be rich in protein derived from plant sources. Only then can the hormones PPY and GLP-1 be balanced aiding in healthy digestion.

Sugar such as in bread and other processed sweets along with high-carbohydrates foods, such as potatoes, sweet potatoes, pasta, and rice cause huge spike in blood sugar and insulin

resistance. These foods should be sparingly consumed and balanced with lots of green vegetables and legumes (Bhandari, 2019).

Fasting is critical for optimal health and hormone balance. Eating can often shock the system and hence, needs to be consumed in small portions. After age 30 a person only needs 2-3 meals maximum per day with no snacks. Ideally, try to eat meals before 6 pm so the body has plenty time to digest food before bedtime. Following intermittent fasting helps in body cleansing and healing especially fasting of 16- 14 hours is proved to maintain optimum health. Overeating causes insulin resistance and spikes in cortisol production (Bhandari, 2019).

Conclusion:

Eating nutritious food and healthy Lifestyle habits are good for health. The intake of processed foods, refined food, sugary products and those foods with bad cholesterol has to be cut down from our diet. Increase the consumption of oraganic foods which are wholesome plant-based and high fibre to keep the hormones in balance line with regular exercise.

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EFFECT OF BLANCHING ON THE ANTIOXIDANT PROPERTIES OF SOME TROPICAL GREEN LEAFY VEGETABLES

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Introduction:

Effect of blanching:

Blanching is a technique that is used to inactivate such enzyme that may harm the nutritional components of fruit products. Different methods were introduced nowadays to blanch food products including water blanching, steam blanching, in-can, and vacuum-steam blanching.

The factor which influence blanching time are:

1. Type of fruit or vegetables
2. Size of the pieces of food
3. Blanching temprature
4. Method of heating

Objective of blanching:

The objective of blanching as a Pretreatment of vegetables for canning is the removal of Tissue, the shrinking of the material so that adequate fills can be contained in the can, and the heating of the material prior to filling so that a vaccum will be obtained after heat processing and boiling.

Advantage of blanching:

1. Lower capital cost
2. Better energy efficiency
3. Uniform treatment
4. It helps to clean the surface of vegetables

Disadvantage of blanching:

1. Leaching of minerals and nutrients such as vitamins
2. Produce effluents with large biological oxygen deman
3. Risk of contaminating by thermophilic bacteria

Uses of blanching:

Blanching is a thermsl process used mostly for vegetable tissue prior to freezing, drying or canning, befor canning, blanching serves several purposes, including cleaning of the product, reducing the microbial load, removing any entrapped gases, and wilting the tissue of leafy vegetables (britannica.com).

Method of blanching:

Unting blanching time as soon as the water returns to a boil. Keep heat high for the time given in the directions for the vegetable you are freezing.

1. Freezing blanching

Blanching (scalding vegetables in boiling water or steam for a short time) is a must for almost all vegetables to be frozen. It stops enzyme actions which can cause loss of flavor, color and texture. Blanching cleanses the surface of dirt and organisms, brightens the color and helps retard loss of vitamins. It also wilts or softens vegetables and makes them easier to pack. Blanching time is crucial and varies with the vegetable and size. Underblanching stimulates the activity of enzymes and is worse than no blanching. Overblanching causes loss of flavor, color, vitamins and minerals. Follow recommended blanching times.

2. Water blanching

For home freezing, the most satisfactory way to heat all vegetables is in boiling water. Use a blancher which has a blanching basket and cover, or fit a wire basket into a large pot with a lid. Use one gallon water per pound of prepared vegetables. Put the vegetable in a blanching basket and lower into vigorously boiling water. Place a lid on the blancher. The water should return to boiling within 1 minute, or you are using too much vegetable for the amount of boiling water.

3. Steam blanching

Heating in steam is recommended for a few vegetables. For broccoli, pumpkin, sweet potatoes and winter squash, both steaming and boiling are satisfactory methods. Steam blanching takes about 1½ times longer than water blanching. To steam, use a pot with a tight lid and a basket that holds the food at least three inches above the bottom of the pot. Put an inch or two of water in the pot and bring the water to a boil. Put the vegetables in the basket in a single layer so that steam reaches all parts quickly. Cover the pot and keep heat high. Start counting steaming time as soon as the lid is on. See steam blanching times recommended for the vegetables listed below.

4. Microwave blanching

Microwave blanching may not be effective, since research shows that some enzymes may not be inactivated. This could result in off flavors and loss of texture and color. Those choosing to run the risk of low quality vegetables by microwave blanching should be sure to work in small quantities, using the directions for their specific microwave oven. Microwave blanching will not save time or energy.

5. Cooling

As soon as blanching is complete, vegetables should be cooled quickly and thoroughly to stop the cooking process. To cool, plunge the basket of vegetables immediately into a large quantity of cold water, 60ºF or below. Change water frequently or use cold running water or ice water. If ice is used, about one pound of ice for each pound of vegetable is needed. Cooling vegetables should take the same amount of time as blanching. Drain vegetables thoroughly after cooling. Extra moisture can cause a loss of quality when vegetables are frozen (nchfp.uga.edu).

Blanching temperature for some vegetables

Vegetables	Temperature ^{0}C	Time (in Min.)
Peas	85-90	2-7
Green beans	90-95	2-5
Cauliflower	Boiling	2
Carrot	90	3-5
Peppers	90	3

Effect of blanching on food:

1) Effect of blanching in raw potatoes

Blanching means a short time heat treatment (70-100^{0}C) of raw potatoes or potato piece. There several reasons are occure, enzyme are inactivated (e.g polyphenoloxidase) to present discoloration. Blanching that result in the formation of firm structure. And native pectin methyl esterase is activated to reduce cross linking of pectin, and free carboxyl group may reacts with granules after gelatinization to form a thermostable pectin network.

2) Effect of blanching in green beans:

Lee *et al.* (2007) evaluated water blanching of green beans with varying time temperature combinations. They concluded that beans could be blanched at temperature lower than 90-100^{0}C but that temperature higher than 82^{0}C were required to ensure adequate destruction of enzyme and to maintain good color, flavor, and texture.

Puupponen-pimia *et al.* (2003) studied that the effect of blanching on 20 commonly used vegetables. They found that change were plant species dependent but in general that dietary fibre components were either not affected or increase slightly, carotenoid and sterols were not affected and minerals were stable although there was some leaching losses of soluble minerals. Phenolic antioxidants and significant losses of antioxidant activity. Losses of vitamin C were up to one third and more than half of the folic acid was lost. Ascorbic acid is water soluble (so is leached from cells,) thermally labile and subjected to enzyme breakdown by ascorbic acid oxidase losses of ascorbic acid are used as in indicator of the severity of blanching and therefore of food quality typical vitamin losses are 15-20% for riboflavin, 10% for niacin and 10-30% for ascorbic acid (Berry-Ottway, 2002)

Blanching helps to remove peel of fruits, modify their texture and to inactivate certain enzymes. Blanching is also used as pre-heat treatment before drying, frezing Or canning of fruits and vegetables.

Some possible undesirable effects of blanching are damage to tissue cells, of colour, leaching of water soluble and heat sensitive nutrients etc due to heat treatment. To avoid this, low temperature process may be followed but it needs longer process time than a high temperature condition. For large sample, hot stream has been considered an efficient heat source for the blanching. Blanching sometimes also refers to preserve color, flavor, and nutritional value of fruits/vegetables.

Usually for almost all vegetables to be frozen, blanching is essential step. In this case, blanching stops some enzyme action otherwise may cause loss of colour, flavour and texture of such vegetables. The process of blanching is used in home kitching and in food industry too as a Pretreatment.

As discussed above, the sole purpose of blanching is to inactive enzyme that otherwise cause browning, off flavor and texture change. Some enzymes that cause deterioration are lipoxygenase etc.

So it would correct to say that blanching presrves the flavors in fruit/vegetables by inactivating such enzymes responsible for off flavor development. Lipoxygenase is common enzyme responsinsible for off-flavor development in many vegetables. As blanching removed trapped air inside fruit/ vegetable tissue (e.g. pears), it results in better texture and reduces oxidation of the product. This inter cellular gas expelling also results in better color retention.

Blanching of some nuts (e.g.Almonds and pistachio) helps softening and easy removal of outer skin. Some more uses of blanching mentioned in literature are for enhancing drying rate

and product quality, extraction of bio-active compounds,decreasing microbial load, surface cleaning etc. (myeblackboard.com)

Conclusion:

- Blanching is an old and well established practice in the food industry.
- Early technological improvements focused on increasing product quality.
- Targeting the right enzyme indicator would reduced blanching time and tackle all these priorities; improving product quality (in increasing retention of nutrients and other fresh like quality attributes) , reducing energy, consumption, and reducing waste production.

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CONSERVATION STATUS OF TASAR SILKWORM

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Introduction:

India is a unique country producing all the four known varieties of silk, namely, domesticated Mulberry silk (*Bombyx mori*), semi- domesticated Eri silk (*Philosomia ricini*), wild Tasar silk (*Antheraea mylitta*) and exclusive Muga silk (*Antheraea assama), the* wild golden silk being unique to India. India is the second largest producer of silk in the world. Among the four varieties of silk produced in 2020-21, Mulberry accounted for 70.72% (23,860 MT), Tasar 8.02% (2,705 MT), Eri 20.55% (6,935 MT) and Muga 0.71% (239 MT) of the total raw silk production of 33,739 MT. Tasar culture is practiced in the forest using host plant in natural conditions. It does not require any investment on plantation of host plant, rearing house and appliances etc.

