Advances In Science & Technology

Editors

Dr. Premkumar Gautam

Dr. Sunil Sangale

Dr. Janhavi Bhagwat

Dr. Kulbhushan Sasane

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Editors

Dr. Prem Kumar Gautam
Associate Professor and Head
P.G. & Research Department of Botany
NTVS'S G.T. Patil College, Nandurbar – 425412 (M.H.).

Dr. Sunil Sangale
Assistant professor
Department of Botany,
Government Institute of Science
Aurangabad – 431004 (MH) India

Dr. Janhavi Bhagwat
Assistant Professor
Department of Zoology
Ramniranjan Jhunjhunwala College of Arts, Science
and Commerce (Empowered Autonomous)
Ghatkopar West, Mumbai- 400086 (MH) India

Dr. Kulbhushan Sasane
Assistant Professor
Rayat Shikshan Sanstha,
Abasaheb Marathe Arts & New Commerce Science College
Rajapur, Ratnagiri- 416702 (MH) India

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Email: naturelightpublications@gmail.com
Contact No: +91 9822489040 / 9922489040

Preface

We are happy to welcome the idea of publishing a book on relevant topic, ***"Advances in Science and technology".*** *Further, it is good that the articles from various sub-disciplines are included in the book. The scholars from different science and technology have attempted to identify the current research and to provide ideas to doing the recent study and different recent techniques and tool arise in science these are included in the book "Advances in Science and technology"*

The Biological Resource Management Strategies and Addressing a Global Problem with its Protections, Fourier Transformation and its Application in Science and Engineering Field, Cropping Pattern, Environmental Setting, Exploring The Spectrum of Cardiovascular Diseases and Effective Prevention, Soil testing of different parameters, Stem cells: and its future aspects, Role of Renewable Energy in Sustainable Development, Revolutionizing Cancer Care with Immunotherapy, Unraveling CRISPR-Cas Systems etc.

This exhibits how variety of topics have been discussed in this edited book. The book provides open forum for the scholars and even graduate students to discuss further so that they can think about strategic planning to use emerging strategies in sciences.

Renowned researchers, scientists, educators, and business professionals have contributed pieces to the book. We would especially want to express our gratitude to the researchers and specialists whose contributions have made this book better.

Date: *30 October 2024*

Editors

Advances in Science and Technology

Table of Content

ADVANCES IN SCIENCE AND TECHNOLOGY

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Biological Resource Management Strategies and Addressing a Global Problem with its Protections

Phool Gend Kumar

Department of Zoology, Brahmanand P.G. College, Chhatrapati Shahu ji Maharaj University, Kanpur, UP- 208001

Email: gpgyadav545@gmail.com

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Abstract

The effective Biological Resource Management (BRM) strategies are crucial for conserving and sustainably utilizing living resources, addressing global environmental challenges Global environmental degradation, biodiversity loss and climate change necessitate innovative BRM approaches. The increasing demand for natural resources threatens ecosystem balance and human well-being. For biological resource management it should be Develop innovative technologies, enhance public awareness, strengthen policy frameworks, foster international collaboration and address emerging challenges. The strategies should be based on, by protecting habitat, species, prey predator, hunting and wild life management. International organization is already involved in attempting to identify and protect critical natural areas worldwide. The international Union for Conservation of Nature and Natural Resources (IUCN) is heading and international efforts to establish a world system of reserves and to improve ecosystem management.

Keywords: BRM, Biodiversity, Threatens Ecosystem, Degradation, and IUCN.

Introduction:

Biological resource management refers to the sustainable use, conservation, and protection of living organisms, such as plants, animals, and microorganisms, to maintain ecosystem health and support human well-being. Effective management strategies are crucial to ensure the long-term availability of these resources. Biological resources management refers to the organized management and utilization of natural resources in the agricultural and aquatic sectors. It involves the interaction between humans and the surrounding natural environment to achieve specific goals in production and economic activities. The management system in the agricultural sector requires a combination of state regulation and self-regulation based on entrepreneurship, market competition, property rights, and

environmental safety. In the aquatic ecosystem, bio resources such as plankton, fishes, and macrophytes play a crucial role in maintaining the stability and functioning of the ecosystem. They act as bio indicators of pollution and are responsible for maintaining the food chain. Additionally, bio resource management systems can be implemented to efficiently manage and store biological resources, such as blood, blood plasma, and laboratory animals, ensuring their proper use and availability. The conservation and sustainable use of biological diversity and genetic resources are also important aspects of bio resource management for the welfare of present and future generations.

Good management of forest or other plants life and of wild life begins with good management of the land. In the most basic forms, good management of land means keeping land in place. This is an obvious part of good farm land management, but good land management is just as important to a continued good harvest of trees year after year. Management by those involved in construction of highways, buildings, or homes is also important to protect streams from sediment runoff and to leave some soil for land scraping purposes.

Fertile land produce healthy plant life, which is provides various kind of benefits such as food, cover, and habitat for wild life. A good management means replacement of land or disturbance of land for beneficial purposes but it can be reversed as soon as possible. But keeping in mind always restoring land in its original forms.

Management of resources:

There are many ways to manage the biological resources, by managing habitat management, wild life management etc. but management strategies are described here.

Habitat management:

A very positive role in the maintenance of certain habits and consequently in the support of certain wild life species. Forest fire has been around much longer than humankind. Fires caused by lightning are natural phenomenon that serves to clear out dead forest debris. At the same time. Fire provides a mechanism for a rapid return of nutrients to the soil.as material burns; it releases carbon dioxide and water, and result in a surge of nutrients remains as ash. Destruction by fire results in a surge of nutrients for the next generation. Fire also allows for reestablishment of some sun- tolerant species.

Burning of prairie land is another example of fire helping to maintain an ecosystem, because these areas are grazed so closely today, such fires are less likely to occur.

Wild life management:

Wildlife management involves the conservation, protection, and sustainable use of wildlife populations and their habitats. Effective management ensures the long-term survival of species, maintains ecosystem balance, and supports human well-being. Species are managed indirectly by good land and habitat management; population can also manage directly. Best wild life management includes the production and protection and harvesting of game species, the maintenance of non-game species, and the control of certain species in certain locations. The roles of

predator and hunting in wildlife species management. There are many ways to manage wildlife, some strategies are given below:

- Habitat preservation and restoration
- Population control (hunting, culling)
- Species reintroduction
- Wildlife corridors and connectivity

Human-wildlife conflict mitigation techniques (fencing, compensation schemes)

Predator control: Predator control is a crucial aspect of wildlife management, aiming to maintain ecological balance and protect vulnerable species. Objectives of Predator Control are:

- Protect endangered or threatened species
- Maintain ecosystem balance
- Prevent overgrazing and habitat degradation
- Reduce human-wildlife conflict
- Support sustainable hunting and fishing practices

A prime example of modern-day attitude towards predators is the controversy over coyotes in the west. Many ranchers are convinced that coyotes are costing them millions of dollars by attaching their herds. other believe that coyotes only cull the old and sickly from herds or that only a few individuals' coyotes in certain areas are to blame and not the whole species. Nevertheless, large poisoning campaigns were conducted in the 1960s.they succeeded in killing not only coyotes but also prairie dogs, eagles, and vultures. Poisoned bait was eaten indiscriminately by many species, not just the target species or the individual animals causing the problems, some of poisons such as "1080" (sodiumfluoroacetate) were distributed in dead carcasses. Not only the animal that is the carcass died but also any animal that fed on the animal that is the carcass.

The above problems short out by establishing a committee; this committee headed under the control of Aldo Leopold's son, Starkar. The committee adopted two principals regarding predator control.it concluded that all native animals should be local and aimed at individual animals causing the problem. However, it was not until 1972 that the coyotes-poisoning campaigns were prohibited on public land, even now the attitudes expressed by Leopold's group have not fully taken hold in predator management and in the minds of the public, in late 1983 the ban on "1080" was modified to allow its use in single lethal doses.

Other Examples of Successful Predator Control Programs:

1. Wolf management in Yellowstone National Park
2. Coyote control in the Great Plains
3. Lion conservation in Africa
4. Shark mitigation in Australia
5. Bear management in North America

Hunting:

Hunting control is a crucial aspect of wildlife management, aiming to maintain healthy wildlife populations, conserve species, and ensure sustainable hunting practices. Effective hunting control requires a comprehensive approach, considering ecological, social, and economic factors. By balancing human and wildlife interests, we can ensure sustainable hunting practices and conserve wildlife populations for future generations.

Hunting regulation is a necessary action should be taken by government as well

as local level because hunting is not a game, it may cause various ecological imbalances in the environment and leading to destruction of food chain and food web, which ultimately it results biological resources destructions.

Hunting Control Methods: there are many methods for controlling hunting, but only methods are given below:

- Licensing and permitting systems
- Harvest monitoring (reporting requirements)
- Enforcement patrols
- camera traps and surveillance
- Biological sampling (age, sex, and population analysis)
- Habitat management (habitat modification, restoration)
- Education and outreach programs

Species protection and the law:

Endangered species act passed by Congress in 1973.this act listed endangered or threatened species. The act also provides that federal agencies may not proceed with or initiate projects that "jeopardize the continued existence" of endangered or threatened species. This includes private project utilizing federal monies or requiring federal permits. Serious challenges to the effectiveness of the act occurred early on .it pitted the small snail darter fish against Tellico dam. In 1975 the snail darter becomes listed as an endangered species. This fish is adopted for running water but when dam manufactured then this fish survival become more dangered.so that in June 1978 the Supreme Court ruled in favor of the snail darter and against the TVA.as a result of this and other controversies, congress amended the endangered species act to establish a special committee to resolve such conflicts.

In january1979 this committee also ruled in favor of the snail darter and against completion of dam, so all committee and court decision the congress passed legislation exempting the Tellico dam from the endangered species act and funded the dam's completion. The provision was attached as an unobtrusive amendment to an appreciations bill for energy and water projects. In late 1979 the gates of the dam were closed and reservoir to fill.

In 1987 the 100th congress reviewed the endangered species act. Conservation wanted to see some changes that would strengthen the law. They wanted criminal penalties for anyone who takes a threatened or endangered plants. More than 900 species are now listed as endangered.

And at least 1000 species are waiting to be evaluated for listing by the DOI or, in case of marine species, by the department of commerce.

Species preservation: There are many efforts are taken to save individual species the California condor and the red wolf are two such examples. The condore, a huge bird with a wing span almost 10 feet wide, has been around since the ice age. It once ranged through the western United States. Loss of habitat, hunting, lead shot, egg collectors, utility power lines, oil sumps, and pesticides all have contributed to the demise of the condor (Nielson, 1987). In the late 1930s there were about 100 condors in existence. In 1985 there were 26 condores in captivity and one in the wild known as AC-9 (Adult Candor-9). there are two approaches involved to save candor, such as hands-off approach by protecting its habitat and other was a

hand-off approaches de-signed to save the candor solely by protecting it habitat. The second example was red wolf is another species preservation story (Bass, 1987; Cohn, 1987). It the story of the return of a near-extinct species to its natural habitat. The red wolf once roamed wild through-out the southeastern united states.it is smaller than the gray wolf but larger than the coyote, both are closely related species. red wolves are not all red in color; they may vary from black to cinnamon to gray. The decline of the red wolf was the result of varieties of factors including hunting for bounties, poisoning by U.S.government- supported programs, and loss of forest habitat.in 1977 the fish and the wildlife services established a recovery plan. there are breeding program between red wolf and coyote but no characters are arising in the red wolf of coyote. this breeding program runs in the several years. but hybrid wolf stigma of predator remains. Finally, in 1987, four pairs of red wolves bred in captivity were released in the Alligator River National Wildlife Refuge in North Carolina. The wolves lived in pens at first to acclimate them to their new surroundings. A dry dog food diet was replaced by red meat and eventually by live prey. Zoos play an important role in the survival of endangered species; zoos provide one important part of the effort to save endangered species; they are not the ultimate solution.

Habitat Protection:

Some General Considerations. There are some who argue that all of the money, time, and effort being put into saving a single species could be better spent saving large expanses of habitat and in that process, large numbers of species. The problem of biological diversity can be addressed on many levels from ecosystem and community to population and species. Some think "emergency room conservation" puts large monetary resources into a few species whose chances of survival are minimal anyway (Scott et al., 1987). Perhaps we should concentrate on preserving and restoring types of habitats rather than individual species.

As we have already mentioned, loss of tropical rain forests threatens two thirds or more of the species on earth. We cannot explore and discover all of the species in the tropical rain forest as fast as they are disappearing. The immediate solution is to find those undisturbed areas of greatest species diversity and work to protect them. Computer mappings and models along with data from remote sensing satellites can be applied toward finding those areas most in need of protection now. There are, for example, fairly good data available on the distribute of known vertebrates. Distribution maps can be overlaid with maps of existing habitat preserve areas and potential preserve areas (Scott et al, 1987).

Restoration of Habitat:

While efforts to protect existing habitat are underway worldwide, other efforts are underway to attempt to restore native habitat that has already been lost. Restoration of habitat is not an easy undertaking. In some cases, natural vegetation must be planted in the normal sequence of successional stages to prepare the area for the climax vegetation. In some habitats fire is encourage in prairie areas, for example- while in others the habitat must be protected from fire or others the habitat

must be protected from fire or other human made disturbances.

Habitat Preservation: *Wetlands*

As the significance of wetlands has come to be realized, efforts have been made to protect them. There are several U.S, laws that bear on wetland protection.

The Coastal Zone Management Act:

Encourage states to protect coastal wetland by providing grants to states for developing and implementing coastal management plans. The act also established and Estuarine Sanctuaries System. About 18 or so such sanctuaries have been established with 50% matching grants available to states from the federal government (Council on Environment Quality, 1987).

The 1986 Emergency Wetlands Resources Act provided $40 million a year for wetland purchase. The Fish and Wildlife Service is to established wetland acquisition priorities. Acquisitions from public and private sources are not expected to be able to protect nearly the number of wetlands that should be protected.

There are several other acts that have some impact on wetland protection is section 404 of the Clean Water Act. Section 404 requires that any person must have a permit from the corps of engineers to discharge dredged or fill material into the waters of the United States. Although use of section 404 has been somewhat successful in protecting coastal wetlands, it has not been so useful in protecting inland wetlands which make up the bulk of remaining wetlands in the United States (Tripp, 1986). There are several reasons for this. There is some controversy over what extent section 404 can be used on inland wetlands. New development and construction activities are definitely covered by the section. Normal farming and time bearing activities are not covered unless they in clude discharges that will restrict the flow of U.S. water (Baldwin, 1987). Eighty percent of wetland loss has been related to conversion of wetland to farmland according to the U.S fish and wild life service (Tripp, 1986). Draining, excavating, or flooding of wetlands is not explicitly addressed in section 404.

In 1984 the Corps of Engineers received 11,000 applications for section 404 permits. About 3% of the applications were denied, 44% were withdrawn, and the remainder was issued (Platt, 1987). About half of the permits that were issued modified the original application in some form. The U.S. office of Technology Assessment (OTA) concluded in a 1984 study that 50,000 acres of wetlands are saved annually, primarily by modifications required by the section 404 permit process (Platt, 1987). The OTA notes, however, that there are variations in districts regarding permit denials.

To Issue a Section 404 permit, the Corps of Engineers is bound by guidelines issued by the U. S. environmental protection agency. The guidelines provide that no permit shall be issued if there is a practicable alternative that will not affect the aquatic environment. Consequently, permits to fill wetlands for projects that are just as suitable on non-wetlands should not be issued in most cases (Platt, 1987). However, all of this is open to interpretation. Often the interpretation of the EPA and of the corps does not coincide. The EPA can

veto the issuance of permit if it finds that the activity would have an adverse impact on water supplies, fish and wildlife or recreation. In 1986 an office of Wetlands was create in the EPA to better carry out their responsibilities in regard to section 404.

Addressing a Global Problem:

In 1985 an international plan sponsored by the World Bank, the World Resources Institute, and the U.N. Development Programme estimated a cost of $8b billion over five years to stem tropical forest deforestation. The report, Tropical Forests: A Call for Acton set out specific recommendation for action in 56 countries. Five issues are included in the report: fuel wood and agroforestry land use on upland watersheds; forest management for industrial uses; conservation of tropical forest ecosystem and strengthening institutions for research, training, and extension. This is a promising sign that the world community is beginning to realize its responsibilities in regard to addressing tropical reforestation. A new policy established by the World Bank in 1986 focused on a commitment to protect wild land in the projects it selects to receive World Bank financial assistance. The policy states that the World Bank will not finance projects in most cases the convert lands for exceptional biological diversity or environmental significance; where possible projects will be sited on already converted land; where this is not possible, sites of lesser wild land value will be selected. Where significant natural areas are converted, and ecologically similar areas will be preserved elsewhere. The World Bank cites the value of retaining wild lands as economically beneficial in regard to drought and flood control, agriculture, tourism, fisheries, and conservation of biological diversity (Fitzgerald, 1986). Good environmental management is good economic management as well. The significance of an economic and development-oriented group like the World Bank issuing such a policy certainly helps drive this point home.

General international organization is already involved in attempting to identify and protect critical natural areas worldwide. The international Union for Conservation of Nature and Natural Resources (IUCN) is heading and International efforts to establish a world system of reserves and to improve ecosystem management. Nations that are party to the convention concerning the protection of the world cultural and natural heritage have designated 57 natural sites as world heritage sites.

The Man and the Biosphere Program (MAB) is an intergovernmental organization established through the U.N. Educational, Scientific and cultural organization (UNESCO) to focus research technical training and public education of the whole world biosphere. In its most basic form, the purpose of MAB is to study the earth's ecosystems and how we relate to them. The work of MAB is coordinated by an international council composed of representatives from 30 nations elected by the UNESCO General Conference.

Conclusions:

- Integrated approaches considering ecological, social, and economic factors are crucial.
- Local communities must be involved in BRM decision-making.
- Science-based policies and regulations are essential.

- International cooperation is necessary for global issues.
- Continuous monitoring and adaptation are vital.
- Effective Biological Resource Management is critical for addressing global environmental challenges, ensuring sustainable development, and preserving life on Earth.

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Study on Fourier Transformation and its Application in Science and Engineering Field

Santosh C. Rudrawar

Dept. of Mathematics, Siddharth College Jafrabad Dist- Jalna-431206(M.S)

Email: santoshrudrawar240@gmail.com

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Abstract

In this paper we propose to discuss properties and application of Fourier transform.in various fields. Many researchers and Mathematicians used F.T. to find solution for their problem. In this paper Fourier transform when applied to partial differential equation reduces the number of independent variables by one.

Keywords: Fourier Transform, Properties, Partial differential equation

Introduction:

Just as the Fourier series decomposes a periodic function into a discrete set of contributions of various frequencies, the Fourier transform provides a continuous frequency reduction of a function. The Fourier series represents the functions in time domain whereas the Fourier transform represents the functions in frequency domain. The Fourier transform is useful in the study of frequency response of a filter, solution of partial differential equation etc.

Definition of Fourier Transform:

The generalization of the complex Fourier series is known as the Fourier transform. The term Fourier transform can be used in the mathematical function of the frequency domain. The Fourier transform helps to extend Fourier series to the non- periodic functions in terms of the sum of simple sinusoids.

The Fourier transform off(x) is given by

$$F(w) = \int_{-\infty}^{\infty} f(x)e^{-iwx}dx$$

The inverse Fourier transform is given by

$$f(x) = \frac{1}{2\pi}\int_{-\infty}^{\infty} F(w)e^{iwx}dx$$

Note: Instead of capital letters we often use the notation f⁀(w) for the Fourier transform and f⁀(x) for the inverse transform.

Property of Fourier Transform

1. Linearity

If F {f_1 (x)} =F_1 (w) and F {f_2 (x)} =F_2 (w) then F { 〖af〗 _1 (x)+ 〖bf〗 _2 (x)} =aF_1 (w)+bF_2 (w) where a & b are any constants.

2. Change of Scale

If F{f(x)} =F(w) then $F\{f(ax)\} = \frac{1}{a}F(\frac{w}{a})$

3. Differentiation

If F{f(x)} =F(w) then {f'(x)} =iwF(w), as f(x)⟶0 as x⟶±∞

4. Convolution

If F {f_1 (x)} =F_1 (w) and F {f_2 (x)} =F_2 (w) then F {f_1 (x)*f_2 (x)} =F_1 (w)·F_2 (w)

5. Modulation

F{f(t) cosf_0(at)} =1/2[F(w+a) +F(w-a)]

F{f(t) sinf_0(at)} =1/2[F(w+a)-F(w-a)]

Application

1. **Application of Fourier transform for wave equation:**

$$\Delta \boldsymbol{u} = \frac{\boldsymbol{\partial^2 u}}{\boldsymbol{\partial t^2}} \quad (1)$$

With the initial conditions

$$u(x,0) = f(x), \quad \frac{\partial u}{\partial t}(x,0) = g(x) \quad (2)$$

Here $\Delta = \frac{\partial^2}{\partial {x_1}^2} + \frac{\partial^2}{\partial {x_2}^2}$ is Laplacian

Now to solve, we take the Fourier Transform of the wave equation and its initial condition with respect to the variablesx_1, x_2. This will convert the wave equation into a solvable ODE equation (1) becomes

$$-4\pi^2|w|^2\hat{u}(w,t) = \frac{\partial^2 \hat{u}(w,t)}{\partial t^2}$$

Here we use the differentiation property of Fourier transform

$$\therefore \frac{\partial^2 \hat{u}(w,t)}{\partial t^2} + 4\pi^2|w|^2\hat{u}(w,t) = 0$$

This is an ODE whose solution is given by

$$\hat{u}(w,t) = A(w)\cos(2\pi|w|t) + B(w)\sin(2\pi|w|t) \quad (3)$$

Now if we take the Fourier transform with respect to x of the initial conditions of the problem, we get that

$$\hat{u}(w,0) = \hat{f}(w) \quad \& \quad \frac{\partial \hat{u}}{\partial t}(w,0) = \hat{g}(w) \quad (4)$$

If we solve for A(w) & B(w) using equation (3) & (4) we get that

$$A(w) = \hat{f}(w)$$

$$B(w) = \frac{\hat{g}(w)}{2\pi|w|}$$

Now we use the Fourier Inverse Formula in conclusion a solution to the problem (1) & (2) is formally defined as

$$u(x,t) = \int (\hat{f}(w)\cos(2\pi|w|t) + \frac{\hat{g}(w)}{2\pi|w|}\sin(2\pi|w|t))e^{2\pi iw}dw$$

2. **Image processing:**

The Fourier transform has extensive applications to signal processing. A number of signal processing techniques such as filtering are modeled using the convolution of two functions. Since the convolution is very computationally intensive especially so in higher dimension it is common practice to take advantage of the convolution theorem. If we first compute the transform of each function multiply the transformed functions and finally compute the inverse transform of their product the result is exactly the convolution of the two initial function.

The greatest advantage comes when considering the symmetric of the Fourier transform allowing us to perform fewer computation for the forward and inverse transform some of these symmetric

along with memory management techniques allow a far more computationally efficient algorithm for computing the Fourier transform on discrete data sets.

In the case of image processing we will consider two dimensional Fourier transform we can model a grayscale image as a function f(x) which assigns an intensity value to each coordinate X=(x_1,x_2) in the plane as is often the case when relating our equation to physical phenomena this will be a real valued function with range [0, 1], a value of 0 represent black pixels and 1 represent a white pixel. The transformed function F(w) assigns a value to each spatial frequency pairW= (w_1, w_2). Here interpreting these elements as vectors introduces the notion of a direction for the planar wave described by the corresponding sinusoid.

Conclusion:

Fourier transform is important tool to resolve many problems of mathematician and researchers in science and Engineering Field. We see Fourier transform used to solve differential equation and image processing and filtering process.

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Cropping Pattern of Jam River basin – A Case Study

[1]Dr. G. D. Mhaske,

[2]Dr. Ujwala G. Mhaske,

[1]Dr. B. L. Gadakh,

[3]Dr. V. M. Pagar.

[1]Department of Environmental Science, KRT Arts, BH Commerce & AM Science (KTHM) College, Nashik - 422002

[2]Department of Physics, HPT Arts and RYK Science College, Nashik- 422005

[3]Department of Geography, Arts, Commerce and Science College, Kalwan (Manur), Tal-Kalwan, Dist-Nashik-423501

Email: ganeshdmhaske@gmail.com

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Abstract

The Jam River basin administratively shares territory with Sangamner Tahsil, Kopergaon Tahsil (Ahmednagar District) and Sinnar Tahsil (Nashik District) of Maharashtra. The Jam basin shows wide variation in soil type, climate and water availability across the region. The cropping pattern of the basin also shows great variation owning to climatic and socio-economic variation. The cropping pattern of the Jam River basin is obtained from the Agriculture Department of the respective tahsils, and to comprehend the relative strength of the major crops in the study area, the ratio of area under crop to the gross cultivated area has been considered. The crop combination of the Jam basin has shown a spatial variation of crop diversity and pattern, In the present study, on the basis of the calculation of the crop combination of the Jam basin, we have found five types of crop combination i.e., mono culture, two crop combination, three crop combination, four crop combination and five crop combination.

Keywords: Cropping pattern, Jam River basin

Introduction:

Agriculture is a vital sector that provides food, fibre and economic growth worldwide. However, the unsustainable use of water resources for irrigation purposes has resulted in the depletion of aquifers in many regions, leading to severe environmental and socio-economic impacts. Groundwater is a vital source of irrigation water for

agriculture, and the choice of crops and cultivation practices can significantly affect groundwater levels. Therefore, understanding the relationship between cropping patterns and Groundwater is crucial for the sustainable management.

Cropping pattern is an essential aspect of agricultural management, as it determines the choice of crops and their cultivation practices in a particular region. The cropping pattern significantly impacts agricultural productivity, food security and water resources. Several factors influence the choice of cropping pattern, including climate, topography, soils, availability of water, climate, technical knowledge, skilled labour, capital etc. The selection of crops and cultivation practices can affect soil moisture, water infiltration rates and water demand, all of which can impact groundwater levels. Therefore, understanding the relationship between cropping patterns and groundwater resources is critical for sustainable management of water resources and ensuring food security. Several studies have highlighted the importance of cropping patterns in managing groundwater resources. For example, a study conducted by Huang et al. (2021) in China showed that the adoption of drought-tolerant crops such as maize and soybean could help reduce water demand and improve groundwater recharge.

Similarly, a study by Pandey et al. (2020) in India found that the adoption of crop diversification practices such as intercropping and crop rotation can help conserve groundwater resources and enhance agricultural productivity. The choice of cropping pattern is also influenced by government policies and market demand. For example, in India, government policies promoting the cultivation of crops such as rice and sugarcane, which require large amounts of water, have led to significant depletion of groundwater resources (Singh et al., 2020). Similarly, market demand for cash crops such as cotton and tobacco has led to the overexploitation of groundwater resources in some regions (Shah et al., 2018).

Therefore, developing a sustainable cropping pattern that optimizes water use efficiency and ensures food security is crucial for the long-term management of groundwater resources. Factors such as soil type, climate, water availability and market demand should be considered while developing a cropping pattern that is sustainable and optimized for local conditions.

There are several other studies that have investigated the relationship between cropping patterns and groundwater resources. For instance, a study by Chen et al. (2019) in China found that the conversion of cropland to orchards and the intensification of vegetable production have led to a decline in groundwater levels in the North China Plain. The study concluded that sustainable land use practices, such as crop rotation and intercropping, are necessary to conserve groundwater resources.

Another study by Aslam et al. (2019) in Pakistan investigated the impact of crop diversification on groundwater recharge. The study found that the cultivation of legumes and vegetables in the wheat-rice cropping system improved groundwater recharge and reduced water demand. Similarly, a study by Vaddoria et al. (2018) in India found that the cultivation

of legumes such as pigeon peas and mung beans can enhance groundwater recharge and reduce water demand.

Distribution of Pearl Millet in Jam River Basin

Pearl millet (Pennisetum glaucum) is a cereal grain plant. It is a drought-tolerant crop that can thrive in hot and dry conditions, making it an important food source in areas where other crops may struggle to grow. It is widely grown in the drought-prone region of Maharashtra. The average gross sown area of five years under pearl millet in the Jam basin is about 12516.2 hectares, about 29.85 percent of the total geographical area of the basin (Table 1). Village-wise, the sown area of the pearl millet varies from 9.01 percent to 47.52 percent.

Table 1 Area covered by different crops

Sr. No.	Crop	Area (Hectare)	Percent
1.	Pearl Millet	12516.2	29.85
2.	Wheat	6096.7	14.54
3.	Other Cereals	3853.4	9.19
4.	Legumes	3278.9	7.82
5.	Oil Seeds	3916.3	9.34
6.	Sugar Cane	1794.6	4.28
7.	Vegetables	4084.0	9.74
8.	Fruits	1555.6	3.71
9.	Fodders	1207.6	2.88
10.	Other Crops	3627.0	8.65
Total		41,930.00	100

The gross sown area under pearl millet is higher in Sinnar tahsil compared to the Kopargaon and Sangamner tahsil. Among all villages, 25.8 percent have net sown areas of 20 percent or more, 49.2 percent have net sown areas of 10 percent to 20 percent, 13.3 percent have net sown areas of 5 to 10 percent and 3.3 percent have net sown areas of less than 2 percent under pearl millet (Fig. 1).

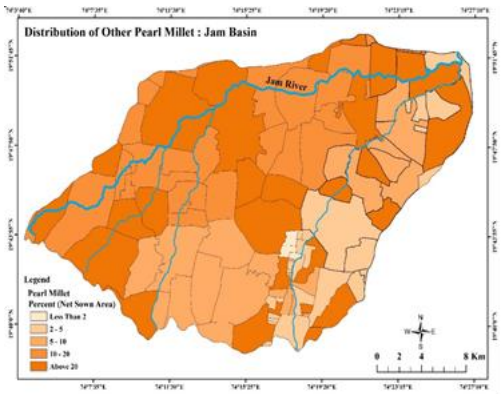

Fig. 1 Distribution of pearl millet in Jam River

Distribution of Wheat in Jam River Basin

Wheat is an important rabi crop in western Maharashtra and a significant area of this region has cultivated under wheat in the past two decades. The total gross sown area under wheat in the Jam basin is about 6096.7 hectares, about 14.54 percent of the total geographical area of the basin. Village-wise, the sown area of the wheat varies from 1.92 percent to 38.07 percent. The gross sown area under the wheat showed a gradual increase over the period (Fig. 2). Under wheat, 18.9 percent of the villages have net sown areas that are 20 percent or more, 29.5 percent have net sowed areas that are 10 percent to 20 percent, 40.2 percent have net sown areas that are between 5 to 10 percent, and 3.3 have

net sown areas that are less than 2 percent.

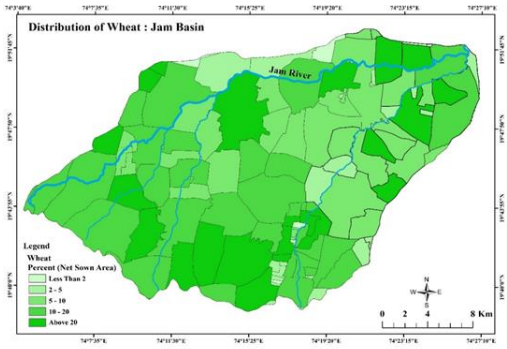

Fig. 2 Distribution of Wheat in Jam River Basin

Distribution of Other Cereals in Jam Basin

Apart from pearl millet and wheat, other cereals, such as sorghum, rice, maize etc., are also grown in the arable lands of the Jam basin in varying intensity. Among other cereals, the contribution of maize and sorghum is nearly 70 percent, while the rest of the cereals contribute about 30 percent. Total gross sown area under other cereals in the Jam basin are about 3853.4 hectares, about 9.19 percent of the total geographical area of the basin. Village-wise, the sown area of the other cereals varies from 0.95 percent to 35.14 percent (Fig. 3).

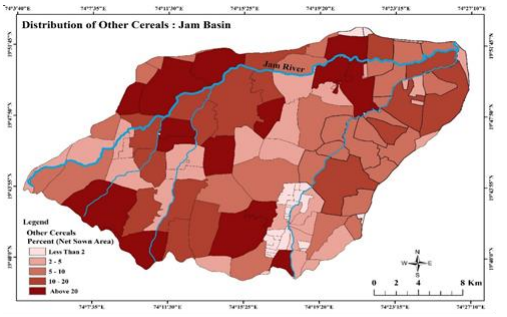

Fig. 3 Distribution of other Cereals in Jam River Basin

Under other cereals, 10.1 percent of the villages have net sown areas that are 20 percent or more, 16.8 percent have net sowed areas that are 10 percent to 20 percent, 47.1 percent have net sown areas that are between 5 to 10 percent, 12.6 percent have net sown area between 2 to 5 percent and 12.6 have net sown areas that are less than 2 percent.

Distribution of Legumes in Jam River Basin

Legumes, also known as pulses, come in a variety of shapes, sizes and colors. Some of the common types of legumes grown in the region are Lentils, lupins, beans and peas etc. total sown area under legumes in the Jam basin is 3278.9 hectares, about 7.82 percent of the total geographical area. Village wise the net sown area under legumes in Jam basin varies from 1.11 percent to 22.84 percent. Under legumes, 9.01 percent of the villages have net sown areas that are 20 percent or more, 18.9 percent have net sowed areas that are 10 percent to 20 percent, 36.1 percent have net sown areas that are between 5 to 10 percent, 18.9 percent have net sown area between 2 to 5 percent and 17.2 have net sown areas that are less than 2 percent (Fig. 4).

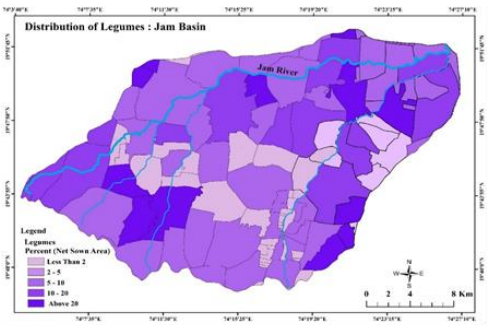

Fig. 4 Distribution of Legumes in Jam River Basin

Distribution of Oil Seeds in Jam River Basin

Oilseed crops are a group of plants that produce oil-rich seeds or fruits, which are commonly used for various purposes,

Major oil seed crops are ground nut, soybean, sun flower, sesame, Jam basin has favorable agro-climatic conditions for oilseed cultivation The total sown area under oil seeds in the Jam basin is 3,916.3 hectares, which represents approximately 9.34 percent of the entire geographical area. On a village level, the net sown area allocated to oilseeds in the Jam basin ranges from 1.65 percent to 30.88 percent. Concerning oil seeds, 11.5 percent of the villages have a net sown area of 20 percent or more, while 23 percent have a net sown area of 10 percent to 20 percent. Additionally, 33.6 percent of villages have a net sown area ranging from 5 percent to 10 percent, 14.8 percent have a net sown area of 2 percent to 5 percent, and 17.2 percent have a net sown area of less than 2 percent (Fig. 5).

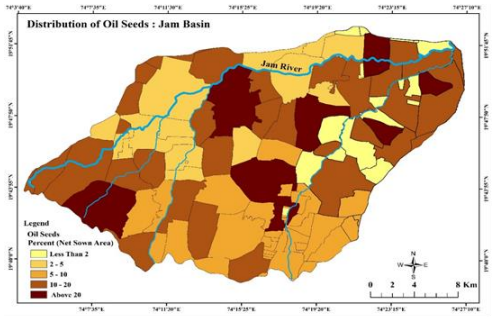

Fig.5 Distribution of Oil Seeds in Jam River Basin

Distribution of Sugar cane in Jam River Basin

Sugar cane is one of the important cash crops in Maharashtra, the distribution of which depends on climate, soil, water availability and market demand/ sugar factories. The total sown area under sugar cane in the Jam basin is 1794.6 hectares, representing approximately 4.28 percent of the entire geographical area. On a village level, the net sown area allocated to sugar cane in the Jam basin ranges from 0.22 percent to 23.41 percent. Under sugar cane, 10.7 percent of the villages have net sown areas that are 20 percent or more, 18.01 percent have net sowed areas that are 10 percent to 20 percent, 39.3 percent have net sown areas that are between 5 to 10 percent, 19.7 percent have the net sown area between 2 to 5 percent and 12.3 have net sown areas that are less than 2 percent (Fig. 6).

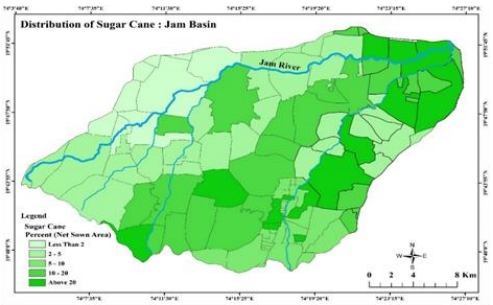

Fig. 6 Distribution of Sugar cane in Jam River Basin

Distribution of Vegetables in the Jam River Basin

Vegetables are a group of edible plants cultivated for their edible parts, including leaves, stems, roots, flowers, or fruits. Vegetables are generally perishable plants which grown considering factors such as soil type, climate and market demand. The total sown area under vegetables in the Jam basin is 4084.0 hectares, representing approximately 9.74 percent of the entire geographical area. On a village level, the net sown area under vegetables in the Jam basin ranges from 1.51 percent to 33.08 percent. Under vegetables,13.9 percent of the villages have net sown areas that are 20 percent or more, 28.7 percent have net sowed areas that are 10 percent to 20 percent, and 9.7 percent have net sown areas that are between 5 to 10 percent. 31.1 percent have a net

sown area between 2 to 5 percent, and 6.6 have net sown areas that are less than 2 percent (Fig.7).

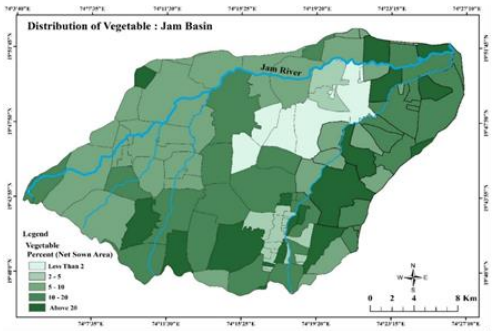

Fig.7 Distribution of Vegetables in Jam River Basin

Distribution of Fruits in the Jam River basin

Fruit production is a crucial and rewarding agricultural activity. Grapes and pomegranates are two of the most prominent crops cultivated in the Jam basin. Apart from these two, guava, sapota, banana, mangoes etc., are also grown in the Jam basin.

The total sown area under fruits in the Jam basin is 1555.6 hectares, representing approximately 3.71 percent of the entire geographical area. On a village level, the net sown area under fruits in the Jam basin ranges from 0 percent to 24.33 percent. In the case of fruits, 6.6 percent of the villages have net seeded sown areas that are 20 percent or more, 18.1 percent have net sowed areas that are 10 percent to 20 percent, and 12.3 percent have net planted areas that are between 5 percent and 10 percent. Between 2 and 5 percent of the net sown area is represented by 33.6 percent of villages, while less than 2 percent is represented by 6.6 percent of villages. There is no data for 28 villages (Fig.8).

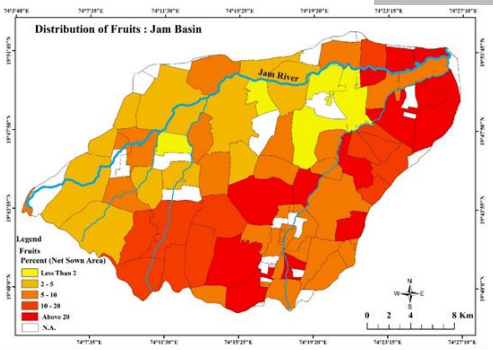

Fig. 8 Distribution of Fruits in Jam River Basin

Distribution of Fodder in the Jam River Basin

Fodder crops are groups of crops grown specifically for feeding livestock, such as cattle, goats, sheep and buffaloes. Popular fodder crops that are grown in the region include alfalfa, berseem, oats and sorghum Sudan grass. The total sown area under fodders in the Jam basin is 1207.6 hectares, representing approximately 2.88 percent of the entire geographical area. On a village level, the net sown area under fodder in the Jam basin ranges from 0 percent to 15.48 percent.

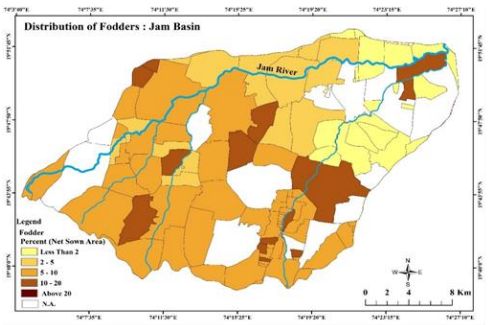

Fig. 9 Distribution of Fodder in Jam River Basin

Under fodder,10.7 percent of the villages have net sown areas of 10 percent to 20 percent, and 28.7 percent have net sown areas between 5 to 10 percent. 33.6 percent of villages have a net sown area between 2 to 5 percent, and 13.1 percent

of villages have a net sown area less than 2 percent. There is no data for 16 villages (Fig. 9).