Tasar silk variety is produced from tropical silk worm *Antherea mylitt* and temperate silkworm *Antherea proyeli.* The main hosts plants are Arjun trees *Terminalia arjuna*, Asaan trees *Terminalia tomentosa* and Oak trees *Querecus sp*. It is very economical as it is used to make sarees, dresses, gowns, Kurta, jackets andvarious other clothings. Beside the advantages of silk production within the country and demand of the production in foreign countries promoted commercial exploitation of Tasar culture. The production scenario of raw Tasar silk during past two decades indicates a fluctuating trend and further decreasing trend in the biodiversity and conservation of Tasar silkworm. Rearing of Tasar silkworm not only help in conservation of forest but also gives opportunity to utilize the vast natural resources with minimum investment along with generation of employment for rural community.

Tasar host plants and distribution

Tasar silkworm is polyphagous, having primarily and secondary food plants based on preference. The tasar silkworm mainly feed on three food plants namely Asan, *Terminalia tomentosa*. Arjun, *Terminalia arjuna* both belong to family Combretaeae and Sal *Shorea robusta* belong to family Dipterocarpaceae. The other primary host plants include a few species of *lagerstroemia* and *Ziziphus mauritiana* and *Hardiwickia binata*. The secondary host plants comprised of *Terminalia chebula*. *T. bellerica*, *T. catappa*, *T. paniculata*, *Z. jujube* and few ficus species and others as listed (Table 1).

Table 1: Difference Host Plants of *Antheraea mylitta D*

Sr. No.	Scientific Name	Local Name
1.	*Carissa carandus*	Karaunda or Karinda
2.	*Semearpus anacardium*	Bhelwa
3.	*Cassia lancelata* *Bauthinia variagata L.*	Kanchan
4.	*Celastrus paniculatus*	Nalkangni
5.	*T. Arjuna* Bedd *T. Belerica* Roxb. *T. Catappa* L. *T. Chebula* *T. Tementosa* W & *A* *Anogeissus latifolia wall*	Arjun, Sadar Bhaira, Behera Jangli Badam Harada Asan, Ani, Saja Dhaura
6.	*Shoera robusta Gaertn*	Sal or Sakooa
7.	*Ricinus communis*	Around or Castor oil plant
8.	*Lrgerstroeia indica*	Daiyeti, Telinga, China
9.	*Bombax malalabaricum DC*	Silk cotton tree
10.	*Ciopadessa fruticosa* BI	Billu
11.	*Ficus religiosa L*	Aswat, peepal
12.	*Careya arborea Roxb* *Eygenia cumin* Druse *(L)*	Kunbi Jamun
13.	*Zizyphus jujube*	Ber
14.	*Prunus domestica*	Plum
15.	*Rhizophora calceolaria*	-
16.	*Canthium diecocum* (Gaerth)	Merill
17.	*Dodonaea viscose Jacg* (L)	Sanalta
18.	*Bassia longifolio*	-
19.	*Toctona grandis*	Sagun

In India, Tasar food plant grow luxuriantly at lower altitudes (up to 600 m ASL) and extending mainly around “Torrid, tropical Zone or hot Zone and distributed up to 400 latitude on either direction. Tasar sericulture practiced in two different climatic zones.

1) Tropical zone which has distinct belt of humid and dense forest spread in the state, Madhya Pradesh, Orissa, Bihar, West Bengal and parts of Uttar Pradesh, Maharashtra, Andhara Pradesh and Karnataka.
2) Temperature Zone, which extends from Western Part of Jammu and Kashmir up to Eastern Part of Manipur. Presently only about 5% of the tropical Tasar host plant is being exploited for the production of Tasar Silk (Rai, 2005).

In Maharashtra Tasar sericulture is confined only to four districts and about 3000 farmers are involved directly or indirectly in Tasar silkworm rearing. The primary food plants like *Largerstroemia* have a distribution from base of western Himalaya in the south of Indo Gangeticec plain and extending up to central India. *Hardwwickia binata* (Anjan) is more prevalent in western and peninsular India. Most of these host plants are available in other tropical countries like Nepal, Burma, Srilanka, Indonesia, Malaysia, Australia, Africa, Afghanistan and Vietnam etc.

Threat to food plants of Tasar silkworm:

The Tasar Food plants are generally affected due to various pest, parasites and diseases causing damages to host plant. Insects belonging to Coleoptera, Lepidoptera, Hemitera, Thysanoptera and Isoptera are the common pests (Table 2).

Table 2: Pests of Tasar silkworm foods plants

Sr. No.	Pests / Diseases	Food Plants attached
	Stem borer	*T. Arjuna*
1.	*Acolasthes holocericea*	*T. tomentosa*
2.	*Sphenoptera Knoibierensis*	
3.	*Sphenoptera Cupriventris Kerr*	
	Gall Fly	
4.	*Phylloplecta Hirsute and Trioza flatcheri*	*T. Tomentosa*
5	*Termites Microtermes, Odontotermes* and *Trinervitermes sp.*	All the food plants
6	Beetle (Defoliators) *Anomala* sp.	All the food plants.
7.	Steam Cancer	*T. tomentosa*
8.	Leaf curl	*T. Arjuna* & *T. tomentosa*
9.	Root rot	*T. tomentosa*
10.	*Ganderma lucidum*	*Shorea robusta (sal)*

Distributin of Tassar silk worm Ecoraces:

The silkworm, *A. mylitta* (Tropical silkworm) belong to family saturnidae. The distribution of these species extends over a large area starting from West Bengal to Karnataka. The availability of different host plants, ecological conditions and geometerological factors have lead to a large number of variants within the species, generally termed as ecoraces. There are 34 ecoraces have been identified (Alam *et al.*, 1998) occupying various geographical region. Most of the ecoraces exist in Bihar, Orissa and Madhya Pradesh and a few in other states like Assam, West Bengal, Maharashtra, Andhra Pradesh and Karnataka. In Maharashtra the prominent tropical ecorace is found in Bhandara, Singbhum and Singbhum and Santhal Paragana in Jharkhand, Raigad and Jagadalur in Chhatisgarh, Mayurghanj and Keonjhr in Orissa. Bengal Adilabad and Warangal in Andhra Pradesh and Belgam in Karnataka.

Maharashtra is India's second largest state, in terms of both population and geographical area. 3000 farmers are involved in tasar plantation covering 10669 hectares. The tasar farmers reared 354 lakh tasar cocoons, out of which 19.33 MT of tasar raw silk was produced. Thus, sericulture provides good employment opportunities for farmer's especially tribal community. The tasar silk is grown in four districts of Vidarbha region i.e., Gondia, Gadhchiroli, Bhandara & Chandrapur in the Maharashtra state (Seri-States of India 2019 – A Profile).

The raw silk production in the country reached of 35,820 MT during 2019-20. The raw silk production was higher during 2019-20 than the previous year (35,468 MT). The shortfall in achievement of targets during 2019-20 was mainly due to delay in onset of monsoon especially in mulberry silk producing belts in South India during 2019 and covid-19 pandemic. Tasar silk production reached highest in 19-20 i.e 3,136 Mt and low during 20-21 and 21-22 may be due to covid-19 pandemic (Table 3).

Table 3: Comparison of mulberry and Tasar silk production in India

Raw silk production statistics (Metric ton)			
Years	**Mulberry**	**Tasar**	**Total**
2017-18	22,066	2,988	31,906
2018-19	25,344	2,981	35,468
2019-20	25,239	3,136	35,820
2020-21	23,896	2,689	33,770
2021-22	25,818	1,466	34,903

Ecoraces of tropical Tasar provide a large variability and gene pool to be exploited in the evaluation of new breed. Some high yielding breeds were developed at Central Tasar Research & Training Institute, Ranchi. Multivoltine pure race Daba is the main source of the Tasar commercial silk. However, it has higher viability and poor productivity whereas railly (BV) exhibits higher productivity but poor viability under captivity. The cross between, Daba x Railly and its reciprocant showed heterosis to the extent of 50% for shell weight. F1 crosses between Railly x Daba and Railly x Sukinda showed better performance than their parent (Shankar Rao *et al.,* 1999).

Threat to Ecoraces:

The important cause of concern over conservation of Ecoraces are (A) Extensive Collection of naturally occurring local cocoons from its habitat by tribal community and traders for raw silk production without leaving sufficient population to multiply in nature; (B) Change in climatic conditions with increase in the Tasar silkworms natural enemies like parasites and predators (Table 4).

Table 4: Natural Enemies of Tasar silk worm

Sr. No.	Name	Stage of Attack
Parasite		
1.	Uzufly – *Blepharpia Zebina*	III & IV Stage/ S.W. rearing
2.	Iehneumon Fly Pimple Punctata	Spining Stage
Predator		
1.	Sting Bug, *Sycanus Furcellata*	1ST, Iind & Early III Stage
2.	Reduviid Bug, Sycanuse Collaris	1st To Late 4th Stage
3.	Praying Mantis, *Hierodula Bipapilla X*	3rd & 4th Stage
4.	*Oecophylla Smarafdina*	1st & 2nd Stage
5.	*Vespa Orientalis*	2nd & Early 3rd Stage
6.	*Polistes Hebraeus*	2nd & Early 3^{r} Stage

Conservation of Ecoraces:

Pressure on ecorace – After the introduction of races such as Sukinda and Daba, the rearing of local ecorace at farmers level has been reduced considerably due to poor stability and multiplication of crop at farmer level. Heavy deforestation has lead to tremendous loss of genetic diversity of host plants and associated fauna. Continuous utilization of cocoons for reeling purpose and less seed availability for further generation has create imbalance in ecoraces.