Distribution of Other Crops in Jam River Basin

The distribution of the crops, which is not mentioned above, is categorized as other crops, including flower crops, medicinal crops, and other commercial crops.

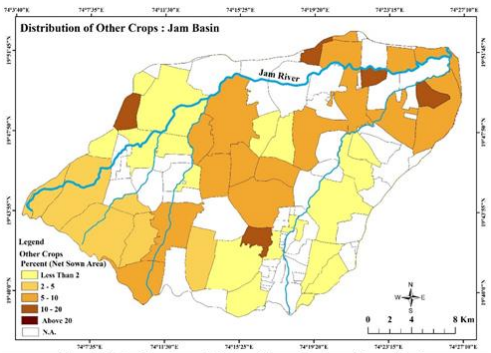

Fig. 10 Distribution of Other Crops in Jam River Basin

The contribution of other crops in the net sown area is 3627.0 hectares, about 8.65 percent of the total geographical area. On a village level, the net sown area under other crops in the Jam basin ranges from 0 percent to 11.21 percent. Under other crops,4.1 percent of the villages have net sown areas of 10 percent to 20 percent, and 12.3 percent have net sown areas between 5 to 10 percent. 6.6 percent of villages have a net sown area between 2 to 5 percent, and 23.8 percent of villages have a net sown area below 2 percent of the total sown area (Fig. 10).

Crop Combination

Study of an individual crop cannot communicate the whole scenario of an agricultural landscape. We seldom come across a crop that is completely growing in an isolated manner, and minor crops have an important function even in locations where a single crop dominates. For a fundamental understanding of agricultural regionalism, crop combination region studies are essential to agriculture geography. In an agriculture system, the crop combination is the output of climate, topography, soil, market demands, economic conditions, etc. which may vary from area to region. However, although each region of individual crops is beneficial for planners, it is much more vital to evaluate the integrated assemblage of diverse crop combinations in regard to the quantum or variety of crops in a region at a given moment.

Crop dominant and diversified zones are identified as a result of the search for generalization of patterns of areal dominance of crops. The notion of crop combination regions seems to be viable since it allows for the creation of distinct zones based on the areal dominance of crops that are spatially connected and coexist in variable degrees. It should also be noted that the purpose of delimiting crop combination zones is to make the agricultural intricacies of the area easier to describe and comprehend. A delimitation is only a tool for better understanding the agricultural condition, not an objective in itself. The study of crop combination is critical to a thorough and deeper knowledge of the agricultural system and is vital for agricultural planning.

Cropping patterns are strongly correlated to the stage of agricultural growth and water availability and are used as an analysis tool for agricultural progress in the area. The current research aimed to identify the current cropping pattern in

order to better understand agriculture practices.

The study was carried out on the most significant food and non-food crops. The percent area under these crops has been organized in decreasing order, and the crop zones have been identified using combination analysis. The investigation was taken out at the district level. To determine the existing agricultural zones of Jam basin, data was gathered from the district socio-economic abstract, agriculture census and tahsil agriculture department, the Weavers technique of combination analysis is used.

To analyze crop combinations, the ranking of crops by total cultivated area was utilized to determine which crops dominate in the Jam basin. There are 12 crops that account for the highest proportion of total cropped land. Other crops are planted alongside primary ones. The first rank crop may range from 100 percent to 35 percent. The nine crops are 1). Pearl Millet, 2). Wheat, 3). Vegetables 4). Ground nut, 5). Sugar cane, 6). Legumes, 7). Onion 8). Fruits and 9). Fodder.

The calculation of the crop combination was done for 122 villages for the year 2020-21, using Weaver's method. The crop combination of the Jam basin has shown a spatial variation of crop diversity and pattern, In the present study, on the basis of the calculation of the crop combination of the Jam basin, we have found five types of crop combination i.e., mono culture, two crop combination, three crop combination, four crop combination and five crop combination.

Table 2 Different Crop Combinations

Crop Combination	**Villages**	**Percent**
Six Crop Combination	16	13.11
Seven Crop Combination	31	25.41
Eight Crop Combination	26	21.31
Nine Crop Combination	28	22.95
Ten Crop Combination	11	9.02
Eleven Crop Combination	4	3.28
Twelve Crop Combination	6	4.92

According to the calculations of the crop combination of the Jam Basin out of 122 villages of the tahsil, 13.11 percent of the villages have a six crop combination, 25.41 percent of the villages have seven crop combinations, 21.31 percent of the villages represent eight crop combination, 22.95 percent of the total villages practice nine crop combination, 9.02 percent of the total villages practices ten crop combination, 3.28 percent of the total villages practices eleven crop combination and 4.92 percent of the total villages practices twelve crop combination. The results of crop combination points that there is dominance of seven, eight and nine crop combination in the Jam Basin (Table 2).

Agriculture Productivity: Kendall's Ranking Coefficient Index

The ranking coefficient method of M.G. Kendall (1939) is more dependable and simpler to use for determining the agricultural production of any region. Kendall introduced this technique for

assessing agricultural efficiency that is based on production per unit area and designed a system of Ranking Coefficients to measure the effectiveness of agricultural practices. In the article titled 'The Geographical Distribution of Crop Production in England' (1939), Kendall used this method to assess the distribution of agricultural production. Kendall breaks down the process is into three phases, the recorded units are ranked in order of output per hectare for each of the selected crops, (b) the ranks obtained by each unit for the selected crops are added, and (c) the sum of the ranks obtained by each unit for the selected crops is divided by the number of crops selected, resulting in the ranking coefficient. Kendall used the following formula to obtain the agricultural productivity

$$\text{Ranking Coefficient Index} = \frac{R1 + R2 + R3 + R4 \dots\dots\dots\dots + Rn}{n}$$

Where,
R = Ranking of the yield of individual crop
n = Number of crops.

The area with the higher yield per unit area will have a low-ranking coefficient index value, suggesting high productivity. In simple words, the area which ranked one in every crop list would have maximum production. But the areal unit with a low ranking would have a ranking coefficient equal to the number of units evaluated, indicating the lowest agricultural production. This technique has a set of shortcomings, in this method, the yield of the unit area of land has no weightage, instead, the Kendall ranking coefficient index confides on rankings, which serves as the reference point to the calculation of the Index. Another drawback of this method is it unable to compare the areal unit on the basis of the yield per unit area, thus the difference between the low yield and high yielding areal units cannot be compared. In the present research, the agriculture productivity of the villages of the Jam basin was calculated for the years 2020-21. For this purpose, the average yield for the selected ten crops per hectare was collected for these villages and ranked according to the production basis on the yields of crops. On the basis of Kendall's ranking coefficient index, the villages are divided into five groups on the basis of the index value. The agriculture productivity of the Jam Basin is calculated for the year 2020-21, ranking the crops on the basis of the average yield. According to Kendall's ranking coefficient index 21.3 percent of the villages shows very high productivity, while 27.9 percent of the villages shows high productivity, 36.9 percent of the total villages shows medium productivity, 9.0 percent villages show low productivity and 4.9 percent villages shows very low productivity (Table 3).

Table 3 Agriculture Productivity: Ranking Coefficient Index

Ranking Coefficient Index	**Category**	**No. of Villages**	**Percentage**
Below 13.5	Very High	26	21.3
13.5-18	High	34	27.9
18-25.5	Medium	45	36.9
25.5-30	Low	11	9.0
Above 30	Very Low	6	4.9

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Unraveling CRISPR-Cas Systems: From Adaptive Immunity to Cutting - Edge Biotechnology

[1]Ms. Ruchika Amish Yadav

[2]Ms. Vinaya Vasant Patil,

[3]Ms. Sandra Balakrishnan,

[1,2,3]Assistant Professor, Department of Botany, SIES College of Arts, Science and Commerce (Empowered Autonomous), Sion (W)

Email: ruchikad@sies.edu.in

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Abstract

CRISPR-Cas systems, originally discovered as an adaptive immune mechanism in prokaryotes, have become one of the most transformative tools in genetic engineering and biotechnology. These systems are classified into two main classes (Class 1 and Class 2), each encompassing various types with distinct molecular mechanisms and functionalities. Class 1 systems are primarily involved in complex, multi-protein interference and adaptation, while Class 2 systems, such as CRISPR-Cas9, provide the simplicity and precision required for targeted genome editing. The ability to induce specific DNA modifications with minimal off-target effects has led to widespread applications in medicine, agriculture, and synthetic biology. This chapter provides an in-depth exploration of the diverse CRISPR-Cas systems, detailing their mechanisms, evolution, and current and potential applications. Furthermore, it highlights the ongoing advancements in CRISPR technology, such as base editing and CRISPR-based therapeutics that promise to further revolutionize the field of genetic manipulation. The future of CRISPR-Cas systems lies in expanding their capabilities for more precise gene therapies, agricultural innovations, and biomedical applications.

Keywords: CRISPR-Cas, genome editing, CRISPR-Cas9, genetic manipulation, DNA modifications

Introduction

Genome editing involves the targeted modification of genomic DNA in various cell types and organisms, encompassing processes such as DNA insertion, deletion, and replacement. These results in gene inactivation, the acquisition of novel genetic traits, and the correction of pathogenic mutations. One of the most

widely used tools for genome editing is CRISPR-Cas (Clustered Regularly Interspaced Short Palindromic Repeats and CRISPR-associated proteins), which has gained significant attention due to its simple design, low cost, high efficiency, good reproducibility, and rapid processing time (Doudna & Charpentier, 2014). Bacterial and archaeal viruses, or bacteriophages, represent a constant threat to prokaryotic organisms. In response, prokaryotes have developed several defense mechanisms. One such mechanism is the CRISPR-Cas system, which functions as an adaptive immune response to viral invaders. Over the past decade, CRISPR-Cas has gained substantial interest not only for its ability to protect prokaryotes from phages but also for its potential therapeutic applications in biotechnology and medicine (Makarova et al., 2020).

CRISPR-Cas is the only known adaptive immune system in prokaryotes, involving small CRISPR RNAs (crRNAs) that facilitate sequence-specific interference with invading nucleic acids. The CRISPR locus consists of repetitive DNA sequences known as repeats, interspersed with unique sequences called spacers. These spacers are derived from the genetic material of viruses, transposons, or plasmids that have previously infected the host cell. The CRISPR array is located near an AT-rich leader sequence and is usually flanked by a set of cas genes, which encode the proteins responsible for CRISPR-Cas function (Barrangou et al., 2007).

The CRISPR-Cas system first came to scientific attention in the late 20th century. Initially identified in Escherichia coli during studies on the enzyme alkaline phosphatase (Jansen et al., 2002), CRISPR sequences were later observed in archaea such as Haloferax mediterranei in 1993. The function of these sequences remained unclear until the early 2000s, when researchers discovered that the spacer regions of CRISPR sequences were similar to sequences from bacteriophages, plasmids, and archaeal viruses, leading to the realization that CRISPR functions as an immune mechanism (Mojica et al., 2005). This discovery, independently made by multiple research groups, identified the CRISPR-Cas system as an acquired immune defense, similar to RNA interference (RNAi) in eukaryotes (Van der Oost et al., 2014).

CRISPR sequences are characterized by repeat regions that generally maintain a constant length and exhibit dyad symmetry, forming palindromic structures. The spacer regions, which also have a constant length, do not exhibit sequence homology but instead correspond to sequences from previous viral invaders, providing the host with a "memory" of past infections (Makarova et al., 2020).

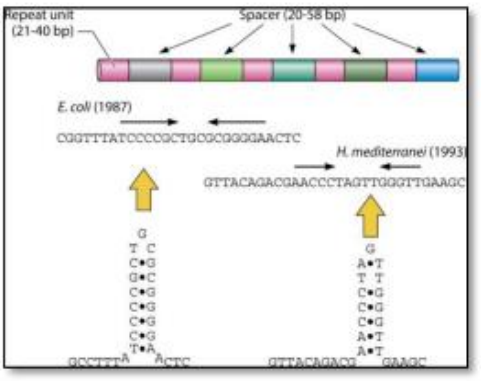

Fig. 1: The structural features of CRISPR. The repeat sequences with constant length generally have dyad symmetry to form a palindromic structure (shown by arrows). Two examples are shown by the first

identified CRISPR from E. coli (bacteria) and H. mediterranei (archaea). The spacer regions also have a constant length but no sequence homology.

Mechanism Of Action of The Crispr-Cas System

The CRISPR-Cas system, originally discovered in bacteria and archaea, has become a revolutionary tool for genome editing. It works by utilizing a combination of RNA and protein components to precisely target and cut DNA at specific locations. Below is a detailed explanation of the mechanism, divided into its key phases: acquisition, expression and interference.

1. Acquisition of Foreign DNA:

The first step in the CRISPR-Cas immune process involves the bacterium incorporating short sequences of foreign DNA into its genome. This foreign DNA, typically from a virus (bacteriophage), is inserted into the bacterial CRISPR locus as "spacer sequences." These sequences are flanked by repetitive DNA elements. This process is called "adaptation" and provides the bacterial cell with a genetic memory of previous infections (Makarova et al., 2011).

2. CRISPR RNA (crRNA) Biogenesis:

Once foreign DNA is acquired, the CRISPR locus is transcribed into a long precursor RNA (pre-crRNA). The pre-crRNA is then processed into smaller, mature crRNAs, each containing one spacer sequence derived from the previous infection. The crRNA is essential for guiding the system to the specific target DNA. In type II systems, the mature crRNA binds to the Cas9 protein, forming a complex that will later target and cleave DNA (Jinek et al., 2012).

3. Target DNA Recognition and Binding:

The crRNA guides the Cas9 protein to a complementary sequence in the invading DNA. The crRNA sequence has a 20-nucleotide "spacer" sequence that is complementary to the target DNA. The Cas9 protein uses this RNA molecule to search for a matching sequence within the foreign genome. When the crRNA-Cas9 complex binds to the target DNA, the Cas9 protein unwinds the DNA and ensures that the crRNA sequence pairs precisely with the target strand (Doudna & Charpentier, 2014).

4. DNA Cleavage:

After the crRNA-Cas9 complex binds to the target DNA, Cas9 induces a double-strand break (DSB) at a specific location. This break is facilitated by two nuclease domains within the Cas9 protein: the RuvC and HNH domains. The RuvC domain cleaves the non-target strand, while the HNH domain cleaves the target strand (Jinek et al., 2012). This creates a DSB, which is critical for the subsequent repair process.

5. DNA Repair:

Following the creation of the DSB, the cell attempts to repair the break. This repair can occur via two main pathways:

Non-homologous end joining (NHEJ): This is an error-prone repair pathway where the broken ends of the DNA are directly ligated without the need for a homologous template. NHEJ can result in small insertions or deletions that disrupt the target gene, leading to loss of function (Boulton et al., 2018).

Homology-directed repair (HDR): In this pathway, the cell uses a homologous DNA template to repair the break with greater precision. If a donor DNA template is provided, HDR can be used to introduce specific genetic changes, such as gene knock-ins, point mutations, or precise gene replacement (Hsu et al., 2014).

The CRISPR-Cas9 system's ability to induce DSBs at specific loci and harness the cell's repair mechanisms makes it an invaluable tool for genome editing across a wide range of organisms.

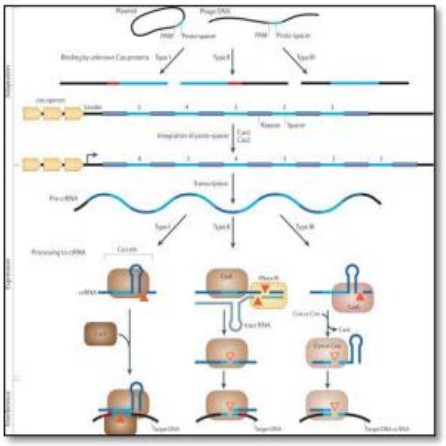

Fig. 2: The three stages of CRISPR-Cas action

Types Of CRISPR-Cas Systems

The CRISPR-Cas system, originally discovered in bacteria as an adaptive immune mechanism, has been revolutionizing molecular biology, particularly in genome editing. The system comprises two main components: the Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) and the CRISPR-associated (Cas) proteins. Over the years, researchers have identified several types of CRISPR-Cas systems, which are broadly classified into two major classes, Class 1 and Class 2. These systems can be further subdivided into various types based on their genetic and functional characteristics.

A) Class 1 CRISPR-Cas Systems

Class 1 CRISPR-Cas systems include Type 1, Type 3, and a variant of Type 4. These systems are often more complex, involving multiple proteins and functioning as multi-protein complexes.

1. Type 1 CRISPR-Cas Systems:

Type 1 systems are the most diverse and abundant in bacteria. The core component of Type 1 systems is the signature protein complex, which includes multiple subtypes: Csm, Csn, or Cse complexes. These complexes are involved in interference (targeting foreign nucleic acids) and adaptation (incorporating foreign DNA into the CRISPR array). Type 1 systems are further divided into three subtypes: Type 1-A, Type 1-B, and Type 1-C. The interference mechanism involves surveillance proteins like Fig. 2: The three stages of CRISPR-Cas action Csm/Csn, which recognize and degrade the invading foreign genetic material (Makarova et al., 2015).

2. Type 3 CRISPR-Cas Systems:

Type 3 systems include both Type 3-A and Type 3-B subtypes and are characterized by their ability to degrade RNA. These systems are primarily involved in RNA interference rather than DNA cleavage, which distinguishes them from other CRISPR types. Type 3 systems utilize a signature protein called Csm (or Csx) complex, which targets and cleaves RNA, inhibiting the replication of foreign RNA viruses. Notably, the Cas10 protein in Type 3 systems also plays a role in cyclic oligoadenylate synthesis, which helps to

activate the interference mechanism (Makarova et al., 2011).

3. Type 4 CRISPR-Cas Systems:

Type 4 CRISPR systems are simpler and are not typically involved in interference with foreign nucleic acids. Rather, they appear to play a role in the regulation of CRISPR arrays and could serve as a form of "self-regulation" for the CRISPR-Cas system (Makarova et al., 2015). Unlike the more commonly studied Type 2 systems, Type 4 systems do not generally offer a straightforward gene-editing application.

B) Class 2 CRISPR-Cas Systems

Class 2 CRISPR-Cas systems are simpler and consist of single proteins that are capable of performing genome editing. The most well-known and widely used system from this class is Type 2, primarily used for gene editing purposes.

1. Type 2 CRISPR-Cas Systems:

Type 2 CRISPR-Cas systems are the best-studied and most commonly employed in biotechnology. This system includes the Cas9 protein, which is responsible for DNA cleavage. In this system, the CRISPR array stores short segments of foreign DNA, and the RNA transcribed from this array guides the Cas9 protein to the corresponding target DNA sequence. The Cas9 protein introduces a double-strand break (DSB) at the target site, which can then be repaired through cellular repair mechanisms like non-homologous end joining (NHEJ) or homology-directed repair (HDR) (Jinek et al., 2012). This system is particularly famous for its use in gene editing, where researchers design synthetic single-guide RNAs (sgRNAs) to direct the Cas9 protein to a specific locus in the genome, making it possible to knock out genes or insert new genetic material (Cong et al., 2013). The versatility and simplicity of Type 2 systems make it the most popular choice for genome editing in a wide range of organisms.

2. Type 5 CRISPR-Cas Systems:

The Type 5 systems, particularly known for the Cpf1 (also called Cas12) protein, offer some advantages over Cas9. Cpf1, like Cas9, creates doublestrand breaks in DNA but does so with a different mechanism. Cpf1 produces sticky ends instead of blunt ends, which may be useful for more efficient genome editing and homology-directed repair. Additionally, Cpf1 can process its own CRISPR array and does not require tracrRNA, unlike Cas9, which simplifies its usage in certain applications (Zetsche et al., 2015).

3. Type 6 CRISPR-Cas Systems:

Type 6 CRISPR-Cas systems are similar to Type 3 in that they target RNA, but they do so in a more specialized manner. The signature protein of Type 6 systems is Csm6 or CsxCas4, which is involved in RNA degradation and defense against RNA viruses. Recent research suggests that Type 6 systems may have broader antiviral potential and could provide tools for developing RNA-targeting therapeutics (Makarova et al., 2011). The different CRISPR-Cas systems, especially those from Class 2, have revolutionized the field of genetic engineering. Type 2 CRISPR-Cas9, in particular, has enabled precise modifications to the genomes of a variety of organisms, from bacteria to plants and animals. The discovery of Cpf1 (Cas12) in Type 5 and its RNA-

targeting potential in Type 6 have expanded the toolbox available to scientists, making CRISPR a powerful and adaptable tool for both basic and applied research in genetics, medicine, and biotechnology (Cong et al., 2013; Zetsche et al., 2015).