In Maharashtra due to better shell percentage and resistance to disease, Bhandara local (Mulki) ecorace is needed to be conserve. The wild tasar-biodiversity of India is facing unparallel threat of extinction from their natural habitat due to environmental degradation and other related issues. The alarming decline in ecorace natural multiplication is attributed due to excessive collection, rapid deforestation and industrialization of their natural habitats (Sinha and Sinha, 1994; Nayak *et al.*, 2000; Hansda *et al.*, 2008).

Following measures to be taken for conserving diversity.

A. The existing race distributed over entire region should be identified, explored and collected.
B. The race should be evaluated for their qualitative characters. They should be subjected for stability test over a number of locations for future utilization and conservation.

Conservation in its natural ecosystem should be preferred and duplication of ecotypes should be avoided.

Conclusion:

The Tasar culture is considered as an agro based industry of tribal community with additional employment. The conservation of tasar silk insect along with various ecoraces and wildlife by feasible strategies, not only maintain its population, but also help in conservation of other endangered flora and fauna.

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NATURAL PIGMENTS OF BACTERIAL ORIGIN AND THEIR POSSIBLE BIOMEDICAL APPLICATIONS

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Introduction:

Microbial pigmented molecules such as bacteriochlorophylls, carotenoids, flavins, indigoids, melanins, pheomelanin, monascins, phenazines, phenazostatin D, prodigiosin, quinone precursors, violacein, glaukothalin, pycocyanin, xanthomonadin, phenazine, canthaxanthin, astaxanthin, β-carotene, etc. are produced as biproducts by several microorganisms. Marine bacterial communities are known to play an important role in regulation of ecological and biogeochemical processes and shaping the biosphere. Some microorganism has enormous potentiality to produce diverse striking traits such as production of pigments and biomolecules etc. Pigment production in some microbes is regulated via the quorum sensing mechanism. Several marine pigmented bacterial species have demonstrated various biological activities such as antimicrobial, anticancer and immunosuppressive activities.

How pigments are extracted from bacteria:

Pigment produced by the bacteria can be isolated using solvent extraction. These pigments can be further purified and characterized for physical and chemical characteristics using various instrumental-based analytical techniques such as TLC, UV–vis Spectroscopy, NMRHPLC and Gel Permeation Chromatography etc.

Occurrence of high frequency of pigmented bacteria is noticed in air–water interfaces, glaciers, ice cores, bacterioneuston (sea surface microlayer) and underlying waters, salt lakes, deep sea hydrothermal vents, and abyssal hot springs (e. g. , Thermus). Recently, various pigmented bacterial communities have been isolated from lava caves. *P. aeruginosa*, a pigmented bacterium, has been reported to isolate from the wounds skin of humans and animals. These PBs are reported to be isolated from different marine niches such as seawater, marine sediment, seagrass, sponge, mussel, sea cucumber, algal mats, corals, freshwater, athalassohaline lagoon, marine solar saltern, microbial mats in Antarctic lakes, oil contaminated soil, nonsaline alkaline groundwater, and sea ice (e. g. , Algoriphagus) (Figure 1).

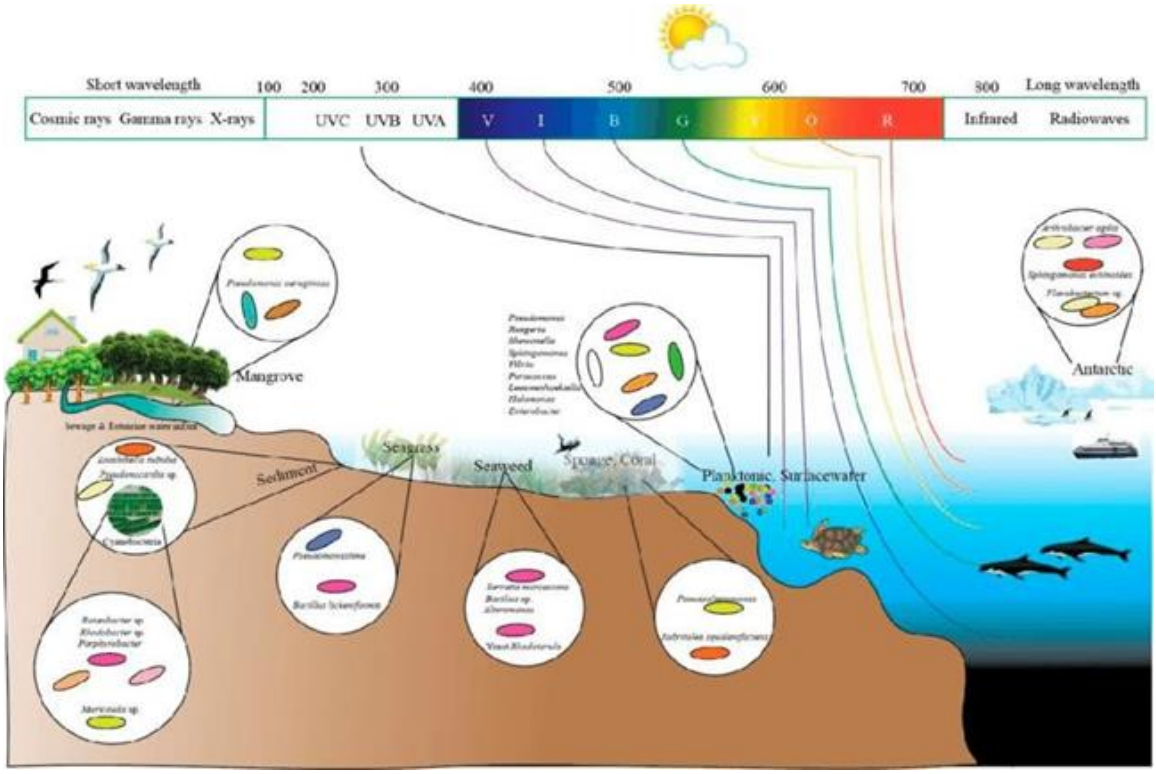


Figure 1: Distribution of marine pigmented microorganisms in different niches

Natural pigments of bacterial origin:

Among bacteria, pigment production is highly variable, although usually present in Actinobacteria. Several genera, such as Streptomyces, Nocardia, Thermomonospora, Microbispora, Streptosporangium, Rhodococcus, and Kitasatospora produce a wide variety of pigments. While the main application of these pigments is in the textile, food, and cosmetic industries, pigments like melanin, quinones, violaceins, and indigoidines have been reported as good antimicrobial agents. Besides, pigments can be used as antioxidants, bioindicators, and anticancer agents; thus, their potential is becoming an important field of biomedical application. Of the entire range of bacterial pigments available, those described next have the qualities necessary to be used in the biomedical industry as promising therapeutic agents (Table 1).

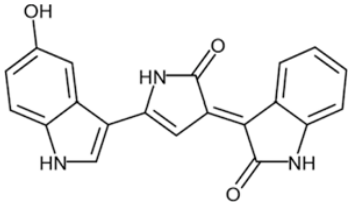
Table 1: List of all bacterial pigments reviewed, their biological activities, and reported genera of pigment producers

Pigment	Colour	Biological Activity	Reported Producers
Violacein	Purple	Antibiotic	Chromobacterium
		Antiparasitic	Janthinobacterium
		Antiviral	Alteromonas
		Antitumoral	Collimonas
		Anticancer	Duganella
			Pseudoalteromonas
Indigoidine	Indigo	Antioxidant	Arthrobacter
		Signaling	Corynebacterium
		Antibiotic	Clavibacter
			Photorhabdus
			Dickeya
			Streptomyces
Melanin	Dark Brown	Photoprotection	Rhizobium
		Antioxidant	Pseudomonas
		Anticancer	Modestobacter
			Streptomyces
Carotenoids	Red/Orange	Antibiotic	Flavobacterium
		Antioxidant	Brevibacterium
		Cytotoxic activity	Paracoccus
			Pantibacter
Prodigiosin	Deep red	Biocontrol	Serratia
		Antibiotic	Janthinobacterium
		Algaecidal	Streptomyces
		Anti-inflammatory	Vibrio
		Anticancer	HahellaHahella
		Antimalarial	Zooshikella
		Antidiabetic	Pseudoalteromonas
		Immune system modulator	
Rhodopsin	Light Pink	Active transport	Halobacterium (Archaea)
		Signaling	Halloterrigena (Archaea

		Cell behaviour modulator (cell reprogramming)	Halorubrum (Archaea) Natromonas (Archaea) Anabaena (Eubacteria) γ-Proteobacteria (Eubacteria)
Pyoverdine	Yellowish green	Bioluminescence Virulence factor Iron uptake	Pseudomonas
Pyocyanin	Greenish-blue	Virulence factor Iron uptake Cytotoxic activity Antibacterial activity	Pseudomonas

Violacein

Chemical structure



All the species known to be able to produce violaceins are heterotrophic, have predominantly been discovered in aquatic ecosystems and many representatives of these species have been isolated from cold environments, such as Arctic ice, freshwater, and marine habitats. Finally, multiple biotechnological applications have been attributed to this pigment acting asan antibacterial, antiparasitic, antiviral, antitumor, and has genotoxic activity in cell lines.

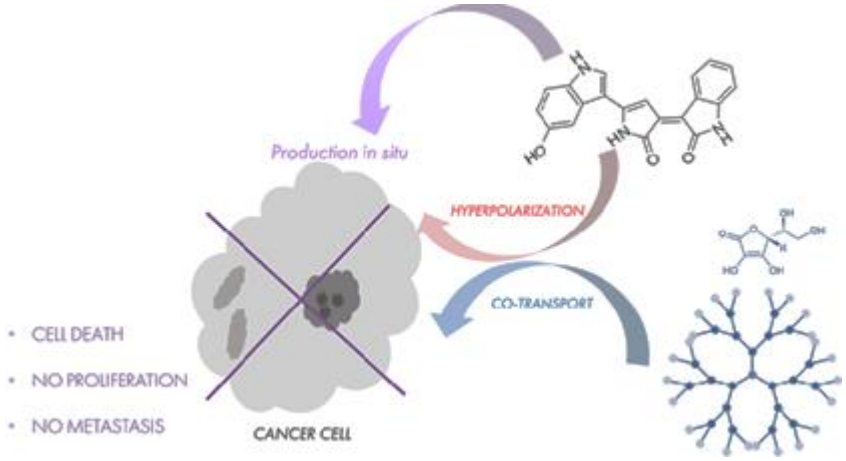


Figure 2: Vioacein affect tumor cells

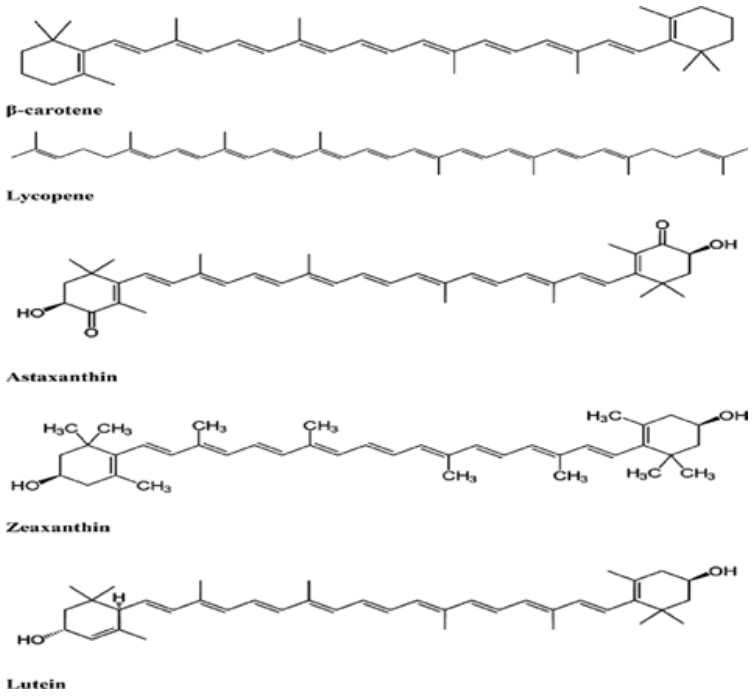
Violacein affects tumor cells in many ways by stopping proliferation and metastasis and provoking apoptosis. Hyperpolarization and permeabilization of membranes were stressed asthe

most important events during violacein action. Some authors use violacein with ascorbic acid loaded dendrimers. In addition, transfer of violacein biosynthetic cluster into an oncolytic bacteria strain led to an in situ production of violacein.

Carotenoids

Carotenoids are pigments in plants, algae, and photosynthetic bacteria. These pigments produce the bright yellow, red, and orange colours in plants, vegetables, and fruits.

Some chemical structure of carotenoids:



Types of carotenoids:

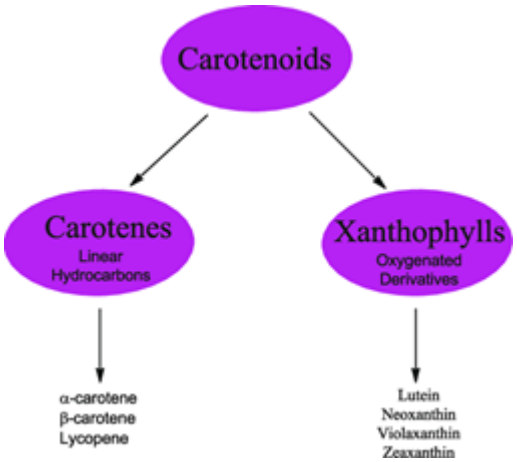


Figure 3: Types of carotenoids

Xanthophylls

There are two main types of carotenoids, the xanthophylls and the carotenes. Xanthophylls are easily recognized by their yellow coloration, and are present in high quantities

in leaves. In the fall, these carotenoids are responsible for yellow leaves. Xanthophylls also give colourto fruits and vegetables like papaya, squash, and peaches. The *macula lutea* in the human retina gets its coloration from these carotenoids, which play a significant role in vision. Theyhelp protect the retina from blue and ultraviolet light, which tends to cause radical ions in the tissue.

Carotenes

Carotenes, unlike xanthophylls, are carotenoids with no oxygen atoms. They reflect mostly red and orange light. Carotenes are responsible for the color of everything from carrots to sweet potatoes to cantaloupe. Carotenes, as an accessory pigment, work by transferring the energy they gather from light into chlorophyll, which can then be used to store energy in the form of glucose. Carotenes are present in nearly every vegetable and fruit in some quantity. While animals cannot produce these carotenoids, they have important biochemical functions, and serve as precursors to many molecules.

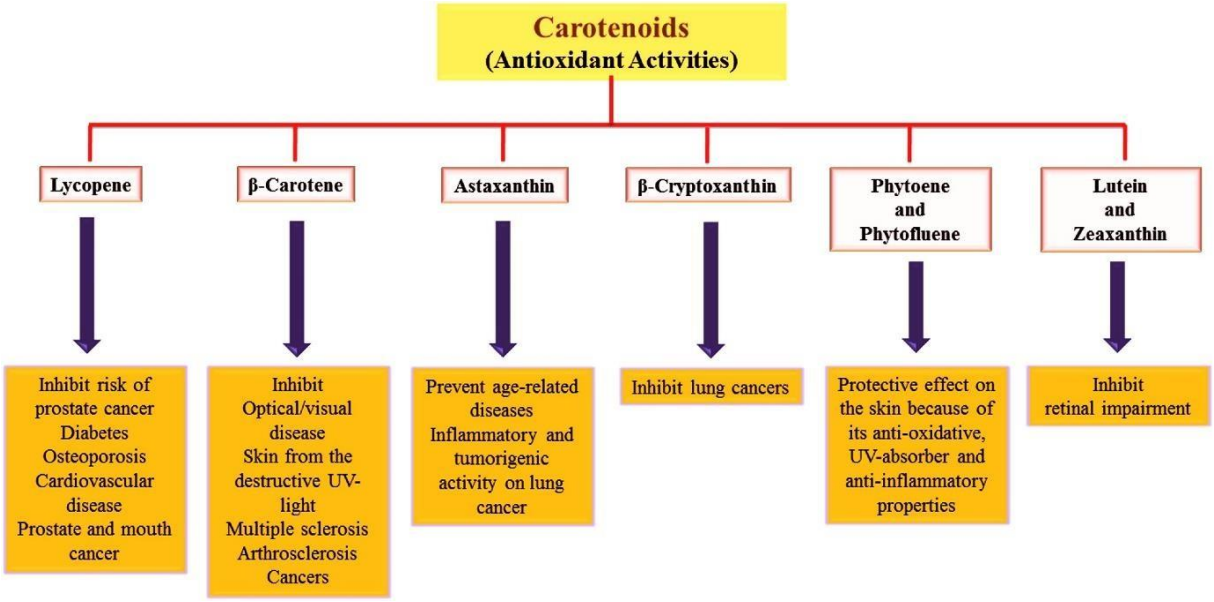


Figure 4: Role of different types of carotenoids in disease suppression

Carotenoids are one of the natural dietary products that can be taken either from supplementsor as additives. Some carotenoids such as zeaxanthin, lutein, β-cryptoxanthin, α- and β- carotene, lycopene, phytoene, and phytofluene consistently found in human skin, plasma and milk. Phytoene and phytofluene has a protective effect on the skin because of its anti- oxidative, UV-absorber, and anti-inflammatory properties. Phytoene and phytofluene are more challenging to detect as compared to other carotenoids. They can be consumed through tomatoes, carrots, citrus, and derivatives. They show the maximum absorb tendency in the UV region. Lutein and zeaxanthin are responsible for retinal yellow pigment formation, and play a crucial role to protect

the eye from light and can hinder retinal impairment. β- Cryptoxanthin plays a vital role as a chemo-preventive mediator against lung cancer and reduces this cancer by downregulating neuronal nicotinic acetylcholine receptor α7/PI3K signaling pathway. Besides, high β-cryptoxanthin and lycopene with diet might be secure against destructive prostate cancer. Current research by several researchers reveal that carotenoids can shift from antioxidant to pro-oxidant activities as consumption of oxygen concentration. The pro-oxidant consequence resulting from revelation to high doses of carotenoids observed *in vivo* (increased DNA destruction distinguished in *in vitro* studies) are connected with the consequent deleterious accomplishment of various putative disruption products. Recently, Haider et al. reported that small doses (1 M) of cleavage product of β– carotene stimulate substantial levels of DNA strand disruptions in foremost pneumocytes type II cells that were focused to oxidative stress. In conclusion, carotenoids serves as an interesting group of natural pigments because it play several functional roles in biology and accountable for a broad range of coloration in the environment. Carotenoids have possessed specific tasks in the antioxidant system (due to their unique structure) for example shielding lipophilic compartments or scavenging reactive species produced in photooxidative processes. Further, they may perform as light filters and preclude oxidative stress by retreating light exposure.

Melanin

Melanin is a group of heterogeneous functional polymeric materials produced by various organisms, including bacteria, fungi, animals, and plants. In humans, melanins are present in the skin, hair, iris, and in the other parts of the body, including the inner ear, the subsantia nigra, and the locus coerruleus of the brain. The chemical structure of melanin is still controversial, but it is highly dependent on polymerization and oxidation conditions during its synthesis, and the final form of melanin depends on the synthesis process or the source of extraction.