Anti-CRISPR Proteins

Like any defense system, CRISPR-Cas is involved in a constant "arms race" with phages, which causes the rapid evolution of both CRISPR-Cas systems and phages causing a significant diversity of genes and the structure of the CRISPR-Cas locus. This is mostly because of relationship between a prokaryote and phage and their continual adaptation and counteradaptation of defense and attack strategies (Westra et al., 2016). Phage evolution is mainly based on minimizing the detection of infection by the protective systems of bacteria. A key feature of the CRISPR-Cas systems is their strict specificity of action that phages can use against bacteria. Mutations in bacteriophage genetic material, which are usually found in PAM sequences or in protospacer regions often referred to as "escape mutations," may lead to ineffective operation of the Cas protein machinery as the exogenous DNA becomes more difficult to detect or not detected at all (Deveau et al., 2008; Semenova et al., 2011). However, the efficacy of such mutations may not be sufficient in a bacterial population with a large variety of spacers. Some phages and other mobile genetic elements have developed refined strategies to evade the CRISPR-Cas immune system, producing small (50 to 150 amino acids) Anti-CRISPR (Acr) proteins which inhibit the interference machinery directly. To date, over 300 Acr proteins have been identified (Wang et al., 2021). These can be divided based on inhibited CRISPR types, stages of inhibition, and the Cas proteins they target. The acr genes are often found closely together in the genome of viruses and bacteria, where they found their way through mobile genetic elements. This allowed researchers to discover them. Many algorithms are currently in use to facilitate this process (Eitzinger et al., 2020; Gussow et al., 2020; Wang et al., 2020). The Acr proteins are named after the system that they inhibit in the order they were discovered (Bondy-Denomy et al., 2018). For example, the AcrIIA4 protein was the fourth discovered Acr, which inhibits CRISPR-Cas system subtype II-A.

Applications Of CRISPR-Cas

CRISPR-Cas technology has revolutionized various fields of biology, providing a precise, efficient, and versatile tool for genetic modification. Its applications span from basic research to therapeutic interventions and agricultural innovations. Below is an overview of the major applications of CRISPR-Cas in different domains.

1. **Gene Editing in Model Organisms:**

One of the earliest and most significant applications of CRISPR-Cas was in gene editing in model organisms such as mice, fruit flies, and zebrafish. The precision of CRISPR allows researchers to introduce targeted mutations or insert genes to study their function, creating animal models that are critical for understanding disease mechanisms (Jinek et al., 2012). For instance, knockout mice have been generated for a wide range of diseases, including cancer

and neurodegenerative disorders, aiding in the development of new therapies (Shao et al., 2018).

2. Therapeutic Gene Editing:

CRISPR-Cas has vast potential in treating genetic disorders. The technology can be used to correct mutations at the DNA level, offering a possible cure for diseases like sickle cell anemia, muscular dystrophy, and cystic fibrosis. In 2019, clinical trials for sickle cell anemia and beta-thalassemia began, wherein CRISPR was employed to edit the patient's hematopoietic stem cells, effectively alleviating disease symptoms (Frangoul et al., 2021). These trials marked a breakthrough in using CRISPR for human therapy, demonstrating both the promise and the challenges of gene editing in humans.

3. Cancer Immunotherapy:

In cancer research, CRISPR-Cas is being used to enhance immune cell therapies. One promising application is in modifying T-cells to recognize and attack cancer cells more efficiently. By editing genes in T-cells, researchers can improve the immune system's ability to target tumor cells (Zhang et al., 2021). Additionally, CRISPR is being applied to modify cancer cells to study their response to various treatments, advancing personalized medicine approaches in oncology (Chavez et al., 2015).

4. Agriculture and Crop Improvement:

CRISPR-Cas is transforming agriculture by enabling precise editing of crop genomes to enhance yield, resistance to pests, and tolerance to environmental stressors. For example, scientists have developed CRISPR- edited rice varieties resistant to bacterial blight, a major agricultural problem (Khan et al., 2020). The technology has also been applied to edit the genes responsible for ripening, allowing for the development of crops with longer shelf lives, which could reduce food waste (Zhang et al., 2019).

5. Livestock Improvement:

CRISPR is also being used in livestock breeding. For instance, scientists have successfully edited genes in pigs to make them resistant to diseases like porcine reproductive and respiratory syndrome (PRRS) (Burkard et al., 2018). Additionally, CRISPR is being used to improve meat quality, growth rates, and reproductive performance in livestock, with the potential to enhance food production globally.

6. Gene Drives in Ecosystem Management:

A particularly novel application of CRISPRCas is in the creation of gene drives, which could alter the genetic makeup of entire populations of organisms. One potential use is in combating vector-borne diseases such as malaria by genetically modifying mosquito populations to suppress or eliminate the spread of the disease (Gantz et al., 2015). While still experimental, gene drives hold the potential to drastically reduce the prevalence of diseases like malaria, Zika, and dengue by modifying the vector species themselves.

7. Synthetic Biology and Bioengineering:

CRISPR-Cas is a key tool in synthetic biology, where it is used to construct artificial biological systems and redesign

organisms for specific purposes. This includes the engineering of microorganisms for biofuel production, the synthesis of pharmaceuticals, or the breakdown of pollutants (Nielsen et al., 2016). By editing genomes of bacteria, yeast, or algae, CRISPR allows for the creation of organisms optimized for industrial processes, potentially revolutionizing fields such as biotechnology and environmental remediation.

Future Prospects of the CRISPR-Cas System

The future of CRISPR-Cas is poised to revolutionize multiple sectors, with transformative advances expected in human health, agriculture, biotechnology, and environmental management. However, despite its successes, CRISPR-Cas faces numerous challenges that must be overcome before its full potential can be realized. The future will see continued advancements in CRISPR technology, along with evolving regulatory, ethical, and societal considerations.

1. **Increased Precision and Efficiency:**

While CRISPR-Cas9 is already a highly effective tool for genome editing, one of the primary future goals is improving its precision and reducing off-target effects. Current CRISPR systems occasionally lead to unintended edits, which can be harmful, especially in therapeutic applications.

Next-generation CRISPR Technologies:

The development of more advanced CRISPR systems, such as CRISPR/Cas12 and CRISPR/Cas13, promises improved accuracy in targeting specific DNA sequences, minimizing the chances of off-target effects (Zhang et al., 2018). These newer variants offer greater flexibility, as well as the potential for targeting RNA in addition to DNA, which could open up new avenues for disease intervention. **Base Editing and Prime Editing:** One of the most exciting future directions in CRISPR technology is the development of base editing and prime editing, which enable more accurate and subtle modifications without introducing double-strand breaks in DNA. These techniques could pave the way for correcting mutations at the molecular level with unprecedented precision, potentially reducing unintended genetic alterations (Anzalone et al., 2019).

2. **Improved Delivery Systems:**

A major challenge for CRISPR-based therapies, especially for human applications, is the effective delivery of CRISPR components to the target cells. Current delivery methods, including viral vectors and lipid nanoparticles, face limitations such as immune responses, off-target delivery, and inefficiency in reaching specific tissues. Non-viral Delivery Methods: The future of CRISPR delivery will likely involve the development of more efficient non-viral methods. Innovations such as nanoparticles, exosome-based delivery systems, and CRISPR-loaded hydrogel matrices are under investigation to enhance the specificity and safety of CRISPR treatments (Bester et al., 2017). These methods could significantly improve the ability to target tissues or organs for therapeutic interventions. In Vivo Genome Editing: Future research is likely to focus on improving the ability to perform in vivo gene editing, directly

editing the genomes of living organisms without the need for ex vivo manipulation of cells. This could have significant implications for treating genetic disorders in humans without the need for invasive procedures (Ming et al., 2020).

3. Expansion of CRISPR in Epigenetics:

While current CRISPR technology focuses primarily on making permanent genetic changes, the future of CRISPR-Cas could involve the more sophisticated manipulation of the epigenome — the chemical modifications to DNA and histones that regulate gene expression without changing the underlying sequence. Epigenetic Modulation: CRISPR-based systems such as CRISPR/Cas9-based activators (CRISPRa) and inhibitors (CRISPRi) are already being used to control gene expression, and future advances could expand their use in epigenetic therapies. By targeting specific epigenetic markers, researchers could potentially treat diseases related to abnormal gene expression, including cancer, neurological disorders, and cardiovascular diseases (Liu et al., 2019). These strategies could allow for more transient, reversible modifications without altering the underlying DNA.

4. CRISPR in Synthetic Biology and Biomanufacturing:

One of the most exciting future prospects of CRISPR-Cas is its integration with synthetic biology — the design and construction of new biological parts, devices, and systems that do not exist in nature. Industrial Biotechnology: CRISPR could become a key tool in biomanufacturing, where microorganisms such as bacteria or yeast are engineered to produce valuable substances, such as biofuels, pharmaceuticals, or biodegradable plastics. The precision of CRISPR will enable the optimization of microbial strains to improve production yields, reduce costs, and lower environmental impact (Nielsen et al., 2016). CRISPR could also help engineer "living factories" capable of producing novel compounds and materials in a sustainable and scalable manner.

Artificial Life Forms:

CRISPR technology could eventually be used to construct completely synthetic organisms with novel properties. This could include microorganisms designed to perform specific tasks, such as cleaning up oil spills, producing renewable energy, or even aiding in medical applications like targeted drug delivery (Niemeyer et al., 2019).

Conclusion

CRISPR-Cas systems represent a groundbreaking advancement in the field of genetic engineering, offering unparalleled precision and versatility in genome editing. From their origins as an adaptive immune system in prokaryotes, these systems have evolved into powerful tools that enable targeted modifications in a wide range of organisms. The classification of CRISPR-Cas systems into Class 1 and Class 2, each with distinct mechanisms and applications, reflects the diverse strategies prokaryotes use to defend against foreign genetic material. Among these, Class 2 systems—particularly CRISPR-Cas9—have emerged as the most widely used and accessible platforms for genetic manipulation, with

applications spanning medicine, agriculture, and synthetic biology.Ongoing advancements in CRISPR technology, such as base editing, prime editing, and the development of next-generation CRISPR systems, are further enhancing the precision, efficiency, and scope of genome editing. These innovations hold immense potential for revolutionizing therapeutic approaches, from curing genetic diseases to improving crop resilience and addressing global health challenges. However, challenges remain, including off-target effects, delivery mechanisms, and ethical considerations, which will need to be addressed as the technology matures.

Ultimately, the future of CRISPR-Cas systems is poised to transform not only the way we understand genetic processes but also how we approach complex diseases, environmental issues, and biotechnology innovations. With continued research and refinement, CRISPR-based technologies will undoubtedly play a central role in shaping the future of science, medicine, and industry.

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Exploring The Spectrum of Cardiovascular Diseases and Effective Prevention: A Comprehensive Review

[1]**Miss Rutuja Dadasaheb Shriram**

[2]**Dr. Sandeep. B. Patil.**

Dr. Shivajirao Kadam College of Pharmacy, Kasbe Digraj Sangli-416312 (MH).

Email: rutujashriram98@gmail.com

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Abstract

cardiovascular diseases (cvds) remain a leading cause of morbidity and mortality worldwide. this review provides a comprehensive overview of the heart and common cvds, including stroke, coronary heart disease (chd), hypertension, atherosclerosis, heart failure, arrhythmias, and cardiomyopathy. the causes and symptoms of each condition are discussed, ranging from genetic predispositions and lifestyle factors to hypertension, cholesterol imbalance, and inflammatory processes. emphasis is placed on the importance of early diagnosis and intervention, along with lifestyle changes that can significantly reduce the risk of developing cvds. key strategies such as maintaining a balanced diet, regular physical activity, and the use of prophylactic medications like antihypertensives, statins, and antiplatelets are highlighted as essential preventive measures. this review underscores the crucial role of preventive healthcare and lifestyle modifications in combating the growing global burden of cardiovascular disease.

Keywords**:** cvd (cardiovascular disease), heart, blood pressure, vessels, blood flow.

Introduction:

the cardiovascular system supplies blood to the body. by responding to various cues, one can regulate the volume and speed of blood flowing through the veins. the cardiovascular system is composed of capillaries, veins, arteries, and the heart. the intricate relationships between the arteries and the heart ensure that all body components receive adequate blood flow. it consists of multiple parts. the sinoatrial node is the initial component of the conduction system. the sinoatrial node rhythmically initiates impulses 70–80 times per minute in the absence of any brain activation. it is referred to as the heart's pacemaker since it sets the fundamental pulse rhythm. the atrioventricular node, atrioventricular bundle, bundle branches, and conduction myofibers are additional components of the conduction system. every single one of [1][2]

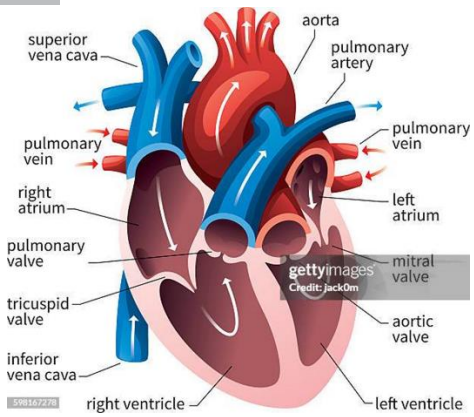

FIG 1.1 [google source]

The Human Heart's Function

The cardiac cycle is characterized by the constant pumping of blood and is regulated by electrical impulses. the sinoatrial (sa) node, the heart's natural pacemaker, is responsible for producing these electrical impulses.[2][3]

Step 1: the superior vena cava, which comes from the upper body, and the inferior vena cava, which comes from the lower body, are the two main veins that carry blood into the heart. the right atrium receives this blood that has lost oxygen.

Step 2: when the right atrium contracts, it pushes the blood to the right ventricle through the tricuspid valve.

Step 3: the right ventricle contracts and the deoxygenated blood passes through the pulmonary valve with the help of the pulmonary artery.

Step 4: the blood is passed to the lungs through the pulmonary artery, in the lungs the blood picks up oxygen and releases carbon dioxide. now the blood becomes oxygenated.

Step 5: this oxygenated blood then comes back to the heart's left atrium through the pulmonary veins.

Step 6: the left atrium contracts and pushes the oxygenated blood to the left ventricle through the mitral valve.

Step 7: the left ventricle pumps oxygen-rich blood through the aortic valve with the help of the aorta. the left ventricle is the strongest chamber of the human heart.

Step 8: aorta is the largest artery of the human body and it distributes oxygenated blood to all the parts of the body by a complex network of blood vessels.

The normal systolic and diastolic values are:

systolic pressure: 120 mm hg
diastolic pressure: 80 mm hg

The heart is the organ in charge of pumping blood through the vessels. blood is directly circulated into the aortic or pulmonary arteries by it. blood arteries are vital because they control the amount of blood that flows to specific bodily parts. blood vessels include arteries, capillaries, and veins. blood can be transported from the heart by arteries that can divide into large and microscopic arteries. large arteries receive the highest blood flow pressure since they are more elastic and thicker to sustain the high pressures.[4]

Objective:

To understand the full range of cardiovascular disease manifestation, their underlying causes,and associated risk factors with the aim of identifying and evaluating effective prevention strategies.

CVDS

The most common cause of sickness and mortality is cardiovascular disease, which includes stroke. this nation is expected to have 50 million people with hypertension and 62 million with cardiovascular disease. cardiovascular disease was responsible for almost 946,000 deaths in the United States in 2000, or 39% of all fatalities there is strong evidence that coronary heart disease is mostly avoidable, according to epidemiologic studies and randomized clinical trials. but there are also indications that the illness may have a heritable component.[5][6]

a person's risk of cvd is influenced by the following factors

- high blood pressure (hypertension)
- elevated levels of "bad," or low-density lipoprotein (ldl),
- cholesterol low levels of "good" cholesterol, or high-density lipoprotein (hdl
- diabetes, obesity, sedentary lifestyle, alcohol abuse, excessive stress, poor diet, and chronic renal disease

some risk factors are not lifestyle-related, such as:

- family history of cvd
- early menopause
- increasing age

Atherosclerosis:

The process by which plaque made of calcium, fat, cholesterol, and other materials forms in the walls of big and medium-sized arteries, reducing blood flow to a particular part of the body, is known as atherosclerosis. additionally, there are two types of atherosclerotic vascular disease: cerebrovascular disease, which results in ischemic stroke in the brain, and cardiovascular disease, which affects the heart and peripheral blood arteries. the first and third main causes of death worldwide are, unfortunately, cardiovascular and cerebrovascular illnesses. approximately 28% of deaths, or 247.9 deaths per 100,000 people annually, were caused by complications from ischemic heart disease.[7]

Medium-sized and big arteries can develop atherosclerosis, a multifactorial, smoldering, immunoinflammatory condition that is fueled by lipids. leukocytes, endothelial cells, and intimal smooth muscle cells are the main contributors to the development of this illness. superimposed thrombosis is the cause of the most severe atherosclerosis-related outcomes, including heart attacks and strokes. as a result, the crucial question is not why atherosclerosis occurs but rather why it abruptly becomes complex with luminal thrombosis following years of slow progression. in the event that thrombosis-prone plaques could be identified and prevented, atherosclerosis would be a far less dangerous condition. ruptures of the plaque cause around 76% of all coronary thrombi that result in death. men are more likely than women to have coronary thrombosis due to plaque rupture (about 80% vs. 60%). cracked plaques are distinguished by a thick, lipid-rich core, angiogenesis, adventitial inflammation, outward remodelling, and a thin, fibrous cap with a high number of macrophages and few smooth muscle cells. the most prevalent cause of coronary thrombosis is ruptured plaque. both ruptured and rupture-prone plaques, it can be inferred, exhibit distinctive pathoanatomical

characteristics that may help with imaging in vivo. in order to prevent heart attacks, this article explains the pathophysiology of atherosclerosis, how it leads to thrombosis, and how to identify plaques that are prone to thrombosis.

CAD\CHD

When the coronary arteries, which are the big blood channels that carry oxygen to the heart, narrow too much, coronary artery disease (cad) results. this occurs when deposits accumulate over time in the arteries. another name for cad is coronary heart disease.

Acute and chronic cad are both possible. a heart attack results from acute coronary artery disease (cad) when a blood clot blocks one or more coronary arteries. a portion of the heart consequently receives no oxygen. acting fast is crucial because failing to do so could result in the death of that portion. a catheter, which is a thin, flexible tube, is frequently used to treat heart attacks in order to rapidly reopen the blocked artery.

Arteriosclerosis, or artery hardening, is the cause of cad. blood channels called arteries carry blood to the body's tissues and organs. small inflammations and damage to the artery wall are the first signs of arteriosclerosis. there, lipids, immune system cells, and other materials gather. we refer to these deposits as plaques. over time, they may enlarge and eventually obstruct the artery's blood supply.

Arteriosclerosis affects at least one coronary artery in cad. in the following illustration, the coronary arteries are indicated in red. the coronary veins, which are represented by the blue vessels, remove blood once their oxygen content has been depleted.[8] [9]

Stroke

A stroke is a neurological condition in which blood arteries get blocked. blood vessels burst and arteries get clogged as a result of clots that form in the brain, stopping blood flow and resulting in hemorrhage. when the arteries supplying the brain burst during a stroke, brain cells abruptly die from a shortage of oxygen. dementia and despair can also result after stroke. [10]

Pathophysiology

The pathophysiology of any illness condition is made up of its etiology, pathogenesis, and the underlying molecular, biochemical, and structural alterations that take place. a thrombus formed on fatty deposits known as atherosclerotic plaque or blood clots created by atrial fibrillation obstruct the arteries supplying the brain, causing an ischemic stroke to begin virtually instantly within minutes of the disruption of the blood supply to brain regions [5]. the ischemic core is the term used to describe the afflicted area of the brain. before the effect or effects of neuroprotective drugs are established, the majority of the cells in this situation die irreversibly. an area of salvageable cells called the ischemic penumbra surrounds the ischemic core and is frequently the focus of therapeutic measures.[11] complex molecular and cellular pathways interact to produce a variety of phenotypic symptoms, such as paresis, dysarthria, paraplegia, and hemiplegia. the area of the brain that receives blood flow from the blocked arteries may cause additional symptoms [6]. ischemia stroke is typified by a

variety of alterations in the affected ischemia core and the surrounding penumbra, much like many other neurodegenerative diseases. these alterations, both large and little, are frequently grouped under five general headings: autophagy, oxidative stress, neuroinflammation, excitotoxicity, and apoptosis. in ischemic stroke, several separate but mutually reinforcing sequences of pathogenic events interact intricately to cause cell death.[12]

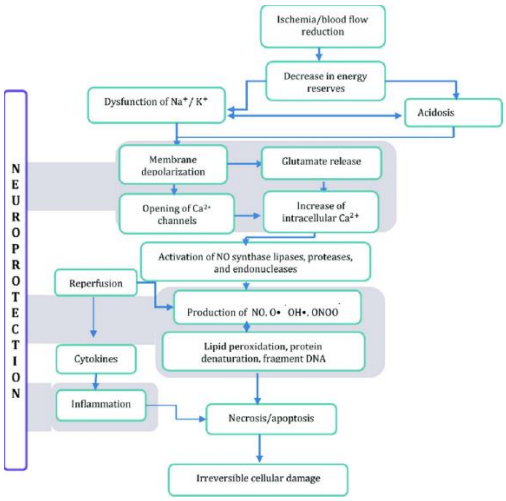

FIG.1.2 Pathogenesis of ischaemic stroke [google source]

Heart Failure

The clinical illness known as heart failure (hf) is brought on by anatomical and functional abnormalities in the myocardium that limit ventricular filling or blood ejection. though malfunction of the pericardium, myocardium, endocardium, heart valves, or great arteries, either alone or in combination, is also linked to heart failure, hf is most commonly caused by decreased left ventricular myocardial function. genetic mutations, excessive neuro-humoral stimulation, abnormal myocyte calcium cycling, increased hemodynamic overload, ischemia-related dysfunction, ventricular remodelling, excessive or insufficient extracellular matrix proliferation, and accelerated apoptosis are some of the main pathogenic mechanisms causing heart failure.[13]

For a 40-year-old male in north America or Europe, the lifetime risk of developing heart failure is approximately one in five, and it rises with age. cardiotoxic agents (e.g., cocaine, anthracycline therapy in oncology, doxorubicin, trastuzumab in treatment of breast cancer), metabolic diseases, obesity, chronic pulmonary diseases, coronary heart disease, hypertension, diabetes mellitus, a family history of heart disease, inflammation or chronic infection, and alcohol abuse are the main risk factors. cardiotoxic substances can cause acute, early-onset, or late-onset chronic cardiotoxicity. the lvef at the conclusion of treatment and the prescribed dosage are linked to cardiotoxicity, which occurs primarily within the first year of anthracycline-containing medication.[14] [15] early identification of depressed patients (echocardiographic strain imaging; cardiac biomarker troponin) and treatment (ace-i, ß blocker, switch in cancer treatment) recovery of reduced cardiac function following anthracycline-induced carditoxicity is essential. heart failure is a degenerative condition that kills roughly 10% of people each year. the primary causes of death are hypoperfusion-induced organ dysfunction or rapid cardiac death (>50%).