Biomedical applications

The properties of melanin, such as antioxidant, optical, electronic, semiconductor, biomedical, and photoprotective actions, are governed by the presence of electrons that are unpaired to the melanin structure.

The anti-tumor activity of PDMN has also been reported. PDMN can kill tumor cells (such as HeLa and 4T1 cells) in animal models with a short irradiation laser time. Another great advantage of PDMN is its excellent biocompatibility and can remain in the blood for several months, so the investigation process can be repeated without duplicating the injection process. Shi *et al.* (2018) prepared dopamine-based fluorescent starch nanoparticles for fluorescence

imaging applications. They showed that the PD-based starch nanoparticles are biocompatible and can be used as fluorescence probes and carriers to deliver active biological components. It has also been reported that MRI, antioxidants, or photothermal therapies have been improved in the presence of PDMN- (PDMN polydopamine melanin nanoparticles based nanoparticles). PDMN-based nanoparticles have also been used as carriers for certain drugs. It has been reported that melanin can act as a potential pH-reactive drug release device.

Figure 5: Various biomedical applications of melanin or melanin-like nanoparticles

Table 2: Various media and supplements required for extraction of some specific pigments

Pigment	Media/Supplement	Incubation Temp.
Violacein	Lactose and tryptophan	22^0C
Indigo	Potato-glucose-peptone agar, Phosphate agar—incorporation of 2-hydroxypyridine and/or Tryptophan	
Melanin	Tyrosine agar, Peptone-yeast extract iron agar, Tyrosine, Zn, Cu, Co, and 3-chlorobenzoate	
Carotenoids	Mevalonic acid, trisporic acid, and Isopentenyl pyrophosphate	
Prodigiosin	Casein hydrolysate agar	24–28^0C
Pyocyanine	Glycerol, leucine, glycine, alanine, and mineral salts	

Prodigiosin

Biological activities of Prodigiosin

Antimicrobial activity

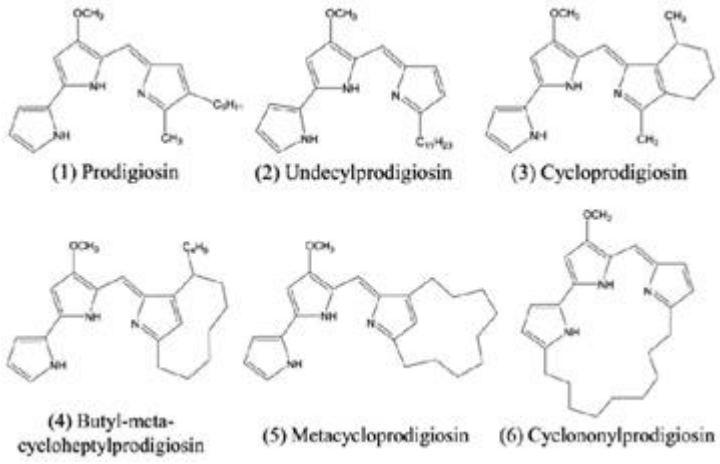
The study of the inhibitory effect of this pigment suggests that it presents a better action against Gram-positive bacteria rather than Gram-negative.

Antibacterial activity

PG showed antibacterial activity against *S. aureus*, *Staphylococcus saprophyticus*, *Enterococcus avium*, and *Streptococcus pyogenes*. Also, this pigment seems to be a goodcuring agent on plasmids of *E. coli* HB101 and *S. aureu.*

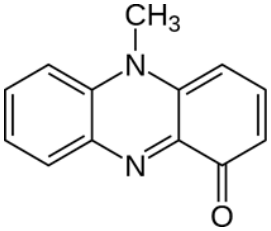
Anticancer activity

One of the most accepted anticancer mechanisms of PG includes mitochondrial dysfunction and ATP depletion. Francisco *et al*. (2007) described PG as a proton sequestering agent that abolishes the intracellular pH gradient, therefore uncoupling the electronic chain transport ofprotons to mitochondrial ATP synthase, and promoting ATP depletion which leads to apoptotic cell death in neuroblastoma cancer cells.



Comparative chemical structure of prodigiosin and its different isoforms

Pyocyanin



Pyocyanin has antibiotic activity against bacteria, fungi and protozoa. About 90 to 95% of P. aeruginosa strains produce pyocyanin which was the main phenazine pigment associated with organism and had powerful antimicrobial, antioxidant and anticancer activities.

In medical applications, phenazine and their derivatives used in antifungal activity against variety of microorganisms e. g. , *Candida albicans* and *Aspergillus fumigatus*, the risk factor of pulmonary candidiasis in patients. Phenazine also known as tubermycin B because its

antibiotic activity against *Mycobacterium tuberculosis*, which causing pneumonia and often fatal infections in susceptible patient population. Also, Allen et al. indicated that phenazine production leads to reduced chemokine and cytokine production by reduced neutrophil numbers and accelerated neutrophil apoptosis, which were associated with impaired bacterial clearance. Active proliferation of human lymphocytes was inhibited by pyocyanin. The development of synthetic anticancer phenazine derivatives was an ongoing area of research aimed at combining known phenazine biological activities with increased target specificity towards cancer cells.

Biomedical applications of biosynthesized gold nanoparticles from cyanobacteria

The smallest cellular life form, *Mycoplasma bacterium*, is around 200 nm in length. Nanoparticles have good in vivo stability and cell uptake efficiency, and are widely used for drug delivery. Metal/metal oxide nanoparticles can also simulate the activity of antioxidant enzymes and catalyze the degradation of superoxide anions and hydrogen peroxide. The degradation of metal/metal oxide nanoparticles releases metal ions and inhibits inflammation.

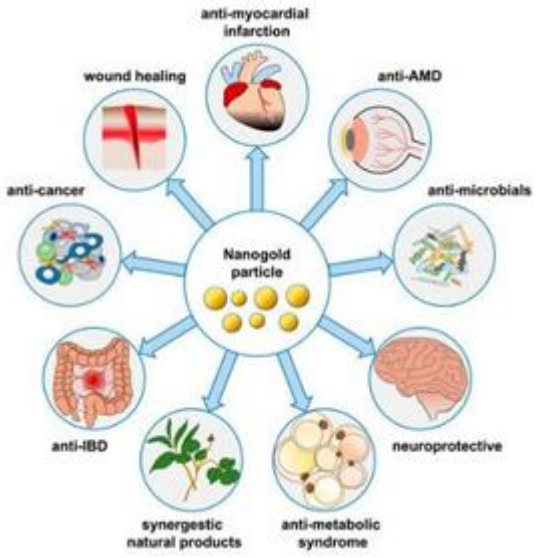


Figure 6: Physiological and pharmacological functions of nanogold in various organ systemsand diseases

Gold at the nanoscale level also exhibits special optical properties. With the difference in nanoscale, gold changes from red to purple. Gold nanoparticles, due to their excellent properties, such as easy synthesis, controllable size, specific surface plasmon resonance, and excellent biocompatibility, have shown fascinating feasibility for the treatment of various diseases.

Table 3: Summary of the effects and mechanisms of gold nanoparticles in disease

Diseases	Applications (Future) or Possible Actions Mechanisms
Cancer, pancreatic, breast, prostate, colon, melanoma, sarcoma, and lung cancers, etc.	Anti-cancer activity; cancer diagnosis; imaging applications; photothermal and photodynamic therapies; anti-cancer drug and gene delivery
Retinopathy age-related macular degeneration (AMD) diabetic retinopathy (DR)	Anti-angiogenesis; anti-inflammation; reduced the VEGF activation and induced cell; proliferation and migration
Skin disorders	Wound healing; acne; synergistic effect with natural products
Bowel diseases	Against inflammatory bowel diseases (IBD); alleviates the lipopolysaccharide-induced intestinal epithelial barrier dysfunction
Metabolic syndrome	Type 2 diabetes and obesity treatment; improvement in glucose intolerance and hyperlipidemia; lipolysis; more effects during liposuction
Cardiovascular diseases	CT imaging as CT contrast agents; anti-inflammatory biological activity; reduce arterial neointimal hyperplasia
Bone cartilage disorders	Rheumatoid arthritis treatment; Promotion and regulation of the differentiation; protection for bone and cartilage tissue; the inhibition of osteoclast; inhibit angiogenic activities, suppress inflammation or serve as antioxidant

Nanotechnology plays a major role in multilayer trends, particularly in the health and life sciences, with a focus on eco-friendly new techniques. Nanotechnology can encourage a newway to prevent hydrophobial, naturally occurring marine medicines with low water solubility using various microorganisms, including simple bacteria and highly complex eukaryote.

Nanotechnology is one of the fastest medical and industrial platforms which could be implemented using desirable methods which improve stability, bioavailability and solubility

Nanoformulated antiaging, antioxidants and anti-inflammatory creams or medicines have been developed with cyanobacterial secondary metabolites. Nanoformulations of anticancer agents were also provided owing to simplifying delivery in a diversity of cancer states.

Pathogenicity of pigmented microbes

Regardless of microbial pigments in various applications, some of the pigments produced by certain microorganisms are known to promote pathogenicity and virulence. On sheep blood agar, P. aeruginosa is often strongly beta haemolytic and can produce different diffusible pigments such as pyocyanin, a green coloured pigment.

Conclusion:

The bacterial pigments previously described in this review have high potential as novel biological compounds with diverse therapeutic applications, but there may still be a long way to go, so it becomes imperative to do a more in-depth study of each of these pigments. Based on their molecular aspects, behaviour and biosynthesis pathways with the purpose of a future scaling up and massification of these pigments in the industry. Clinically, we found prospective biomedical or behavioral studies on compounds/drugs and as synthetic. The advanced biotechnological techniques would open new avenues for large scale industrial production of natural pigments for various applications and to substitute the synthetic pigments. analogs, and derived from, and derived from isolated from marine cyanobacteria, which are designed to treat different diseases including treatments of different kinds from cancer, among them sarcoma, leukemia, lymphoma, liver, lung, kidney, prostate, and ovarian cancer. Finally, the composition of these pigments can be highly variable, which results in a wide range of compounds able to offer unique biological properties possibly still waiting to be discovered.

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DRAGONFLY AND DAMSELFLY DIVERSITY AND DISTRIBUTION IN AND AROUND PANVEL CITY, RAIGD, MAHARASHTRA (INDIA)

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Abstract:

The insects of the order Odonata serve as ecological indicators, and research indicates that some species have a strong correlation with particular ecological circumstances. In Navi Mumbai, Maharashtra State, India, Panvel City is one of the metro areas that is changing quickly. Several biological habitats are being affected as a result of urbanization and industry. There is no scientific study data about Odonata available particularly in this area. In the current study, a survey was conducted to determine Odonata diversity, and 15 species were reported, including two suborders, two families, and two subfamilies. The families *Libellulidae* and *Coenagrionidae* have been identified, with the *Libellulidae* dominating in this research region.

Keywords: Odonata, Dragonflies and damselflies, Species diversity, Panvel city, Biodiversity.

Introduction:

Dragonflies and damselflies are predatory insects that live in forests, fields, meadows, ponds, and rivers. They are distinguished by their lengthy bodies, expanded wings, and huge eyes (Manwar *et al.*, 2012). It initially appeared some 250 million years ago during the Carboniferous era, and contemporary groups of these insects originate from the upper Jurassic and Cretaceous eras (150-60 million years ago) (Shende and Patil, 2013). There are 5,952 odonate species known worldwide, with India having 474 species and 50 subspecies belonging to 142 genera and 18 families. (Subramanian, 2014). Odonates are excellent environmental indicators because they are sensitive to changes in habitat, ambient temperature, and meteorological conditions (Tiple, 2012). Odonata may be found in a wide range of habitats throughout the ecological gradient, from permanent flowing rivers and lakes to small transient rain puddles (Corbet, 1999). They have some habitat preferences, and their distribution is heavily engaged in diverse microhabitats (Sheldon and Walker, 1998).

Maharashtra is a state in central-western India that is rich in Odonata species due to its peculiar geographical location. Some species can withstand a broad variety of environmental circumstances, whilst others are extremely sensitive (Chovanec and Waringer, 2001; Schindler *et al.*, 2003; Chovanec *et al.*, 2004; Ameilia *et al.*, 2006; Smith *et al.*, 2006). Because the Odonata are habitat sensitive in India's Western Ghats, they are constrained to a small biological region (Subramanian 2007; Subramanian *et al.*, 2011).

A rise in anthropogenic activity in and around Panvel city disrupts the variety of Odonates. As a result, updated species occurrence data is required on a regular basis in order to develop specialized conservation strategies. This publication updates knowledge on the distribution of Odonates data and makes comments on the species' geographic distribution and dangers linked with them.

Materials and Methods:

Study area:

Panvel is a node of Navi Mumbai and is located in Maharashtra's Raigad district in the Konkan area. The coordinates for this location are: 18.990713, 73.116844. Panvel is located near Panvel Creek, which flows into Thane Creek. The Kalundre River flows through the city's south-west section and empties into Panvel Creek.

Figure 1: Location map of study area representing vicinity of Panvel City

Study Location:

The sampling areas for this study were chosen based on the availability of waterbodies, grasslands, and paddy fields. These places were chosen based on their strategic placement and various human activity.

Sampling and Identification:

The current investigation was conducted from June 2019 to May 2020. The study locations were polled on a monthly basis. Manual sampling was used, and only insect photography was done in their natural environment using a DSLR camera (Nikon d3500). Identification was carried out with available standard taxonomic literature Fraser (1933), Fraser (1934), Fraser (1936), Subramanian (2005) and Subramanian (2014).

Results and Discussion:

During our twelve-month inquiry, we discovered 15 species of the order Odonata, including two suborders, two families, and two subfamilies. The families Libellulidae and Coenagrionidae have been identified, with the Libellulidae dominating in this research region. This family has 14 species (95% of total species), while the Coenagrionidae family has only one Odonata (05% of total species). Among suborder Anisoptera (Dragonflies), total 12 species of Odonata such as *Orthetrum sabina sabina* (Drury), *Crocothemis servilia servilia* (Drury), *Pantala flavescens* (Fabricious), *Aethriamanta brevipennis, Brachydiplax sobrina, Acisoma panorpoides, Orthetrum Chrysis, Neurothemis Fulvia, Brachythemis Contaminata, Rhodothemis Rufa, Cratilla Lineata,* and *Neurothemis tullia* belonging to family Libellulidae and 03 species such as *Ceriagrion coromandelianum* (Brauer), *Ischnura senegalensis* and *Paragomphus Lineatus* belonging to family Coenagrionidae.

Odonata species' dominance may be ascribed to the abundance of marshy environments, bushes, and marshland. The abundance of the species Brachythemis contaminate shows that the water quality of the bodies of water is poor, and pollution from the research region may have also aided in the spread of this species. According to research, Brachythemis contaminate is a contaminated water dragonfly that may be seen in large numbers when sewage is released (Kulkarni and Subramanian, 2013). Due to their trophical evolutionary history and adaptations to temperate climates, dragonflies and damselflies are said to be suitable model insects for studying the impact of environmental warming and climate change (Hassall *et al.*, 2008).

A study of the diversity patterns of Odonata in Maharashtra province might provide insight into shifting climatic conditions and their impact on surrounding flora. Prasad (1996) has published the first exhaustive checklist of Odonata of Maharashtra State. The study of Odonata diversity patterns can provide insight into the changing climatic conditions caused by anthropogenic activities and their impact on adjacent flora.

Table 1: Checklist of Odonata species from in and around Panvel City during June 2019 to May 2020

Class	Order	Suborder	Family	Subfamily	Scientific name
Insecta	**Odonata**	Anisoptera	Libellulidae	-	*Orthetrum sabina sabina* (Drury, 1773)
		-	Libellulidae	_	*Crocothemis servilia servilia* (Drury, 1773)
		-	Libellulidae	-	*Pantala flavescens* (Fabricious, 1798)
		-	Libellulidae	-	*Aethriamanta brevipennis* (Rambur, 1842)
		-	Libellulidae	-	*Brachydiplax sobrina* (Rambur, 1842)
		Zygoptera	Coenagrionidae	-	*Ceriagrion coromandelianum* (Brauer)
		Anisoptera	Libellulidae	-	*Acisoma panorpoides* (Rambur, 1842)
			Libellulidae	-	*Orthetrum chrysis*
		Anisoptera	Libellulidae	-	*Neurothemis fulvia* (Drury, 1773)
			Libellulidae	-	*Brachythemis contaminate* (Fabricius, 1793)
			Libellulidae	-	*Rhodothemis rufa* (Rambur, 1842)
			Libellulidae	-	*Cratilla lineata* (Brauer, 1878)
		Zygoptera	Coenagrionidae	Coenagrion oidea	*Ischnura senegalensis* (Rambur, 1842)
			-	Gomphidae	*Paragomphus lineatus* (Selys, 1850)
		Anisoptera	Libellulidae	-	*Neurothemis tullia* (Drury, 1773)

Conclusion:

The ecology in and around Panvel is deteriorating at an alarming rate. The area around Panvel will be dominated by intensive industrialisation and urbanisation in the future years. In such circumstances, all sorts of pollution are growing day by day, with negative consequences for animal variety. Establishing the present Odonata checklist necessitates an effort to collect species occurrence data across a large region. This criterion is quite likely to change as additional data comes in from throughout the state. Because of overexploitation of vegetation, grassland affects the ecosystem and disturbs it, pushing species diversity to the brink of extinction. The destruction of the natural equilibrium of the environment has an impact on the animal food chain. This is main research to determine the number of species and to investigate the natural habitat that has been affected by anthropogenic activity in and around Panvel City.

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BIOPLASTICS: SUSTAINABLE ALTERNATIVE FOR CONVENTIONAL PLASTICS

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Abstract:

This chapter analyses field of environmental chemistry concerning bioplastics as sustainable alternatives to address increasing environmental concerns associated with traditional plastics. It explores various aspects, such as the types of bioplastics, including biodegradable, compostable, and bio-based plastics, their production methods, properties, and applications. The fate and biodegradation of bioplastics in different environmental compartments are analysed, considering factors like temperature, moisture, and microbial activity. Integrating bioplastics into waste management systems is discussed, considering its challenges and opportunities, including its impact on recycling and composting processes. The existing policies and regulations related to bioplastics are reviewed, and recommendations are provided to enhance frameworks supporting sustainable bioplastics' growth. Overall, this review offers insightful information on the ecological chemistry of bioplastics, underscoring their significance as environmentally friendly alternatives to traditional plastics. Continued research and efforts are crucial for promoting the sustainable production, use, and disposal of bioplastics.