Arrhythmia

An irregular cardiac rhythm is called an arrhythmia. the only heart rhythm that is considered normal is a sinus beat. this rhythm is produced in the sinoatrial (sa)

node and is carried through the atrioventricular (av) node, where it is slowed down. after that, it passes via the bundle of his, the branches of the left and right bundles, and finally the purkinje fibers. arrhythmia occurs when this conduction channel is disrupted. arrhythmias can be categorized using a number of different standards. bradyarrhythmia, which is defined as a heart rate of less than 60 beats per minute (bpm), and tachyarrhythmia, which is defined as a heart rate of more than 100 bpm, are the two most common classifications based on the rate of conduction.[16]

Evaluation Of Arrhythmia

An electrocardiogram (ECG) is the initial test performed on patients suspected of having arrhythmias and is typically used to make the diagnosis. but occasionally, the patient might experience a paroxysmal arrhythmia. based on the frequency of symptoms a patient has as a result of a suspected arrhythmia, 17][18]

1. **Artrioventricular Reciprocating Tachycardia (Avrt):**

As in wolff-parkinson-white syndrome (if a delta wave is present but there is no arrhythmia, there is no need for treatment or research). [19]

2. **Tachycardia Artrioventricular Nodal Reentrant (Avnrt)**

mechanism: re-entry is caused by slow and rapid fibers found in av node and peri-nodal tissue.

Signs and symptoms include syncope, palpitations, shortness of breath, chest tightness, and sudden tachycardia.

3. **Artrial Flutter**

The most prevalent arrhythmia in the us is atrial fibrillation. over 20% of the general population will experience it at some point throughout their lives. according to their duration, there are five types:[20]

Mechanism: the tricuspid annulus in the right atrium is typically the center of the reentrant circuit. Symptoms may include palpitations, dyspnea, or hypotension, or they may be asymptomatic. Results from the ekg: a sawtooth-looking p wave with varying degrees of av block is indicative of regular tachycardia. management objectives include av blocking medications (beta-blockers or calcium channel blockers) to regulate ventricular rate; nevertheless, cardioversion or ablation to restore sinus rhythm is the preferable method. [21]

Ventricular Tachycardia

The origin of ventricular tachycardia is beneath the av node. in the us, it is the leading cause of unexpected cardiac fatalities. When the fast ventricular rhythm stops on its own within 30 seconds, it is known as non-sustained ventricular tachycardia

Mechanism: channelopathies brought on by structural anomalies, electrolyte imbalances, metabolic imbalances, and pro-arrhythmic medication effects. Ischemic or structural heart disease are risk factors. Signs and symptoms include palpitations or a lack of symptoms. [22]

Bradyarrhythmia

A heart rate below 60 beats per minute (bpm) is referred to as a bradyarrhythmia. this condition includes a number of rhythm abnormalities, such as sinus node problems and atrioventricular (a-v) blocks. bradycardia of the sinuses

Mechanism: vagal tone is elevated. in athletes, it may be physiological.
symptoms and indications: usually without any symptoms. if pathological, it may result in dizziness or orthostasis. [23] [24]

Cardiomyopathy:
Obstructive hypertrophic cardiomyopathy
Mechanism: ventricular arrhythmias are precipitated by aberrant enlargement of the heart's septal area, which blocks the subaortic outflow pathway.
Risk Factor: autosomal dominant mutation in the beta myosin heavy chain gene, which codes for cardiac sarcomeres. this should be suspected in a patient who has two first-degree relatives with a history of sudden cardiac death.
symptoms include palpitations, syncope with effort, and the onset of early heart failure symptoms.
Treatment: the cornerstone of treatment is beta-blockers. patients with obstructive physiology who have an outflow gradient more than 50 mmhg should have surgery. patients who exhibit symptoms following maximal medicinal therapy, abnormal systolic blood pressure response to exercise, septal thickness greater than 30 mm, ventricular fibrillation on telemetry, or runs of ventricular tachycardia are recommended to use the defibrillator.[25]

Cardiovascular Disease Prevention Bt Diet Modification
Reducing excess calories and altering the diet's composition might help prevent primary and secondary cardiovascular issues in a variety of settings when healthful foods are readily available and economically priced. current guidelines suggest that diets should be high in fruits, vegetables, whole grains, nuts, and legumes, moderate in low-fat dairy and seafood, and low in processed meats, sugar-sweetened beverages, refined grains, and sodium. supplements cannot take the place of a balanced diet, but they might be beneficial for some people. people may choose to consume a poor diet due to a variety of reasons, including lack of knowledge, availability issues, high costs, time constraints, societal and cultural norms, marketing of subpar foods, and palatability.[26] [27]

Dietary Pattern and Diet Quality:
Dietary patterns and quality are the most comprehensive metrics for assessing eating habits. these metrics include indices based on a priori scoring, such as the alternative mediterranean diet score (amed), alternative healthy food index (ahei), and dietary approaches to stop hypertension (dash) diet score, as well as exploratory techniques like principal component analysis and cluster analysis. because it can identify possible dietary and nutrient combinations that studies of individual nutritional items cannot, a holistic assessment of the diet is helpful.[28][29] although the components and weighting of individual diet indices vary, most place an emphasis on consuming a lot of fruits, vegetables, whole grains, and nuts; moderate amounts of alcohol and low-fat or nonfat dairy; and little in the way of processed meats, sodium, added sugar, and saturated fat. [30][31] Two dietary patterns—prudent and western—have typically been found using principal component and factor analysis to account for the majority of the diversity in eating habits at the population level.while western diets contain large

amounts of processed meat, french fries, desserts, sugar-sweetened beverages, red meat, and high-fat dairy, prudent diets are abundant in fruits, vegetables, legumes, whole grains, fish, and chicken. a western eating pattern was linked to a 14% increase in risk for cvd, while those in the greatest category of adherence to a sensible diet had a 31% lower risk than those with the lowest adherence, according to a meta-analysis of 22 cohort studies (56). the similarity between results from interventions and cohort studies conducted in numerous countries for different dietary components and indicators the causal effect of a healthy diet in preventing cvd is supported by trials [32][33]

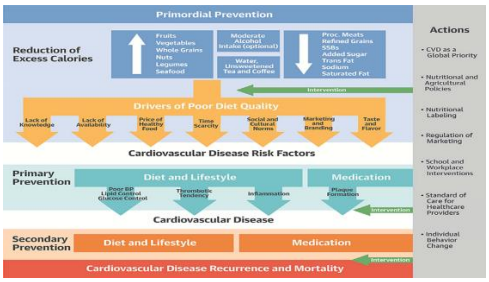

FIG 1.3. lifestyle strategies for risk factor reduction, prevention, and treatment of cardiovascular disease

[FIG 1.3 google source]

The risk of cardiovascular disease (cvd) in general and coronary heart disease in particular is significantly influenced by daily behaviors and routines. weight control, healthy eating, regular exercise, and quitting smoking have all been shown to dramatically lower the risk of cvd. a cluster of these lifestyle changes was shown to reduce the risk of diabetes and cardiovascular disease by more than 90% and 80%, respectively, in two large cohort studies. "Lifestyle medicine" is the umbrella term for the study of how lifestyle variables affect the risk of cvd. even though there is ample evidence that lifestyle choices have an impact on cvd, only a small percentage of people engage in these behaviors. [34][35]

Physical Activity

One important risk factor for chd is physical inactivity.18 however, significantly less than half of adults engage in regular aerobic exercise, even if they meet the minimal requirements. less than 20% of teenagers engage in the recommended 60 minutes or more of physical activity per day, making young people significantly less likely to meet suggested criteria.[36]

Smooking

There is substantial evidence from numerous sources that smoking cigarettes raises the risk of heart disease and stroke. this evidence has already been thoroughly compiled elsewhere. and is included in the aha 2020 strategic plan as a suggestion.3. men are somewhat more likely than women to smoke cigarettes: around 18 out of 100 adult men (17.5%) and nearly 14 out of 100 adult women (13.5%) continue to smoke. overall, 15.5% of persons who are 18 years of age or older smoke cigarettes. women who smoke cigarettes face the same health hazards as men.[37] these elements may also affect drug compliance and other aspects of lifestyle.49 treatment for these diseases may benefit from lifestyle practices including mindfulness, frequent exercise, and relaxation response.[38]

Blood Glucose/Diabetes

Diabetes is a key and well-known risk factor for cvd. heart disease (cvd) is the leading cause of disease and death among diabetics. among the most crucial

treatment strategies for reducing the risk of cvd in diabetics is lifestyle therapy, which consists of consuming a healthy diet and according to the american diabetes association, diabetes and hypertension patients should be treated to a systolic blood pressure target of fewer than 140 mm hg and a diastolic blood pressure target of less than 90 mm hg.

The acc and aha's 2017 guidelines for prevention, detection, evaluation, and management of high blood pressure in adults suggest that people with diabetes should aim for blood pressure readings of less than 130/80 mm hg.frequent exercise.[39][40]

A key component of diabetes care is lifestyle modification, which includes mnt, exercise, quitting smoking, counseling, psychosocial support, and diabetes self-management education.

In order to maintain and achieve a healthy body weight, as well as to maintain individual glycemic control and lipid goals in order to postpone or prevent problem from diabetes,mnt, encourages that healthy eating patterns that emphasize a range of nutrient dense meals at suitable levels.[41]

For those with diabetes who are overweight or obese, weight control and, if required, weight loss is crucial. with the exception of ldl cholesterol, all cardiovascular risk factors decreased in participants in the look ahead trial who dropped an average of 7% of their body weight. [42]

Result

Identification of high risk,and development of effective prevention strategies.

Conclusion

Cardiovascular disease remains a leading global health concern, with multiple types ranging from coronary artery disease to heart failure and arrhythmias. understanding the pathophysiology and risk factors of these conditions is crucial for prevention and management. prophylactic care, including lifestyle modifications such as a balanced diet, regular exercise, smoking cessation, and effective management of underlying conditions like hypertension and diabetes, plays a pivotal role in reducing the burden of cvd. additionally, early detection and the use of pharmacological interventions like statins and antihypertensives can further mitigate risks. comprehensive public health strategies focusing on education, prevention, and timely treatment are essential to curb the growing incidence of cardiovascular diseases worldwide.

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Soil testing for its physical parameters from Jalna District, Maharashtra

[1]Dr. More R.D,

[2]Dr. Chavan S.D,

[3]Dr. Moharir S.P.

[1,2,3]Dept. Of Chemistry, Siddharth Arts, Commerce and Science College, Jafrabad. Dist. Jalna-431206 (M.S.)

Email: rahuldmore2@gmail.com

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Abstract

The main objective of present study is to analyse the soil in the rural areas of Jalna district, Maharashtra. And aware the farmers about soil testing so that they can use appropriate number of fertilizers to crops and increase fertility of soil and increase productivity. So, the income also will be increased of rural area. For this investigation four villages selected named Sipora-Ambhora, devulgaon jhari, varkheda viroa and Dahigaon of Jalna District. Soil collected from these rural villages is analysed for their physical parameters. Physical parameters such as Temperature, PH, Moisture content and Electrical conductivity studied. Data is provided to farmers and on the basis of this data idea given to farmers for using which fertilizer should be used to particular type of soil.

Keywords: PH, Nutrients, Fertilizers, Organic Carbon.

Introduction

The upper layer of the mantle rock consisting mainly of very small particles and humus is known as “soil”, which can support the growth of plants. Soil mainly consists of mineral rock particles, portions of decayed organic matter, soil water, soil air and living organisms. The major factors on which the formation of soil depends upon are parent material, climate, vegetation, life forms and time. In general, soil is composed of four elements, Inorganic or mineral fractions derived from the parent material, Organic matter (decayed and decomposed plants and animals), Air and Water. Soil is formed under specific natural conditions and each of the elements of the natural environment contributes to this complex process of soil formation known as “pedogenesis”. [2]

Different Types of Soil in India

In the ancient period, soils were mainly classified into two – Urvara (fertile) and Usara (sterile).

The first scientific classification of soil was done by Vasily Dokuchaev. In India, the Indian Council of Agricultural Research (ICAR) has classified soils into 8 categories. [1] The types of soil in India according to this are:

1. Alluvial Soil

Alluvial soils are widespread in the northern plains and river valleys. It covers about 40% of the total land area of the country. They are rich in potash but poor in phosphorus.

2. Black Cotton Soil

Black soil is also known as "Regur Soil" or the "Black Cotton Soil". It covers about 15% of the total land area of the country. Black soils are rich in iron, lime, aluminum, magnesium and also contain potassium. However, these soils are deficient in nitrogen, phosphorus and organic matter. Cotton, pulses, millets, castor, tobacco, sugarcane, citrus fruits, linseed, etc. are mainly cultivated in black soil.

3. Red & Yellow Soil

Also known as the "omnibus group". It covers about 18.5 % of the total land area of the country. It is found in regions of low rainfall This type of soil is generally deficient in nitrogen, phosphorus and humus. Wheat, cotton, oilseeds, millets, tobacco, and pulses are mainly cultivated in red and yellow soil.

4. Laterite Soil

The name has been derived from the Latin word "later" which means brick. It accounts for about 3.7% of the total area of the country. These are typical soils of the monsoon climate which is characterized by seasonal rainfall. With rain, lime and silica are leached away, and soil rich in iron oxide and aluminum are left leading to the formation of laterite soil. Laterite soil is deficient in organic matter, nitrogen, phosphate and calcium; however, iron oxide and potash are in abundance.

5. Mountainous or Forest Soil

This type of soil is found in forest regions where rainfall is sufficient. The texture of the soil depends on the mountain environment where they are found. The soils found in the lower valleys are fertile. Also called forest soil

6. Arid or Desert Soil

Also known as arid soil, it accounts for over 4.42 % of the total land area of the country. The color ranges from red to brown. Desert soils are sandy to gravelly in texture, have low moisture content and low water-retaining capacity.

7. Saline and Alkaline Soil

These soils have high percentages of sodium, magnesium and potassium, and hence are infertile. The high salt content is mainly because of the dry climate and poor drainage

8. Peaty and Marshy Soil

These soils are found in regions of heavy rain fall and high humidity, and it supports the good growth of vegetation. Peaty soils are rich in humus and organic matter. These soils are generally heavy and black in color. In many places, these soils are alkaline. These are found in southern Uttarakhand, the northern part of Bihar, and the coastal areas of West Bengal, Odisha and Tamil Nadu.

Soil testing for nutrients is important for farming because it helps ensure that plants have the right amount of nutrients at the right time. In India, soil testing can

help farmers for identifying nutrient deficiencies. Soil testing can help farmers to identify nutrient deficiencies and add the right fertilizers to make up for them. Soil testing can help farmers create a cost-effective plan for managing nutrients. Nutrient imbalances can severely impact plant growth. For example, too much nitrogen can cause fertilizer burns, while too little can stunt plant growth.

For increasing the agricultural productivity and production the management of soil testing based upon nutrients has emerged as a key issue. Optimal use of nutrients based on soil testing or analysis can increase crop productivity and reduce the waste of these nutrients leading to increase the productivity. The research work on the crop in a particular area should be conducted and the management practices of the concerned farmer. The result of the soil analysis confirms which fertilizer recommended was the actual connecting link between agricultural research and its practical application in the fields of the farmer. Farmers use large quantities of chemical fertilizers as nutrients, without soil analysis. For plant growth a small amount of fertilizer is needed. The farmer finds difficulty in knowing the proper use of fertilizers, which would match soil of their field. Farmer must take into account that what is the requirement of fertilizer to their crops. Soil analysis is the solution to this problem of the farmers. Analysis is based on various physical and chemical parameters. Soil analysis can improve the crop fertility, productivity and wastage of fertilizers. Soil is composed of both organic and inorganic matter and it is essential for life on earth to exist. Soils are 45% mineral particle size, 5% organic matter, 25% air and 25% water etc. The combination of texture, structure, porosity, chemistry, colour and temperature are the properties of soil. Soil is made up of different- sized particles. Sand particles tend to be the biggest [2]. Present study is an attempt to determine the amount of nutrients in Soil of Jalna District, Maharashtra. This knowledge will help farmers determine how much fertilizer they should use for taking maximum production of crop in their farm.

Material and Methodology

Material

Four Soil Samples were collected from Jalna district, Maharashtra. Soil samples collected (from the 0 to 10 cm depth) from field were cleaned from herb and plant remains.[3]

Soil samples were collected in plastic sample bags. Plant residues and stone pieces were removed by hand. Soil sample were air dried and passed through a 2 mm brass sieve. Samples were stored at 30°C Temperature in oven until use. Then 100g soil sample was transferred to sample bag. Sampling date, Location of the sampling and sampling number were marked on the bags and soil samples were brought to the laboratory. Four samples were selected and study was carried out based on wide range of physio-chemical properties and chemical properties.

Table 1 List of Collected Soil samples.

Sr. No	**Sample Name**
1	Sipora Ambhora
2	Deoolgaon jhari
3	Warkheda viro
4	Dahigaon

Longitude and latitude

Methods

The soil samples were brought to laboratory for further analysis. The soil reaction (pH) and electrical conductivity (EC) were determined as per the procedure described by suspension method. The suspension method for analysing soil pH and electrical conductivity involves preparing a soil-water suspension and measuring its pH and electrical conductivity: [5]

1. **Preparation of the soil-water suspension**

Known amount of air-dry soil taken into a container after weighing, added deionized water, and shake to dissolve soluble salts. The standard ratio is 1 part soil to 5 parts waters.

2. **Measuring the pH**

pH meter is used to measure the pH of the suspension. Dip the electrode into the solution, stir, and wait for the display to stabilize. Rinse the electrode with distilled water between samples.

3. **Measuring the electrical conductivity**

Conductivity meter is used to measure the electrical conductivity of the suspension. The meter Calibrated using a KCl reference solution. Rinse the conductivity cell with the soil suspension, then refill without disturbing the settled soil. Rinse the cell with deionized water between samples.[4]

4. **Measuring the Temperature**

Temperature of a soil is measured with help of a routine mercury thermometer in a metal cone by penetrating it into the soil up to 2 cm depth.

5. **Measuring moisture in soil**

The soil moisture content also called water content is an indicator of the amount of water present in soil. The test sample is selected in such a way that it is adequately representative of the soil from which it is collected. For the measurement of natural moisture content, the appropriate mass of specimen is about 100 gm. soil sample kept immediately in the moisture can and closed it to prevent loss of moisture by evaporation. The lid from the container removed and placed the moisture can in the oven at 105-1500C. This takes approximately 24hours. the sample is is Allowed to cool for the sometime in the oven. Then close the can sand put them in the desiccators for further cooling. When it is cooled, the lids replaced on the container and weighed.

Results and Discussions

Physical parameters

The acidity or alkalinity of the soil can be study by soil reaction or PH. The PH is very important property of the soil is it determines the capacity. The PH values fluctuated less than 7.6(table-2). The PH value for soil if acidic then it is < 6.5, if it is Normal 6.5-7.8, Alkaline 7.8- 8.5, Alkali > 8.5. This one of the most important soil properties which affect crop growth. The major source of heat is sun and heat generated by the chemical and biological activity of the soil is negligible.[6]

Total soluble salts are estimated by aqueous soil extracts from the Electrical Conductivity value of 4 soil samples were ranges from 1.17mS/cm to 3.7mS/cm (Table 2), Electrical conductivity is used to estimate the soluble salt concentrations in soil and is

commonly used as a measure of salinity. Soil with EC below 0.4mS/cm are considered marginally or non-saline, while soils above 0.8 mS/cm are considered severely saline.

The moisture content ranged from 7.4% to 5.4% from four different locations of Jalna District. The soil type was found to be sandy. The differences in texture can affect many other physical and chemical properties of the soil. Soil texture plays a prominent role in soil production. Soils with predominantly large particles tend to drain quickly and have lower fertility. Very fine texture soils may be poorly drained, tend to become waterlogged, and are therefore not well-suited for agriculture [7]

Conclusion

The soil Contain a low soluble salt and are poor in organic matter. Sandy soils are of open character usually loose and friable. Sand facilitates drainage and aeration status.

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Stem Cells: and Its Future Aspects

[1]**Amruta Sunil Gaikwad,**

[2]**Rutika D Harshad,**

[3]**Sandeep Balvant Patil.**

[1,2,3]Research Scientist, Biocyte institute of Research and Development, Sangli, Maharashtra, India

Email: gamruta021@gmail.com.

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Abstract

In recent years, stem cell treatment has emerged as a very innovative and promising area of research. High hopes have been raised by the advancement of medical procedures. The identification of various stem cells and potential treatments are the main topics of this review article. that these cells can be used to develop. In the lab, stem cell genesis is followed by carefully regulated stem cell therapies, cell culture, and derivation. Assays for teratoma development and quality control are essential tasks. when assessing the characteristics of the examined stem cells. Achieving controlled differentiation under ideal circumstances requires the use of appropriate derivation techniques and culturing media. Extracellular vesicles and graphene scaffolds can be utilized in numerous applications involving stem tissue. Because of their adaptability, based therapies should be considered. The difficulties that stem cell therapy must overcome to gain acceptance serve as a summary of the review. globally. This creates a lot of opportunities. Innovative treatment represents a paradigm shift in contemporary medicine, offering hope for incurable illnesses.

***Keywords*:** Stem cells, Differentiation, Pluripotency, Induced pluripotent stem cell (iPSC), Teratoma formation assay, Stem cell derivation, Tissue banks, Tissue transplantation.

Introduction

While embryonic stem cells (ES) are derived from human embryos, adult stem cells are derived from mature organs and tissues. Adult stem cells are the body's main tool for repairing and restoring damaged tissue. Furthermore, cells isolated from the umbilical cord after delivery are referred to as cord blood stem cells, stem cells found in amniotic fluid are known as amniotic fluid stem cells, and stem cells recovered from the placenta are known as placental stem cells. Stem cells from cord blood are

used to treat children with blood cancers. Placental stem cells can be used to produce huge amounts of fetal mesenchymal stem cells (MSCs). Every stem cell in the body is surrounded by a special area called a niche. Stem cells demonstrate the capacity to adjust when an external stressor, such as an injury or transplantation into a new habitat, modifies their niche. This suggests that they have the capacity to differentiate into a wider variety of cells that their new environment requires. For instance, milk-producing glandular structures may emerge if skin sweat gland stem cells are transplanted into mammary fat pads. Apart from adjacent stem cells covering a gap, Within the body, devoted offspring might dedifferentiate and assume the same role. Moreover, adult stem cells have the ability to develop into PSCs known as induced pluripotent stem cells (iPSCs). They are a good alternative to ES cells. [1]

Classification of stem cells

Stem cells are the non-specialized cells found in the human body. They are capable of developing into any type of organ cell. as well as the ability to refresh oneself. Both adult and embryonic cells contain stem cells. There are several expert acts. A single-potent Because its developmental potential diminishes at each step, a stem cell can only differentiate into a limited number of distinct

cell types in contrast to a pluripotent stem cell. [1] The ability to divide and differentiate into distinct organism cells is possessed by totipotent stem cells. Cell creation is made possible by totipotency, which has the highest differentiation potential. both embryonic and extra-embryonic structures. A former the totipotent cell's A zygote, which forms after a sperm fertilizes an egg, is an appropriate form. These cells could potentially unite to form a placenta or grow into a single germ layer. The core mass of cells in the blastocyst develops pluripotency around four days later. Pluripotent cells originate from this configuration. [2]

Pluripotent stem cells (PSCs) can create the cells of all germ layers; however, they cannot form extraembryonic tissues like the placenta. ESCs, or embryonic stem cells, are one example. ESCs are found in the preimplant's inner cell mass.Another example is induced pluripotent stem cells (iPSCs) derived from the epiblast layer in transplanted embryos. They start with totally pluripotent cells, like iPSCs and embryonic stem cells, and end with representatives that have lower po cells that are multi-, oligo-, or unipotent. Their pluripotency is not fixed. The tera test for teratoma production is one method for assessing their spectra and activity. iPSCs are created synthetically. from somatic cells, and they exhibit traits similar to those of PSCs. Both now and in the future, their development and use hold out a lot of potential for regenerative medicine [3].

Multipotent stem cells have a more constrained spectrum of differentiation than pluripotent stem cells, despite the fact that they can specialize in different cells of specific cell lineages. Consider

hemopoietic stem cells, which have the ability to develop into several types of blood cells, as an example.

An oligopotent cell emerges from an etic stem cell after differentiation, a process known as hematopoiesis.

Cells from that lineage are then the only ones with its special activity capabilities. However, there are some multipotent cells that can converge. [4]

Oligopotent stem cells have the ability to develop into a variety of cell types. Myeloid stem cells are one kind of stem cell that can differentiate into white blood cells but not red blood cells. One feature of unipotent stem cells is their limited capacity for differentiation and a distinctive quality of repeatedly splitting. This final feature makes them a promising candidate for therapeutic use in regenerative medicine. Only one type of cell can be produced by these cells [5].

Certain Current Uses of Stem Cells

Stem cells have a wide range of uses, including the development of artificial organs for research and transplantation as well as mitochondrial therapy. Among these modifications are:

Transplanting HSCs

To replace their destroyed bone marrow cells, patients with tumors, leukemia, lymphoma, and other blood diseases can get healthy HSC transplants. Bone marrow transplants have a long history of using allogeneic (cells from a different person), syngeneic (cells from identical twins), and autologous (patient cells) cells. regarded as common medical procedure [6]

HSC treatment (HSCT)

HSCT has been used to treat multiple sclerosis in clinical trials. Multiple sclerosis is an autoimmune disease that impacts the central nervous system. The standard approach to treating multiple sclerosis is disease-modifying treatment (DMT). The immune system is affected by DMT.by altering it, altering the trafficking of immune cells, or reducing the quantity of immune cells. However, there may be negative side effects and it needs to be taken regularly. In clinical trials, HSCT has produced superior results than DMT [6].

Therapy using placental stem cells

Placental stem cells have shown promising results and the ability to cure a range of conditions, such as Alzheimer's, pancreatic, hepatic, and myocardial infarction, muscular dystrophy, lung fibrosis, and severe lytic lesions in bones. In tissue, they are beneficial. engineering in addition [6].

Implantation of autologous limbal stem cells (holoclar)

Patients who have lost their corneal epithelium may benefit from treatment with stem cells called holoclones, which are obtained by autologous limbal cell culture. Burns to the eye that cause limbus destruction or a lack of limbal stem cells can cause blindness.In Europe, people with moderate Holoclar is now legally available to people with severe limbal stem cell deficiency [7].

Advancements in the field of artificial organ engineering

When cultivated in a three-dimensional environment under permissive development conditions, stem cells multiply and differentiate into structures that resemble their source without the need for external input. The reason these formations are called "organoids" is that they resemble organs and provide stem cells with a place to live. Organoids differ from one culture to another in terms of size, form, cell makeup, and other traits, but they also have an It cannot be replicated using current technology at the organizational level.

These organoids are used in a variety of studies. [7]

Engineering of hollow organs

Stem cells offer promising results for the development of hollow organs such as the trachea and vagina. A case study illustrates how autologous stem cells can be effectively utilized to create new trachea for patients with mustard gas. be produced with stem cells. A number of diseases that are either ignored or have inadequate treatments can be cured by using the appropriate scaffold in combination with MSCs to create an artificial vagina. [7]

Consequences of antiaging

The aging process is defined by molecular factors such mitochondrial dysfunction, telomere shortening, loss of proteostasis, DNA damage, and stem cell depletion. The metabolism of cells is gradually changed by adipose-derived stem cells to resemble young cells by decreasing reactive oxygen species, boosting mitochondrial synthesis, and encouraging mitophagy. Additionally, there is enrichment in the pathways linked to nucleotide metabolism and mitochondria [7].

Reducing damage to the mitochondria

Mitochondrial dysfunction is a major cause of many diseases that don't seem to be related, such as neurological disorders, cardiac diseases, sepsis, cancer, diabetes, and fluoroquinolone-associated impairment. MSCs support cells with mitochondrial injury or malfunction. prompt the transfer of healthy mitochondria, promote mitophagy, and hasten recovery [8].

Diabetic treatment

Different types of stem cells have been used to treat diabetes in clinical trials. Diabetes mellitus may result from genetic predispositions and lifestyle choices (type 2 diabetes), autoimmune diseases (type 1 diabetes), or even pregnancy-related hormonal changes. (diabetes during pregnancy). Although insulin injections are frequently used to treat diabetes, they have disadvantages due to their short-term effects and high cost. This issue can be resolved by stem cells directly repairing the pancreatic cells. Stem cells are also used to treat diabetes-related diseases such non-healing wounds [8]

Modelling diseases and researching differentiation

Since its inception, diPSCs have been used by researchers in a wide range of settings, such as the pathophysiology of illnesses, the production of novel iPSC-forming methods, the examination of genetic disease inheritance, the research of neurodegenerative disorders, etc. [8].

Cell-free treatment

Extracellular vesicles (EVs), such as exosomes, and membrane-bound vesicles produced from stem cells have been shown to affect neurodevelopment, neurodegeneration, neuroprotection, and improvement of brain function. Due to their non-invasive nature, EVs can the blood-brain barrier, do not result in tumors, and aid in reducing the dangers and restrictions connected to cell-based treatment [9].

Wound recovery

Because they secrete antimicrobial substances, stem cells have antibacterial capabilities, aid in the regulation of the immune system, and encourage cell proliferation and differentiation at the

wound site. Immune rejection is eliminated with the use of autologous stem cell [9]

Handling burns injuries

Stem cells show more potential and better results than current methods for treating burn injuries. The direct application of tissue-engineered transplants, stem cells, or Exosome therapy has promising results in burn wound healing [9].

The significance of research

Stem cells are being employed to investigate ailments such as congenital heart disease and neurodevelopmental disorders, as well as the influence of the environment on cell and tissue development [9]

Present Restrictions

There are several reasons why stem cell research is now progressing slowly. The majority of stem cells cannot be cultured, traditional 2D culturing methods are expensive and ineffective, it is difficult to replicate the stem cell niche, and differentiation is lost.

These include things like capacity during culturing, the lack of standardized 3D culturing methods, the absence of suitable scale-up methods, etc. PSC injections have the potential to result in teratomas, which are benign tumors made up of tissues from all germ layers. Numerous cell types are produced in placental stem cell cultures; therefore, producing extremely pure, specialized cells in a sustainable way is challenging. Furthermore, the infusion of stem cells may cause the body to produce an immune response. Therefore, it is essential to create better and more efficient solutions. [9]

Future aspects Gene editing using stem cells

Treatment options for hereditary diseases and genetic disorders are expanded by the combination of stem cell technology with CRISPR-Cas9 gene editing methods. Gene-edited stem cells may be able to treat inherited diseases and lessen the chance that dangerous Future generations would inherit the mutations.

Use of stem cells in autoimmune diseases

Stem cells have the potential to heal AIDS-related immunological deficiencies They have the ability to treat autoimmune diseases because they regulate the immune system and promote tissue regeneration. Subsequent research endeavours will centre around devising safe and effective stem cell therapies for ailments like multiple sclerosis, rheumatoid arthritis, and type 1 diabetes [10]

Regenerative health care

The goal of regenerative medicine is to use new, healthy cells derived from stem cells to replace or repair damaged or diseased tissues and organs. This could fundamentally alter the way that conditions like Parkinson's, spinal cord injury, heart disease, and others are managed. [10]

Personalised medical care

Isolating stem cells from a patient's cells has been possible since the creation of iPSCs, offering an infinite supply of distinct cells with potential therapeutic uses. Given that the patient and IPSCs can be genetically matched, the likelihood of immune rejection can be significantly reduced, and tailored

therapies for a variety of ailments can be made available. [10]

Engineering of tissues

Organoids open the door to more accurate and effective treatment methods through their application in disease modelling, medication testing, and personalised medicine [10]

Artificial bodily parts and organs

In the not-too-distant future, stem cells might be utilized to produce fully functional artificial organs and body parts. This could provide patients in need of specialized treatment and alleviate the organ shortage for transplants [10].

Value and Social Aspects

Whether human ES cells are categorized as embryos or specialized body tissue has a significant impact on their ethical acceptability. People's attitudes are influenced by this distinction; some think that early embryos have little moral standing, while others emphasize the protection of embryos. Stem cells can currently come from three different sources: adult stem cells from donors, embryonic stem cells (EG cells) from aborted fetuses, and ES cells from fragmented preimplantation embryos. Because it is challenging to distinguish viable embryogenic germ cells from spontaneously aborted tissue, there are practical challenges even though there are fewer ethical issues with obtaining stem cells from naturally aborted fetuses. About 60% of fetal malformations are caused by 20% of spontaneous abortions have chromosomal abnormalities. The use of ES or EG cells produced from elective abortions raises special ethical difficulties for those who oppose abortion or the destruction of early embryonic life. This dilemma calls into question potential complicity with suspected misbehavior, particularly in religious contexts like Roman Catholicism.When the capacity for somatic cell cloning is compared to the potential for embryonic development, it appears that the former may have greater developmental potential. Human development is naturally aided by embryonic disc cells, the source of stem cells. But these cells are pluripotent, not totipotent, because they cannot generate the necessary structures for future development when they are isolated from the embryo. The use of genetically modified embryos and mouse stem cells to grow and populate a complete creature in a 1993 Canadian study provided evidence that advanced technology could make these cells totipotent

From an Indian Point of View

More than 80 diseases, including leukemia, phagocyte abnormalities, leukodystrophy syndromes, and bone marrow failure syndrome, can be cured by HSCs derived from cord blood. Life Cell preserves and makes cord blood available to treat a number of ailments the baby may be experiencing. Companies like as Stem peutics are using bone marrow-derived stem cells to treat ischemia, diabetic foot, and osteoarthritis in the knee. Peripheral blood stem cells are used to treat Lyme disease. The Department of Biotechnology, Government of India, and the Institute for Stem Cell Science and Regenerative Medicine are in charge of several top-notch research facilities devoted to stem cell development and research, with the aim of becoming the leading institute for stem cell research

and application in India. The advancement of medical scientists

Conclusion

There is already a lot of public discussion surrounding the use of human stem cells in research. Even if stem cell research appears to have a promising future, it is imperative to address the issues and ethical issues that arise from such groundbreaking developments. The potential applications of stem cell research are endless, and the journey has only just begun.

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Role of Renewable Energy in Sustainable Development in India

Esha Yadav

Professor**,** Department of Zoology, Brahmanand P.G. College, Kanpur, 208004, India

Email: esha1880@gmail.com

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Abstract

With its rapidly growing population and expanding economy, India faces numerous challenges in achieving sustainable development. A key driver of sustainable development is the transition towards renewable energy sources. Research based on renewable energy has become an essential topic in the twenty-first century due to the higher energy crisis. On the other hand, the energy extraction process, like the combustion of fossil fuels, gives rise to the enormous pollution level in the world; thus, using these energy sources leads to the rapidly decreasing their reverse. This paper delves into the concept of sustainable development in India and the existing renewable energy policy framework. It examines the critical role that renewable energy plays in achieving the Sustainable Development Goals (SDGs), highlighting its potential to transform economies, mitigate the effects of climate change, and enhance the well-being of billions worldwide.

Keywords: Renewable Energy, Sustainable Development, Climate Change, Economic Growth

Introduction

According to the Sustainable Development Commission, “Sustainable development is the development that meets the needs of the present, without compromising the ability of future generations to meet their own needs." Sustainable development considers the societal, environmental, and economic factors to ensure optimal balance while pursuing an enhanced quality of life. While sustainability is a long-term objective, sustainable development includes the various methods and strategies that can be effectively leveraged to achieve the goal of sustainability (Dey et al. 2022).

As the world transitions to a low-carbon economy, the demand for clean and sustainable energy sources is more pressing than ever. Climate change poses a significant threat to the environment and various aspects of life, such as human and animal health, food and water security, and economic stability (Gayen et al. 2024). India faces significant environmental challenges, including climate change, extreme

weather events, changing precipitation patterns, sea-level rise, air and water pollution, deforestation, soil degradation, and biodiversity loss. These challenges are worsened by industrialization, urbanization, and intensive agriculture, which significantly strain resources, infrastructure, and the environment.

Sustainable development strategies aim to address these challenges through pollution control measures, conservation efforts, and sustainable land use practices. Sustainable development seeks to decouple economic growth from environmental degradation by promoting green technologies, resource efficiency, inclusive economic growth, social welfare programs, community development initiatives, and inclusive development policies. Sustainable development efforts include climate adaptation and mitigation strategies such as renewable energy deployment, afforestation, and climate-resilient infrastructure development (Panwar et al. 2011)

As the world grapples with environmental degradation and the urgent need to mitigate climate change, India must pave the way for a greener future. This paper sheds light on the innovative approaches, policies, and initiatives implemented to tackle environmental challenges and promote a sustainable development path. India's journey towards a greener and more sustainable future encompasses various efforts, including renewable energy projects and sustainable agricultural practices.

Renewable Energy Sources for Sustainable Development

We are already seeing the damage caused by irresponsible dependence on fossil fuel-based energy sources. The longer we pursue unsustainable development, the more frequent and severe its consequences are likely to become. Natural resources like sunlight, wind, tidal, geothermal, etc., are available all across the world, and free of cost are popularly known as renewable energy resources or non-conventional energy resources. Clean and renewable energy resources are developed due to the shortage of naturally available energy sources like fossil fuels and natural gases. Among all non-conventional energy resources, solar energy or sunlight energy is the most popular as well as widely used for the extraction of useful energy and power. Solar energy has become one of the most promising alternatives for conventional energy resources. In contrast to conventional energy resources, renewable energy resources are much more eco-friendly and much cleaner and produce energy without the harmful effects of pollution.

Renewable energy sources for sustainable development come from natural and consistent energy flow in the environment. Here is a look at some of the renewable energy sources for sustainable development:

- **Solar energy:**

Direct solar energy is a term used to describe all renewable energy sources for sustainable development that make use of direct sunlight (Barber, 2007). Ocean thermal and wind energy leverage solar energy once it is absorbed by the Earth and transformed into other forms. Solar energy makes the use of solar irradiance to produce electricity to meet

lighting needs. Moreover, solar energy is also used to produce fuel that can be leveraged for transportation or other suitable purposes (Khare et al. 2013)

- **Hydro energy:**

One of the crucial renewable energy sources for sustainable development, hydropower is generated by manipulating the elevation of water from a higher to a lower level (Bousquet et al. 2017). The energy is harnessed to produce electricity or move turbines. Powered by mature technologies, hydropower does not involve the production of any greenhouse gas and is therefore termed a green source of energy. The main benefits of using hydro-energy are that it is clean because no fuel is burned, the water needed to run the power plant is free from pollution, and it is sustainable because rainwater replenishes the reservoir (Bakis, 2007).

- **Wind energy:**

Ever since the advent of wind energy, it has taken centre stage and become one of the most reliable renewable energy sources for sustainable development. Wind energy focuses on harnessing the kinetic energy from flowing air and is primarily used to move large turbines and produce electricity (Amanda and David, 2013). This wind energy has several environmental impacts. For example, land use and landscape settings change due to wind energy development. This will influence the local biological system, the Earth's ecosystem, and the living environment, including surface climate, noise pollution, bird and bat mortality, and GHG emissions. Like solar energy, wind energy production is dependent on weather conditions. Low wind speed can reduce the efficiency of wind turbines.