Keywords: plastic, bioplastic, sustainable, pollution

Introduction:

The issue of plastic pollution has emerged as a significant environmental concern, as conventional plastics impose a wide range of detrimental impacts (Ghada *et al.,* 2021). Originating from fossil fuels, these plastics are non-biodegradable, resulting in their persistence in the environment for extended periods, often spanning hundreds of years. Improper disposal practices and inadequate waste management have led to the accumulation of plastic waste in landfills, oceans, and ecosystems worldwide. This alarming situation adversely affects marine life, terrestrial organisms, and overall ecosystem health. Urgent measures are required to address plastic pollution and mitigate its environmental impacts, necessitating the exploration of sustainable alternatives such as bioplastics (Chen, 2014).

Bioplastics offer promising solutions to the environmental challenges posed by traditional plastics. Derived from renewable resources, these materials are designed to be biodegradable, compostable, or bio-based, making them more environmentally friendly options (Saharan and Sharma, 2012; Venkatachalam and Palaniswamy, 2020). Bioplastics encompass various

polymers, including polylactic acid (PLA), polyhydroxyalkanoates (PHAs), and starch-based polymers, each exhibiting unique properties and applications (Shah *et al.*, 2021) Consequently, bioplastics find utility in various sectors, including packaging, agriculture, textiles, and biomedical applications.

Gaining a deep understanding of bioplastics' environmental chemistry is paramount in making informed decisions, developing effective policies, and promoting sustainable utilization of these materials (Chen, 2014). The findings and insights presented in this chapter can provide valuable guidance to industries, policymakers, and researchers in making well-informed choices regarding the adoption and advancement of bioplastics. Ultimately, promoting bioplastics can contribute to establishing a more sustainable and circular economy, reducing the ecological footprint associated with conventional plastics.

Types of bioplastics

- **Biodegradable bioplastics**

  Among the various types of bioplastics, biodegradable bioplastics offer a promising solution to address environmental concerns. These innovative materials are designed to naturally break down over time through microbial action or enzymatic breakdown processes (wikipedia.org). Examples of biodegradable bioplastics include polylactic acid (PLA), polyhydroxyalkanoates (PHAs), and polybutylene succinate (PBS). What makes these bioplastics particularly appealing is their ability to degrade into smaller fragments, ultimately transforming into carbon dioxide, water, and biomass under appropriate conditions. Biodegradable bioplastics find practical applications in single-use items like food packaging, disposable cutlery, and agricultural films, aligning with their intended usage duration (Kumar *et al.*, 2014).

- **Compostable bioplastics**

  Compostable bioplastics represent a specialized category within the biodegradable bioplastics' family, designed to undergo degradation under specific conditions typically found in industrial composting facilities. These bioplastics meet recognized composability standards, such as the European EN 13432-2000 or the American standard ASTM D5338-98 (Benzirhn *et al*., 2015). Certain types of polylactic acid (PLA) fall into this category. When placed in a controlled composting environment, these compostable bioplastics break down into carbon dioxide, water, and compost with a composition similar to humus. Compostable bioplastics find applications in food service ware, agricultural mulch films, and compostable packaging, where they contribute to diverting organic waste and facilitating the production of high-quality compost (Kumar *et al.*, 2014).

- **Bio-based bioplastics**

  Bio-based bioplastics are derived from renewable resources, primarily plant-based feedstocks, offering a sustainable alternative to traditional plastics derived from fossil fuels (Kuruppalil, 2011; Saharan and Sharma, 2012). Polymers such as polylactic acid (PLA), polyhydroxyalkanoates (PHAs), and polyethylene furanoate (PEF) fall under the category of bio-based bioplastics. The advantage of these materials lies in reducing reliance on finite fossil fuel resources, resulting in a lower carbon footprint. Bio-based bioplastics have versatile applications in various sectors, including packaging, textiles, automotive components, and consumer goods (Kumar *et al.*, 2014). However, it is essential to consider the overall environmental impact of bio-based bioplastics, considering factors such as land use, energy consumption during production, and potential indirect land-use change effects (Marjadi *et al.*, 2010).

- **Hybrid bioplastics**

  Hybrid bioplastics represent an exciting development combining the benefits of biodegradable or compostable polymers with conventional plastics to enhance performance while retaining desired properties. These resources attempt to achieve a balance between the advantages offered by traditional plastics and the environmental benefits of biodegradable alternatives (Onovo *et al.*, 2022). Hybrid bioplastics incorporate biodegradable or compostable components, resulting in improved ecological profiles without compromising necessary properties such as durability, flexibility, or barrier properties required for specific applications. For example, blends of bio-based polymers like PLA with petroleum-based plastics fall into hybrid bioplastics. They find potential applications in flexible packaging, agricultural films, and durable goods, where balancing performance and environmental considerations are crucial (Zhang *et al.*, 2023).

Limitations and challenges:

Despite their potential environmental benefits, bioplastics face certain limitations and challenges. One challenge lies in the availability of suitable feedstocks, such as crops or waste streams, which can pose issues related to resource availability, land use competition, and potential impacts on food security. Additionally, the performance characteristics of bioplastics, including mechanical strength, thermal stability, and barrier properties, may not always match those of conventional plastics. Ongoing research and development efforts are necessary to improve the properties of bioplastics and bridge the performance gap. Proper disposal and management of bioplastics also present challenges, necessitating separate waste collection systems and establishing appropriate treatment infrastructure to ensure their effective utilization and environmental advantages are realized.

Environmental fate and biodegradation

- **Fate of bioplastics in soil**

  The environmental fate of bioplastics in soil depends on various factors, including polymer composition, soil type, temperature, moisture content, and microorganisms. Studies have shown that some biodegradable bioplastics, such as PLA and PHAs, can undergo degradation in soil environments (Mo *et al.*, 2023). Microorganisms in the soil produce enzymes that break down the polymer chains, leading to the biodegradation of bioplastics. The biodegradation rate can vary significantly depending on environmental conditions, with warmer and moister soils generally promoting faster degradation (Bizukojc, 2021).

- **Fate of bioplastics in water bodies**

  When bioplastics enter aquatic environments, their fate and degradation pathways can differ from soil ones. Water temperature, pH, oxygen levels, and UV radiation influence the degradation process. Biodegradable bioplastics can undergo hydrolysis, where water molecules break the polymer chains into smaller fragments. These fragments may then be further degraded by microorganisms in the water or sediment. The degradation rates can vary depending on the bioplastic, water conditions, and microbial activity (Vijyanand *et al.*, 2023).

- **Fate of bioplastics in waste management systems**

  The fate of bioplastics in waste management systems, including composting and anaerobic digestion, is an essential consideration for their sustainable disposal. Compostable bioplastics, designed to degrade in industrial composting facilities, undergo controlled degradation under specific conditions, including temperature, moisture, and microbial activity. The process results in the conversion of bioplastics into carbon dioxide, water, and compost. In anaerobic digestion, bioplastics can be broken down by microorganisms without oxygen, producing biogas as a by-product (Liu and Zhang, 2019; Abraham *et al.*, 2021).

Biodegradation

- **Factors influencing biodegradation**

  Several factors influence the biodegradation of bioplastics, including environmental conditions, polymer composition, and the presence of additives or fillers. Temperature and moisture levels significantly impact the biodegradation rate, with optimal conditions varying for different bioplastics. The chemical structure and crystallinity of the polymer can affect its susceptibility to degradation. Additives, such as plasticizers or flame

retardants, may hinder biodegradation and require specific considerations for their environmentally friendly disposal (Jones, 2023).

- **Monitoring biodegradation**

  Monitoring the biodegradation of bioplastics is essential for assessing their environmental performance. Techniques such as gravimetric analysis, spectroscopic methods, and molecular processes can be employed to track changes in bioplastic mass, chemical composition, and microbial communities during biodegradation (Jones, 2023). Long-term monitoring studies in various environmental settings provide valuable insights into the rate, extent, and mechanisms of biodegradation for different bioplastics.

- **Implications of biodegradation products**

  The breakdown products of bioplastics during biodegradation can have implications for the environment. These degradation by-products, such as monomers, oligomers, or smaller fragments, may persist in the background and potentially have ecotoxicological effects. Understanding the fate and toxicity of these degradation products is crucial to assess the overall environmental impacts of bioplastics and ensure their safe implementation.

Ecotoxicological impacts

- **Aquatic ecotoxicity**

  The potential ecological impacts of bioplastics on aquatic ecosystems have garnered significant attention regarding their toxicity to various marine organisms, including algae, zooplankton, fish, and benthic organisms (Vijyanand *et al.,* 2023). While some studies have reported minimal or no adverse effects, others have indicated possible consequences such as altered behaviour, growth reduction, reproductive disruptions, and changes in community structure. Factors like polymer type, degradation rate, exposure concentration, and the organisms' sensitivity influence bioplastics' ecotoxicity.

- **Terrestrial ecotoxicity**

  The ecological ramifications of bioplastics in terrestrial environments have also been investigated. Research has focused on assessing the effects of biodegradable and compostable bioplastics on soil organisms, plants, and terrestrial invertebrates (13). Findings have demonstrated varied impacts, including alterations in soil microbial communities, changes in plant growth, and potential effects on soil-dwelling organisms. The ecotoxicity of bioplastics in terrestrial ecosystems is influenced by factors such as the composition of the polymer, rate of degradation, type of soil, and duration of exposure (Vijyanand *et al.*, 2023).

- **Microplastics and bioaccumulation**

  Microplastics, which arise from the degradation of bioplastics and encompass fragments and fibres, has raised concerns due to their potential accumulation in organisms and transfer through the food chain. Aquatic organisms, especially those that filter feed, may ingest microplastics, (Shruti *et al.,* 2019), resulting in their collection and associated additives. The possibility of microplastic transfer through different trophic levels and the subsequent effects on higher organisms like fish and other marine species is an ongoing area of investigation. Understanding the ecological implications of microplastic pollution resulting from the degradation of bioplastics is crucial for comprehensively assessing their environmental impact.