- **Geothermal energy:**

Acquired from the interior part of our planet as a source of heat, geothermal energy is a reliable renewable energy source for sustainable development (Kristmannsdóttir and Ármannsson 2003). While the Earth's crust has heat in abundance, the heat is unevenly distributed. The heat is mined from reservoirs with the help of a well or other means. Once the heat reaches the surface, it can be used to produce electricity or for any other purpose that requires heat energy (Sayed et al.

- **Biomass energy:**

Recent resource depletion and environmental degradation have made the reliance of modern civilizations on fossil fuels extremely difficult (Rawindran et al. 2022). Thus, biomass energy can be considered an alternative source of fuel. The topic of biomass energy has gained traction in the renewable energy community. It is made up of solid wastes, human sewage, food processing waste, and energy crops, as well as leftovers from forests, timber, and crops (Dogan and Inglesi-Lotz, 2017; Zafar et al. 2021). The biofuels are categorized into different generations: first generation, second, and third generation (Datta et al. 2019). All these generations have their advantages and limitations,

- **Tidal energy:**

Waves on the ocean surface are created with the passage of wind. The higher the intensity of the wind and the longer the intensity is sustained, the energy produced increases significantly. The

ocean accounts for 71% of the global surface and has the potential to meet the power requirements of the world population. Energy can be obtained from oceans with the help of thermal differences between shallow and deep seawater, wind, tides, and waves

Renewable Energy and Sustainable Development: The Interrelation

Renewable energy shares a direct relationship with sustainable development. The impact that renewable energy sources have on productivity and human development allows it to open fresh opportunities in climate change mitigation, access to clean energy, social and economic development, minimizing the health and environmental impacts, and energy security (Østergaard et al 2022). Renewable energy technologies offer numerous environmental benefits, including reduced greenhouse gas emissions, improved air quality, and decreased reliance on finite fossil fuel resources (Algarni et al. 2023). These benefits contribute to long-term sustainability. Renewable energy sources are essential for achieving sustainable development and mitigating the impacts of climate change. While they offer numerous environmental benefits, their deployment should be guided by responsible practices and informed policy decisions. Continued research, innovation, and collaboration are essential to optimizing the environmental performance of renewable energy technologies on the path to a sustainable future.

To ensure a better future sustainable development attempts to balance economic, social, and environmental factors. The goal is to develop a society where everyone has access to the resources, they require to lead respectable lives without endangering the environment. The objective is to make sure that development's social, economic, and environmental components are interconnected and mutually supportive of one another.

Role of Renewable energy in the sustainable development of India

Sustainable development requires a transition from fossil fuel dependency to cleaner energy sources. This transformation's key component is renewable energy, which promises fewer negative environmental effects (Osman et al. 2022). Let's discuss a few of the most important ways that technologies for renewable energy contribute to sustainable development. Renewable energy plays a crucial role in the sustainable development of India across several dimensions:

1. Energy Security:

India's heavy reliance on fossil fuels, especially oil and coal, makes it vulnerable to price fluctuations and supply disruptions. Transitioning to renewable energy sources such as solar, wind, and biomass can enhance energy security by diversifying the energy mix and reducing dependence on imported fuels. In the contemporary world, renewable energy is a trustworthy source of power. Renewable energy technologies, especially decentralized systems, offer a cost-effective and sustainable solution to extend energy access to remote and underserved communities.

2. Environmental Sustainability:

The use of renewable energy sources helps reduce greenhouse gas emissions, air pollution, and water usage associated

with traditional fossil fuel-based energy generation. This contributes to India's efforts to combat climate change and improve environmental quality. The transition to renewable energy is widely recognized as essential for reducing CO2 emissions and combating climate change. Numerous studies have documented the environmental benefits of renewable energy (Li et al. 2023). For instance, Liu et al (2022) found that countries with higher shares of renewable energy in their energy mix tend to have lower CO2 emissions. Renewable energy sources, such as solar, wind, and hydroelectric power, produce little to no CO2 emissions during operation. Research by Miremadi et al (2023) and Mo et al (2024) indicates that increasing the share of renewable energy in the energy mix can significantly reduce a country's carbon footprint.

3. Economic Development:

The renewable energy sector has the potential to create jobs and stimulate economic growth. India's renewable energy targets have led to significant investments in the sector, driving innovation, manufacturing, and infrastructure development. Particularly in the production and installation of renewable energy systems, renewable energy technologies have the potential to boost economic expansion and create jobs (Agrawal et al. 2024). For instance, the expansion of the solar power industry has resulted in the creation of a large number of jobs in the fields of solar panel manufacturing and system installation.

4. Rural Development:

By providing rural people with access to energy, renewable energy technologies can support the development of rural areas by enhancing agricultural output, driving economic growth, and enhancing the quality of life. It is vital to consider how our environment is impacted by everything in it. It is everyone's responsibility to protect the environment and natural resources. Over many years, severe climatic shifts have resulted from the uncontrolled utilisation of non-renewable resources. As a result, adopting renewable energy will improve energy access in rural areas, thereby promoting economic activities, education, and healthcare services and contribute to reducing climate change and ensuring a sustainable future.

5. Energy Access:

India has a large population without access to modern energy services. Renewable energy sources can boost energy security by reducing the need for imported fuels and boosting the reliability of the energy supply. By using readily available resources like solar and wind power, nations can increase their energy independence and decrease their reliance on foreign energy sources (Rajakumar and Khare, 2021). The Indian government has initiated several measures to bring electricity to all areas. Investment policies in renewable energy have boosted energy accessibility to a larger level and helped people all around the country, even those in distant places.

6. Mitigation:

By reducing reliance on fossil fuels, renewable energy plays a crucial role in the reduction of greenhouse gases and mitigating climate change. India's efforts to increase the share of renewables in its energy mix are aligned with its

commitment to the Paris Agreement and global climate goals.

Conclusion

Renewable energy sources have become a vital component of sustainable development efforts worldwide. Here we explore the environmental impacts of various renewable energy technologies, aiming to shed light on their contributions to a more sustainable future (Tian et al. 2024). We assess the advantages and disadvantages of renewable energy sources, highlighting their potential to mitigate climate change and reduce dependence on fossil fuels while addressing their environmental challenges. This chapter examines the environmental impacts of renewable energy technologies, including wind, solar, hydro, geothermal, and biomass energy, and evaluates their potential to contribute to a sustainable future. Wind energy is one of the fastest-growing renewable energy sources, with minimal greenhouse gas emissions during operation. However, concerns arise regarding land use, noise, and impacts on wildlife. Advances in technology and proper site selection can mitigate these concerns. Solar energy is clean and abundant but involves energy-intensive manufacturing processes. It also raises issues related to land use and disposal of photovoltaic panels at the end of their life cycle. Research into recycling and sustainable manufacturing practices is vital. Hydropower is a mature renewable energy source, but dam construction can disrupt ecosystems and alter water flow. Proper planning, fish ladders, and habitat restoration efforts can minimize these impacts. Small-scale hydropower and run-of-river projects offer more environmentally friendly alternatives. Geothermal energy has minimal environmental impacts compared to other renewables. However, drilling geothermal wells and managing geothermal fluids can pose challenges. Improved drilling techniques and responsible fluid management are crucial to reducing these impacts. Biomass energy has the potential to be carbon–neutral, but its sustainability depends on responsible land use and feedstock selection. Clearing forests for biomass production can lead to deforestation and loss of biodiversity. Sustainable feedstock sourcing and efficient conversion technologies are essential.

The transition to renewable energy is not without challenges. Intermittency, energy storage, and resource availability are issues that require technological innovation and effective policy measures. Trade-offs between environmental conservation and renewable energy development need to be carefully balanced. Effective policies and regulations are crucial for maximizing the environmental benefits of renewable energy. India is fourth in the world with a perspective of total renewable energy scope (including large hydro), wind power capacity, and solar power capacity (Gielen et al., 2019). Solar energy dominates India's renewable energy mix, with a total installed capacity of 63.3 GW. Wind energy is the second-largest contributor, with a full installed capacity of 41.9 GW, followed by biomass and small hydro with 10.2 GW and 4.93 GW, respectively (Electricity Market Report 2023, IEA, Paris, 2023) (Korkovelos et al. 2018). India pledged a 40% share of electricity production from non-fossil feedstock at COP-21 in Paris in 2015.

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ADVANCES IN SCIENCE AND TECHNOLOGY

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Revolutionizing Cancer Care with Immunotherapy

[1]Ms. Vinaya Vasant Patil,

[2]Ms. Sandra Balakrishnan,

[3]Ms. Ruchika Amish Yadav.

[1,2,3]Assistant Professor, Department of Botany, SIES College of Arts, Science and Commerce (Empowered Autonomous), Sion (W)

Email: vinayap@sies.edu.in

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Abstract

Cancer immunotherapy has revolutionized cancer treatment by harnessing the body's immune system to target and eliminate cancer cells. Unlike traditional treatments such as surgery, chemotherapy, and radiotherapy, which directly target tumors, immunotherapy aims to stimulate or re-engineer the immune response, selectively attacking cancer cells while sparing healthy tissue. The concept of cancer immunotherapy dates back to the late 19th century when Dr. William B. Coley first observed that bacterial infections could lead to tumor regression. Over time, advancements such as immune checkpoint inhibitors, CAR-T cell therapies, monoclonal antibodies, cancer vaccines, and oncolytic virus therapies have shown promising results in treating various cancers. Immune checkpoint inhibitors, such as pembrolizumab and nivolumab, block proteins like PD-1 and CTLA-4, which prevent immune cells from attacking tumors. CAR-T cell therapy involves modifying a patient's T cells to express receptors specific to cancer cells, enhancing the body's ability to target and destroy tumors. Monoclonal antibodies are engineered to target cancer-specific antigens, marking cancer cells for destruction. Cancer vaccines aim to stimulate an immune response against specific tumor-associated antigens, while oncolytic viruses directly infect and kill cancer cells, also triggering immune responses. Despite the successes of immunotherapy, challenges remain, including immune-related side effects, tumor heterogeneity, and immune evasion mechanisms. Tumor cells can often adapt to avoid immune detection, complicating treatment. Advances in personalized cancer therapy, driven by genetic profiling and bioinformatics, are key to overcoming these challenges. By tailoring treatments to individual genetic and molecular tumor profiles, personalized immunotherapy aims to improve efficacy and minimize side effects. As research continues, immunotherapy is expected to become a cornerstone of cancer treatment, offering durable responses and improved outcomes for patients.

Keywords: Cancer immunotherapy, immune checkpoint inhibitors, CAR-T therapy, monoclonal antibodies, personalized medicine.

Introduction

Human body is a perfect example of coordinated communication. The human body functions as a complex organ system made up of multiple interdependent systems that work in harmony to support life. These systems collectively meet the needs of cells, tissues, and organs, and their cooperation is essential to maintaining balance, or homeostasis, for overall health. The functioning of each organ system is driven by its organs, which are composed of tissues and ultimately by cells – the fundamental and functional units of life that control and sustain the activities of the human body. Hence, human body removes old and damaged cells by the processes namely, apoptosis and necrosis; replacing them with healthy ones by the process of cell division. A dynamic balance between cell death and division maintains tissue homeostasis, which ensures that cell numbers remain relatively constant in tissues and organs, and that the body's structure and function are preserved.

When the balance between cell death and cell division is disrupted, tumours may develop, which can invade nearby tissues and spread to other parts of the body. This compromises organ function and overall health and, if left untreated, can lead to death. This condition is known as cancer. In addition to mutations, epigenetic modifications, or epimutations, can also lead to an imbalance between cell division and death. Mutations affect coding DNA, leading to the activation or deactivation of key genes or proteins involved in regulating cell division and cell death. In contrast, epimutations modify chromatin structure through epigenetic mechanisms, which upregulate or downregulate gene expression without altering the DNA sequence itself. [1]

Mutations and epimutations enable a normal cell to acquire the characteristic features of cancer cell, as outlined by Hanahan and Weinberg, which include: the ability to proliferate without external growth signals, insensitivity to growth-inhibitory signals, resistance to programmed cell death (apoptosis), unlimited replicative potential (immortality), the capability to develop new blood vessels (angiogenesis), and the potential to invade surrounding tissues (invasion) and eventually spread (metastasis). [2]

As per WHO report, global cancer cases are rising significantly, with around 20 million new cases reported in 2022 and projections suggesting this could increase to 35 million annually by 2050 due to population aging and growing exposure to risk factors like tobacco, alcohol, obesity, and environmental pollutants. Lung, breast, and colorectal cancers remain the most prevalent worldwide. [3]

Surgery, chemotherapy, and radiotherapy – conventional treatments have been essential, yet they also have their limitations. Recent advances are introducing more targeted and innovative therapies, which include stem cell therapy, gene therapy, immunotherapy, hormone therapy and targeted therapy along with use of nanotechnology for diagnosis and drug delivery system. [4]

Immune System:

The immune system serves as the body's defense mechanism, guarding against harmful invaders like bacteria, viruses, fungi, and parasites. In addition to recognizing pathogens, the immune cells also detect virus-infected cells and cancer cells that display altered antigens on their surface. The immune system comprises of primary and secondary lymphoid and cells of immune system. Bone marrow and thymus – the primary lymphoid organs are involved in the production and maturation of lymphocytes, whereas secondary lymphoid organs, including spleen, lymph nodes, Peyer's patches in the intestine and other mucosal tissues, are the sites where mature immune cells become activated by encountering pathogens. [5]

The immune system responds to foreign invaders and altered self-cells through two main mechanisms: humoral immune response and cell mediated immune response. In the humoral response, antibodies recognize antigens presented on the surfaces of bacteria, viruses, or altered self-cells (like infected or cancerous cells). Upon recognition, these antibodies, secreted by T helper (TH) cells, bind to the surface of the targets. Once coated with antibodies, these cells are more readily identified, engulfed, and destroyed by phagocytic cells, such as macrophages and dendritic cells, or eliminated by cytotoxic cells, for example, natural killer (NK) cells. In case of cell mediated immune response, macrophages and dendritic cells – the antigen presenting cells (APCs) recognize, engulf and digest the foreign invaders. They then display fragments of their digested proteins i.e. small peptides (processed antigens) to helper T (TH) lymphocytes, using major histocompatibility complex (MHC) molecule, specifically MHC II. TH lymphocytes with the help of T cell receptors (TCR) recognize these presented antigens and work to eliminate the infection. In case of altered self-cells, MHC class I molecule present on their surface, present small peptide fragments derived from processing of altered proteins to cytotoxic T (TC) lymphocytes. These fragments are recognized by cytotoxic T lymphocytes, which then target and destroy the affected cells. [5,6]

Introduction to Cancer Immunotherapy:

Cancer immunotherapy represents one of the most innovative approaches in modern medicine, focusing on harnessing the body's own immune system to identify and attack cancer cells. Unlike traditional therapies, which generally target tumours directly, immunotherapy works by stimulating or re-engineering the immune response to recognize cancer as a threat, aiming for selective targeting and destruction of malignant cells while sparing healthy tissue.

History of Cancer Immunotherapy:

Interest in using the immune system to treat cancer dates back to the late 1800s with Dr. William B. Coley, who observed that some cancer patients improved after bacterial infections. He developed "Coley's toxins," a mixture of killed bacteria, which showed some success but had inconsistent results, leading to the preference for radiation and chemotherapy. Research into cancer

immunotherapy slowed mid-20th century until Helen Coley Nauts founded the Cancer Research Institute in 1953. In 1957, E. Donnall Thomas explored bone marrow transplants for leukemia. In the 1980s, Dr. Steven Rosenberg advanced the field by using immune cells to treat melanoma. By the 2010s, breakthroughs like immune checkpoint inhibitors and CAR T-cell therapies demonstrated long-term remissions in some patients. In 2013, Science recognized cancer immunotherapy as the "Breakthrough of the Year." Today, targeted therapies and genetic profiling help tailor treatments, making cancer therapies more effective and less toxic. [7]

Types of Cancer Immunotherapy:

There are various forms of immunotherapy used in cancer treatment.These include: Immune checkpoint inhibitors, T-cell transfer therapy, Monoclonal antibodies, Treatment vaccines/ cancer vaccines and Immune system modulators.

1. Immune Checkpoint Inhibitors (ICI)

Immune checkpoints are regulators that prevent strong immune responses that could damage healthy cells. These checkpoints activate when proteins on T cells (immune checkpoint proteins) bind to partner proteins on other cells, including cancer cells, which sends a signal to turn off the T cells. This mechanism can allow cancer cells to evade destruction. Immune checkpoint inhibitors are drugs that block these interactions, preventing the "off" signal and enabling T cells to attack and eliminate cancer cells. For example, CTLA-4 binds to the co-stimulatory molecules on antigen-presenting cells and limits T-cell proliferation; whereas PD-1 binds with PD-L1 on tumour cells to inhibit the activity of activated T cells. Monoclonal antibodies, such as pembrolizumab, nivolumab, and ipilimumab, are widely used in cancer treatment to block immune regulators like CTLA-4, PD-1, and PD-L1. Immune checkpoint inhibitors are approved for treating various cancers, including breast, bladder, cervical, colon, head and neck, Hodgkin lymphoma, liver, lung, kidney (renal cell), skin (including melanoma), stomach, rectal cancers, and any solid tumor with defective DNA repair. [8, 9]

2. T-Cell Transfer Therapy

T-cell transfer therapy, also known as adoptive cell therapy, boosts patient's immune cells' ability to fight cancer. It includes two main types: TIL therapy and CAR T-cell therapy. Both involve collecting patient's immune cells, growing them in the lab, and then infusing them back into patient's body. Both therapies may involve chemotherapy or radiation beforehand to enhance the effectiveness of the transferred cells. [10]

TIL therapy: TIL therapy makes use of tumour-infiltrating lymphocytes (TILs) from patient's tumour. These lymphocytes are able to recognize the cancer cells but their low count at the site reduces their ability to clear the tumour. The goal of this therapy is to increase the number of these T cells in vitro and transfer them into patient's body. A TIL therapy named lifileucel (Amtagvi) has received approval from the Food and Drug Administration (FDA) for the treatment of melanoma. [10]

CAR T-cell therapy: Chimeric Antigen Receptor T-cell (CAR-T) therapy modifies patient's T cells to produce a receptor specific to cancer cells known as chimeric antigen receptor (CAR), which enables them to target specific cancer cell proteins more effectively. [10]

3. Monoclonal Antibodies

Monoclonal antibodies are lab-engineered molecules designed to target specific antigens on cancer cells, either marking them for destruction by the immune system or directly inducing cell death. It is a type of targeted cancer therapy that uses monoclonal antibodies engineered to interact with particular targets on cancer cells. Some monoclonal antibodies also act as immunotherapy by assisting the immune system in targeting cancer cells. There are three types of mAbs: naked, conjugated, and bispecific. Naked mAbs trigger immune responses like cytotoxicity, apoptosis, and receptor blocking (e.g., HER2). Conjugated mAbs deliver chemotherapeutic or radioactive agents directly to tumors. Bispecific mAbs combine two IgG chains to bind distinct antigens, enhancing treatment efficiency and reducing the frequency of administration. Examples: Rituximab binds to the CD20 protein on B cells and certain cancer cells, prompting the immune system to destroy them. Other monoclonal antibodies, like blinatumomab (Blincyto®), help bring T cells closer to cancer cells by binding to both CD19 on leukemia cells and CD3 on T cells, enabling T cells to kill the leukemia cells more effectively. [11, 12]

4. Cancer Treatment Vaccines

Cancer treatment vaccines, harness the body's immune system to provide durable responses and prevent recurrence. Combining vaccines with treatments like immune checkpoint inhibitors, chemotherapy, or radiotherapy can enhance their effectiveness. These vaccines work by recognizing tumor-associated antigens, which are substances found on cancer cells but not on normal cells or present at much lower levels. Cancer vaccines include DNA, peptide, dendritic cell (DC), and whole-cell types, each with unique benefits and challenges. DNA vaccines enhance T cell production and can be combined with immune checkpoint inhibitors for stronger antitumor effects. For instance, the DNA vaccine VGX-3100 targets precancerous cervical lesions (CIN2/3) and is in Phase III trials. Peptide vaccines are cost-effective but often face immune suppression issues. DC vaccines, like FDA-approved Sipuleucel-T (PROVENGE) for metastatic prostate cancer, use patient cells to trigger responses. Whole-cell vaccines use modified tumor cells but face challenges like immune tolerance. Combining these vaccines with other treatments may enhance efficacy. Overall, cancer vaccines are a developing area with challenges in immune response variability, but they show potential, especially when combined with other therapies. Oncolytic virus therapy uses viruses that selectively infect and destroy cancer cells without damaging normal cells. The FDA-approved therapy T-VEC (Imlygic®), derived from herpes simplex virus type 1, is injected into tumors, where it replicates, causing cancer cells to burst. This releases

substances that trigger an immune response throughout the body. [12, 13]

5. Immune System Modulators

Immune system modulators include cytokines, BCG, and immunomodulatory drugs, all of which play a role in enhancing the immune response to cancer.