- **Knowledge gaps and future research**

  Despite the growing body of research on the ecotoxicological impacts of bioplastics, several knowledge gaps still need to be discovered. Long-term studies encompassing different environmental compartments and a wide range of organisms are necessary to understand the environmental risks associated with bioplastics. Further investigation is needed to comprehend the fate and effects of biodegradation products, particularly microplastics. Additionally, it is crucial to elucidate the interactions between bioplastics and other environmental stressors to assess the real-world implications accurately. Future research should also focus on developing sustainable and non-toxic alternatives to plastic additives and fillers used in bioplastics.

- **Life cycle assessment methodology**

  Life Cycle Assessment (LCA) systematically evaluates a product's or process's environmental impacts across its entire life cycle (Hobbs *et al.,* 2021). It encompasses various stages, including raw material extraction, manufacturing, use, and disposal. LCA provides a comprehensive framework to assess bioplastic's environmental burdens and benefits by considering impact categories such as greenhouse gas emissions, energy consumption, resource depletion, water usage, and ecotoxicity. This holistic perspective enables a thorough understanding of the environmental performance of bioplastics. LCA studies have been conducted to analyse the environmental performance of bioplastics in comparison to conventional plastics (Roijen *et al.,* 2022). These assessments consider bioplastic type, feedstock sourcing, manufacturing processes, transportation, and end-of-life scenarios. The findings of LCA studies indicate that the environmental impacts of bioplastics can vary based on variables such as energy sources during production, waste management efficiency, and specific applications. LCA serves as a valuable tool for

identifying critical areas within the life cycle of bioplastics and aids in decision-making for more sustainable material choices (Ali *et al.,* 2021).

Bioplastics in waste management

- **Challenges in waste management**

  Waste management presents significant challenges, with conventional plastics contributing to global plastic pollution and landfill accumulation. Bioplastics offer potential solutions by providing alternatives designed to be biodegradable, compostable, or recyclable. By incorporating bioplastics into waste management practices (Liu and Zhang, 2019), it is possible to reduce the environmental impact of plastic waste and foster a more sustainable approach to plastic disposal.

- **Bioplastics and recycling**

  Bioplastics can be integrated into existing recycling systems, which are compatible with the infrastructure and processes (Fredi and Dorigato, 2021). Certain bioplastics, such as bio-based PET or bio-based polyethylene, can be recycled through conventional plastic recycling channels. However, challenges arise due to the chemical and physical properties differences between bioplastics and conventional plastics. Proper sorting and labelling systems are crucial to enable the effective recycling of bioplastics and prevent contamination of recycling streams.

- **Composting bioplastics**

  Compostable bioplastics are specifically designed to degrade in industrial composting facilities, producing nutrient-rich compost. These bioplastics undergo controlled degradation under specific temperatures moisture, and microbial conditions. Composting bioplastics requires suitable infrastructure and composting facilities to provide the conditions for efficient degradation (Song *et al.,* 2009). This composting process offers a sustainable end-of-life option for bioplastics, contributing to the production of compost that can be used in agriculture and landscaping.

- **Anaerobic digestion of bioplastics**

  Another waste management option for bioplastics is anaerobic digestion. Microorganisms break down bioplastics without oxygen, generating biogas, primarily methane (Batori *et al.,* 2018). This biogas can be utilized as an energy source, reducing greenhouse gas emissions and dependence on fossil fuels. Anaerobic digestion provides a renewable energy recovery pathway for bioplastics, contributing to a circular and sustainable waste management system (Vardar *et al.,* 2022).

- **Advancing towards a circular economy**

  Integrating bioplastics into waste management aligns with the principles of a circular economy. A circular economy approach minimizes waste generation, maximizes resource efficiency, and promotes material reuse, recycling, and composting. When effectively managed within a circular economy framework, bioplastics can contribute to reducing plastic waste, shifting to a more sustainable way of using natural resources and a resilient waste management system (Rosenboon *et al.*, 2022).

- **Regulations for waste management and recycling**

  Regulations governing waste management and recycling are instrumental in establishing the necessary infrastructure and processes for effectively handling bioplastics throughout their life cycle. These regulations address critical aspects such as collecting, sorting, and treating bioplastic waste, ensuring appropriate disposal, recycling, and composting. They may also incorporate extended producer responsibility (EPR) measures, holding manufacturers accountable for the post-consumer phase of bioplastics and promoting their sustainable management (Abraham *et al.*, 2021; Fredi and Dorigato, 2021).

Future perspectives and research directions:

- Advancements in Bioplastics

  Bioplastics is continuously evolving, with ongoing research and development endeavours to enhance bioplastic materials' performance, sustainability, and end-of-life options (Atwesh *et al.,* 2021). Potential bioplastic developments include exploring novel feedstocks, such as algae or waste biomass, that offer improved environmental benefits and reduce competition with food crops. Additionally, advancements in bioplastic processing techniques, such as the incorporation of bio-based additives and biodegradable options, have the potential to expand their applications and improve their functionality (Saharan and Sharma, 2012; Venkatachalam and Palaniswamy, 2020).

- **Enhancing performance and functionality**

  To drive broader adoption and market acceptance, future research should prioritize enhancing the performance and functionality of bioplastics. This includes improving their mechanical properties, thermal stability, barrier properties, and compatibility with existing manufacturing processes (Benzirhn *et al*., 2015). Innovation in bioplastic formulations and processing techniques makes it possible to develop materials that demonstrate comparable or superior performance to conventional plastics while retaining their environmental advantages.

- **Sustainable sourcing of feedstocks**

  The sustainable sourcing of feedstocks for bioplastics is a critical area for future research. Efforts should explore alternative feedstock options that minimize land use, water consumption, and deforestation. This may involve investigating non-food-based sources, utilizing agricultural and industrial waste streams, and promoting regenerative farming practices. Research should also emphasize optimizing resource efficiency, reducing the environmental impact associated with feedstock production, and evaluating the social and economic sustainability aspects of bioplastic feedstock sourcing.

- **Biodegradation in realistic environments**

  Gaining a better understanding of the biodegradation behaviour of bioplastics in realistic environments is essential for assessing their environmental fate and potential impacts (Ruggero *et al.*, 2019). Future research should study the kinetics, mechanisms, and by-products of biodegradation for bioplastics under various conditions, including soil, marine, and freshwater environments. This research can inform the development of standardized testing protocols and predictive models that assess biodegradability and the potential ecological effects of bioplastics in real-world scenarios.

- **Life cycle assessment and environmental impact analysis**

  Continued advancements in life cycle assessment (LCA) methodologies are necessary to evaluate bioplastics' environmental performance comprehensively. Future research should focus on refining LCA models and improving data collection methods, taking into account regional and sector-specific variations. This includes updating impact categories, enhancing data availability and quality, and considering the dynamic nature of waste management systems. Additionally, conducting comparative LCAs between bioplastics and conventional plastics can provide insights into the sustainability benefits and trade-offs associated with bioplastic alternatives (Samir Ali *et al.*, 2021; Roijen *et al.*, 2022).

Conclusion:

In summary, the field of environmental chemistry has made notable advancements in the field of bioplastics, offering sustainable alternatives to conventional plastics. This comprehensive chapter has covered various aspects of bioplastics within environmental chemistry, including their types, ecological fate, biodegradation, ecotoxicological impacts, life cycle assessment, waste management, policy and regulatory frameworks, prospects, and research directions.

Bioplastics hold significant promise in addressing the environmental challenges posed by traditional plastics. They can reduce dependence on fossil fuels, lower carbon emissions, and alleviate plastic waste accumulation. However, it is crucial to consider the specific characteristics

and properties of different types of bioplastics, as they can vary in terms of biodegradability, composability, recyclability, and environmental impacts.

A thorough understanding of bioplastic's environmental fate and biodegradation is essential for assessing its potential impacts on ecosystems. Studies on biodegradation in realistic environments are necessary to determine degradation rates, by-products, and effects on soil, water, and marine systems. Additionally, comprehensive life cycle assessments play a vital role in evaluating the overall environmental performance of bioplastics and identifying opportunities for improvement throughout their life cycle.

The successful integration of bioplastics into waste management systems requires the development of appropriate infrastructure, adequate labelling and sorting techniques, and collaboration among stakeholders. Recycling, composting, and anaerobic digestion present potential pathways for managing bioplastics, but challenges exist due to variations in material properties and the need for dedicated facilities.

Policy and regulatory frameworks play a crucial role in shaping the sustainable development and management of bioplastics. Establishing labelling and certification standards, waste management regulations, and sustainability criteria guide the responsible use and disposal of bioplastics. International cooperation and harmonization are vital to creating consistent frameworks and minimizing trade barriers.

Looking ahead, research efforts should focus on emerging bioplastics, their integration into the circular economy, performance enhancements, sustainable sourcing of feedstocks, understanding biodegradation in realistic environments, advancing life cycle assessment methodologies, and promoting education and consumer awareness. These research directions will contribute to developing more sustainable bioplastic materials, efficient waste management systems, and informed decision-making by consumers and policymakers.

To conclude, bioplastics offer significant potential as environmentally friendly alternatives to conventional plastics. Continuous research, innovation, and collaboration will be vital in reducing plastic pollution, mitigating environmental impacts, and facilitating the transition toward a more sustainable and circular economy.

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Ecology Research Volume V

ISBN: 978-93-91768-57-7

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ISBN 978-93-91768-57-7
9 789391 768577