Cytokines: White blood cells produce cytokines which regulate the immune system's response to cancer. Interferons (e.g. INF- α), can activate white blood cells like natural killer cells and dendritic cells to respond to cancer cells. Interleukins (e.g., IL-2), stimulates the growth of white blood cells like killer T cells and natural killer cells, helping to boost the immune response against cancer. IL-2 also aids B cells in producing substances that target cancer cells. Hematopoietic growth factors, such as erythropoietin, IL-11 and Granulocyte-macrophage colony-stimulating factor (GM-CSF), are used to counteract side effects of cancer treatment by promoting the production of red blood cells, platelets, and white blood cells, reducing the risk of infections and supporting immune functions against cancer. [14]

BCG: Bacillus Calmette-Guérin is a weakened form of the tuberculosis bacteria, used primarily for treating bladder cancer. When introduced directly into the bladder, it stimulates an immune response that targets cancer cells. It is also being researched for use in other cancer types. [14]

Immunomodulatory drugs: These drugs boost immune function and include drugs like thalidomide (Thalomid®), and pomalidomide (Pomalyst®). Thalidomide and pomalidomide work by increasing IL-2 production and inhibiting tumor growth by preventing the formation of new blood vessels, a process called angiogenesis. [14]

Advances and Challenges in Cancer Immunotherapy:

Personalized cancer immunotherapy tailors treatments to a patient's tumor genetic and molecular profile, identifying unique mutations and antigens. Advances in genetic sequencing and bioinformatics enable therapies like neoantigen vaccines and T-cell treatments. Combining immunotherapy with chemotherapy, radiation, or targeted therapies can improve outcomes. However, stimulating the immune system can trigger immune-related adverse events, from mild inflammation to severe conditions. Research aims to mitigate these side effects with biomarkers and targeted delivery. The field is advancing rapidly, exploring RNA-based vaccines, AI-driven immune profiling, and scalable CAR-T products. Understanding tumor microenvironment interactions are crucial for overcoming immune evasion and enhancing treatment effectiveness. [15, 16, 17, 18]

Conclusion:

Cancer immunotherapy has transformed the landscape of cancer treatment, offering hope for more effective, durable responses in many cancers that were previously difficult to treat. By leveraging the power of the immune system, immunotherapy represents a promising path toward more personalized and less invasive cancer care. However, significant challenges

remain, particularly in managing side effects, addressing tumor heterogeneity, and expanding the applicability of immunotherapy across a broader spectrum of cancers. As research continues to advance, cancer immunotherapy has the potential to become a cornerstone of oncology, offering patients better outcomes and a greater quality of life. [15, 16, 17, 18]

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Environmental Setting of Jam River basin – A Case Study

[1]Dr. G. D. Mhaske,

[2]Dr. Ujwala G. Mhaske,

[3]Dr. V. M. Pagar,

[1]Dr. B. L. Gadakh.

[1]Department of Environmental Science, KRT Arts, BH Commerce & AM Science (KTHM) College, Nashik - 422002, India

[2]Department of Physics, HPT Arts and RYK Science College, Nashik- 422005, India

[3]Department of Geography, Arts, Commerce and Science College, Kalwan (Manur), Tal-Kalwan, Dist-Nashik-423501, India

Email: ganeshdmhaske@gmail.com

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Abstract

The study area is part of the upper basin of the Godavari River, administratively part of the Nashik and Ahmednagar district. This article contains a concise description of the environmental setting, the present study area with brief details on its location, physiography, drainage pattern, irrigation, climate (temperature, rainfall, humidity, cloud cover and winds), geology, forest, hydrogeology of the study area, LULC, occurrence of groundwater in Jam River Basin followed by socio-economic environment and cropping patterns. Numerous settlements in Sinnar, Sangamner and Kopargaon tehsil benefit from this river for their drinking and irrigation needs.

Keywords: Jam River basin, Environmental Setting, LULC

Introduction:

The study area is a spatial extent considered as the core of research and on which the research statements are resolute. Understanding the reasons for variations in water and soil quality requires an evaluation of climate, geology, terrain, land use and other natural factors. This chapter has explained Location, Physiography, Drainage, Irrigation, Climate, Geology, Soil, Forest, Hydrogeology, Socioeconomic environment, General development scenario, Major crops, Geography, Geomorphology, Precipitation, LULC and other topics. Jam River is the right bank tributary of the Godavari River, originates at Mhasya hills at an elevation of 883 meters near Dodi village and travels for a distance of

52.2 km before meeting Godavari River near Dauch Budruk village. In light of this, the current chapter provides information on the physical environment and socio-economic environment of the Jam River Basin. Farming is the primary source of employment in the area, and once natural resources are degraded, remediation becomes time-consuming. In consideration of different agricultural and socio-economic problems, study of environmental setting in Jam River basin is important.

Location

Jam River basin lies between 74º 6'28" to 74º 25'56" E longitudes and 19º 44'27" to 19º 52'18" N latitudes, covering an area of 636.67 sq. km. The east-west stretch of the study region is 41.23 kilometres, and the north-south extension of the region is 23.84 kilometres. Administratively part of Sinnar Tahsil (Nashik District), Kopargaon and Sangamner Tahsil (Ahmednagar District), which includes 94 villages. Dodi bk, Dodi kh, Nandur Shingote, Marhal bk, Marhal kh, Talegaon, Paragon bk, Pangari bk, Pangari Kh, Ranjangaon, Nimon, Wavi, Pathare, Pohegaon, Ghari are some of the major settlements in the basin.

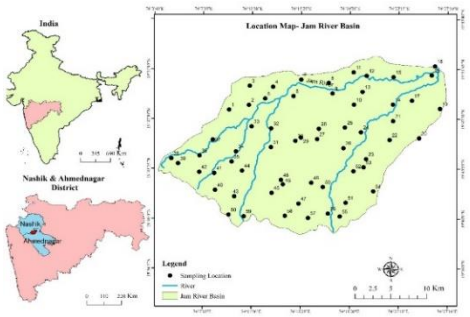

Fig.1 Location map of Jam River basin

Physiography

The Jam River basin is part of the upper Godavari River watershed. The average elevation of the Jam River basin is 585 meters, the maximum elevation in the basin is 883 meters and the minimum elevation is 500 meters. The average slope of the basin is 3.82° and the general slope of the basin is from east to west. The prominent geomorphic feature of the basin is pediplain which occupies nearly 87 percent geographic area of the basin, followed by the pediment, which occupies about 8.87 percent of the geographical area, and dissected plateau covers about 4.13 percent of the geographical area of the basin.

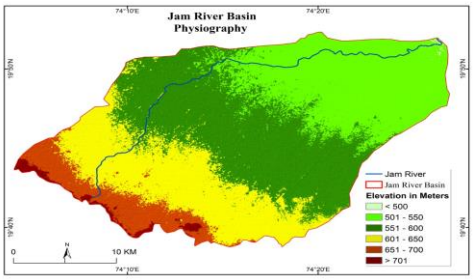

Fig. 2 Physiography of the study area

Drainage

Jam River originates at Mhasya hills at an elevation of 883 meters near Dodi village and travels for a distance of 52.2 km before meeting the Godavari River near Dauch Budruk village. The study area is part of the Godavari watershed catchments, divided by offshoots of the Sahyadri system. Jam River is the major and highest-order stream in the study area.

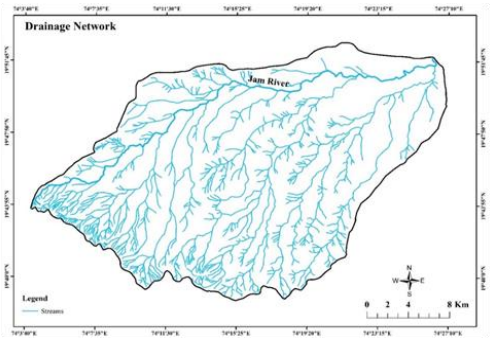

Fig. 3 Drainage map of the study area

The major tributaries of the Jam River are Sabar Nala, Khadaki Nala, Lande Nala, Gavan Nala, Dodni Nala, etc. The Jam River is the sixth ordered seasonal stream where the major river and its network form a dendritic drainage pattern. The total number of streams in the Jam River system is 695, wherein 454 are first-order streams, 185 area second-order streams, 39 are third-order streams, 13 are fourth-order streams, 3 are fifth-order streams and one first-order stream.

Irrigation

Many large and small percolation tanks are present at the banks of the Jam River and its tributaries. Small irrigation tanks at Malwadi, Pangari, Marhal, Dodi, Mirgaon, Pathare etc. are notable examples. These irrigation tanks have considerably improved the basin's potential for irrigation. These tanks are not perennial, and some of these tanks dry out during the summer. In general, farmers heavily rely on groundwater for irrigation purposes. Due to considerable groundwater availability in the downstream portions of the percolation tanks, the agricultural land is heavily irrigated, especially in the middle and lower sections of the basin. On the other hand, the majority of the land is covered in grass at the higher parts of the basin. However, there are areas of non-irrigated farmland along watercourses and hill slopes where rural residents still use conventional farming practices. The majority of the agricultural area in the basin's downstream region is irrigated, with sugarcane being the primary crop, followed by maize, onions and grains.

In the tehsils of Sinnar, Sangamner and Kopargaon, agriculture relies on the Jam River. Canal water is accessible on the Jam River basin's upper and lower reaches. The command area for the Bhojapur Dam includes the top side. One of the largest surface water delivery projects in the Jam basin is the Bhojapur dam of the Mhalungi River. The goal of this project is to supply water to portions of Sinnar and Sangamner talukas that are suffering from drought. The Nandur Madhyameshwar right canal governs a portion of the bottom side (Pathare village), and the lower canal of the Jam River basin is also served by public lift irrigation systems and private canals.

6. Climate

The climate of Jam Basin is distinguished by overall dryness throughout the year, with the exception of the south-west monsoon season. The winter season lasts from December to roughly the middle of February, while the summer season lasts until May. The south-west monsoon season lasts from June to September, whereas the post-monsoon season lasts from October to November. According to Köppen and Geiger, (1936) this climate is classified as Aw (Tropical Savanna Climate). The characteristics of the climatic phenomenon are as follows,

Table 1: Mean temperature and humidity (2018)

Month	Mean high °C	Mean low °C	Average Monthly Temp. °C
Jan	29.6	11.9	26.8
Feb	32.6	12.6	28.6
Mar	36.2	15.5	30.5
Apr	38.1	19.4	31.3
May	38.4	22.9	32.5
Jun	34.2	22.5	28.4
Jul	29.1	21.9	27.6
Aug	28.2	21.6	26.34
Sep	28.5	21.1	26.1
Oct	31.9	18.7	27.9
Nov	29.7	14.8	25.4
Dec	29.9	11.9	25.9
Year	32.2	17.9	28.1

Source: District Socio-Economic Abstract

Temperature

Jam Basin is categorized as a drought-prone region and faces frequent drought and scarcity of water. The tahsil has a semi-arid climate under the Koppen climate classification. The average annual high temperature is 32.2 °C, and the average annual low temperature is 17.9°C. The average annual temperature of Jam Basin is 28.9 °C. Summer temperatures often cross 40°C, while winter temperatures drop below 10 °C. May is the warmest month, and January is the coolest month of the year.

Rainfall

Jam River basin lies in the monsoon regime, where the south-west monsoon yields the majority of the rainfall. The average annual rainfall in the Jam Basin is 789 mm. The average rainy days in the year were around 66 days. About 30 percent of the rainfall occurs in the month of July, 22 percent in August and about 18 percent in the month of September. The Jam Basin also marks spatial variation in the rainfall. Generally, the western margins yield comparatively higher rainfall than the eastern region.

Table 2: Monthly rainfall and humidity distribution

Month	Normal Rain (mm)	Rainy Days	Humidity (%)
Jan	1.1	1	59.3
Feb	2.3	1	53.8
Mar	0.8	1	50.6
Apr	1.4	1	49.22
May	2.3	1	45.8
Jun	153.9	12	89.7
Jul	221.6	19	92.3
Aug	171.8	18	88.6
Sep	147.9	9	67.9
Oct	62	3	61.1
Nov	18.5	2	58.88
Dec	6	0	60.5
Year	789.6	68	64.80

Source: District Socio-Economic Abstract

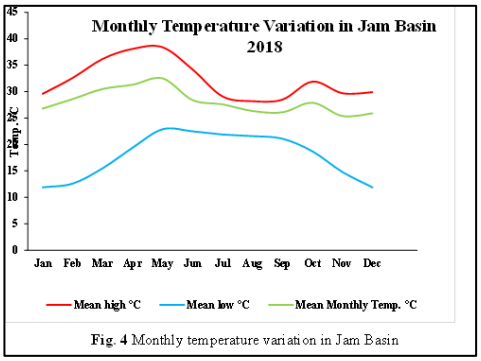

Fig. 4 Monthly temperature variation in Jam Basin

Humidity

Humidity is low during summer due to increased evaporation losses from the atmosphere. The diurnal variations in humidity during this period are high. Water vapor gets condensed due to falling nighttime temperatures and high daytime temperatures. In the Summer months, the relative humidity ranges from a minimum of 23 to a maximum of 66 percent during the day. During the monsoon period, the relative humidity varies from 72 percent to 93 percent, and the relative humidity during winter shows maximum diurnal variation varying from 35 percent to 85 percent.

Cloud Cover

During the south-west monsoon season, the sky is significantly cloudy to overcast. During the remaining period of the year, skies are mostly clear or lightly clouded.

Winds

Winds are normally low to moderate, with occasional strengthening later in the summer and during the south-west monsoon season. During the south-west monsoon season, the winds are westerly or south-westerly. Winds are light and variable in the direction in the mornings and north-easterly or easterly in the afternoons during the post-monsoon season and blow from the south-west to the north-west in the mornings and from the north to the east in the afternoons during the cold season. Winds blow from the south-west to the north-west throughout the summer.

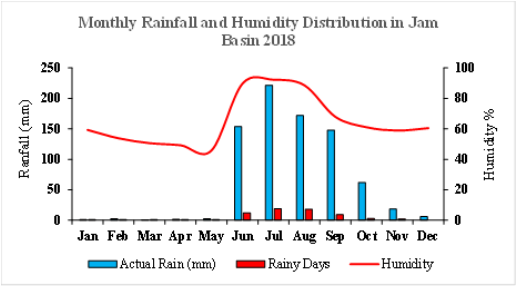

Fig. 5 Monthly rainfall and humidity distribution in Jam Basin

Geology

Geology is the basic component of the physical environment. The study area under investigation comprises basaltic lava flows of upper Cretaceous to lower Eocene age. Deccan trap comprising "pahoehoe and Aa" lava flows of the basaltic composition of late cretaceous to Palaeocene age (68 to 62 million years) occupy the entire study area. The Deccan volcanic basalt mainly characterizes the geology of this area. However, these basalts are petrologically and geochemically wide. The basalt stream is the product of a fissure-like eruption. The current is thickness ranges from less than a meter to almost tens of meters. Something like the pahoehoe lava river comprises various river units with vertical base sections Amygdales tube, a central section of dense rock and an upper section of height. In essence, vesicles are homogeneous and exhibit unique hydrogeological features locally and on a regional scale, not only at the local level. Therefore, this section shows the geology and geological features of the region, first the area, then the hydrogeological features and land use

patterns. The 'Aa' type of flow has a thin greyish clinker top which shows blocks of vesicular basalt and very fine-grained basaltic material occurring in the basal portion. However, the main section (middle part) of flow comprises dark or dark grey, dense and fresh basalt. Sometimes over this is found a section of flow breccia ranging in thickness from a few centimeters to nearly half the thickness of the flow.

Soil

Three soil groups are found in the Jam Basin: Vertic Cumbisol, Chromic Vertisols, and Calcisols. Chromic Vertisol is clayey soil with deep, broad fractures and slickened sides within 100 cm of the soil surface during certain times of the year. When they are dry, they shrink; when wet, they expand. Because of the quantity and kind of clay they all have, vertisols are a reasonably homogeneous group of soils. Chromic Vertisol occupies nearly 78.5 percent of the geographical area of the tehsil. Vertic Cumbisols are soils in the early stages of development (incipient). The commencement of pedogenesis is usually marked by a brownish discoloration under the surface horizon. Rather than a geological structure, the subsurface has soil. This soil occupies nearly 12.9 percent of the geographical area of the tahsil. Calcisols are soils with a considerable secondary buildup of calcium carbonate due to evaporation precipitation from solution in dry or semi-arid circumstances. This soil makes up roughly 8.6 percent of the geographical area. (Fig.6).

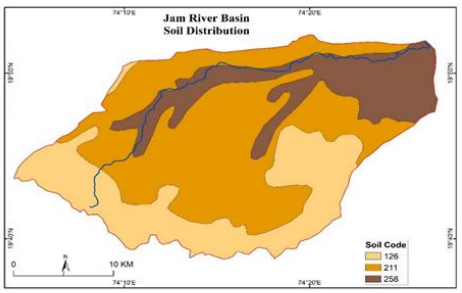

Fig. 6 Soil distribution map in the study area

Forest

The study area is part of the upper basin of the Godavari River, administratively part of the Nashik and Ahmednagar district. About 5.49 percent of the total geographical area of the study area is under forest and majority of the forest in the area categories under reserve forest. The plain region is extensively cultivated thus forest mainly found along the southern margin, eastern margin and central region of the study area. The forest in this tract is Dry Tropical Forest which are deciduous in nature. The most valuable species found is Teak (Tectona grandis) in association Shisham (Dalbergia latifolia), Bija (Pterocarpus marsupium), Saj (Terminalia tomenlosa), Dhawda (Anogeissus latifolia), Dhaman (Grewia tiliaefolia), Semal (Bombax malabaricum; Silk cotton tree), Siivan (Gmelina arborea), Kahu (Terminalia arjuna), Landia (Lagerstroemia parviflora), Harra (Terminalia chebula), Kekda (Garuga pinnata), Maharukh (Ailanthus excelsa), Moha (Madhuca latifolia),Tendu (Diospyros melanoxylon), Aonla (Emblica officinalis), Beheda (Terminalia belerica), Bhilawa (Semecarpus anacardium), Amba (Mangifera indica), Bor (Zizyphus jujuba), Palas (Butea frondosa), Babul (Acacia arabica), Khair (Acacia calechu), Anjan (Hardwickia

binata), Jamun (Eugenia jambolana), Bhosa (Bauhinia recemosa), Amalatas (Cassia fistula), Bel (Aegle marmelos), Kumbhi (Careya arborea), Gular (Ficus species), Bhirra (Chlo-roxylon swietenia), Hiwar (Acacia leucophloea). Many local variations do occur on account of soil texture, depth, topography and biotic factors. In the region with extreme aridity the babul and shrubs are found.

Hydrogeology of the Study Area

Basaltic lava flows occupy about 90% of the area. The current is arranged horizontally for long stretches. It is called a plateau. These flows occur in a layered sequence and make up a large entity with the vesicle unit at the bottom of the stream and the vesicle unit at the top. Groundwater in Deccan Traps basalt occurs in the upper part and in weathered areas, broken parts at a depth of 20 to 25 m. At a deeper level, it happens below semi-restrained in a cramped manner (CGWB, 2014). In the case of the study area, alluvium occurs in small and discontinuous patches along the banks and flood plain of river Godavari. In alluvium, granular material like sand and gravel usually occurring in a thin layer with thickness varies from 7-21 m. It comprises reddish and brownish clays with sand, gravel and kankar intercalations. Groundwater in the alluvium belt occurs both under semi-confined and confined conditions. (CGWB, 2014).

Occurrence of Groundwater in Jam River Basin

The Jam River basin is characterized by Basaltic and Alluvial types of aquifers:

Basaltic Aquifer

Basalts are the most productive aquifers of all volcanic rock types. The permeability of basaltic rocks is highly variable and depends largely on the factors like the cooling rate of the basaltic lava flow, the number and character of interflow zones, and the thickness of the flow. Fresh basalt is a generalized anxiety disorder, dark grey to dark grey, fine to medium grain and generalized anxiety disorder. A texture that indicates the presence of phenocrysts. These currents are obvious. It consists of different flow units. Each pahoehoe flow comprises flows, a unit from a dumpling to a flat plate type. These flow units rarely exceed the thickness. It shows three different parts characterized by different characteristics of 5 meters.

Alluvial Aquifer

Alluvial aquifers are generally shallower than sedimentary and fractured rock aquifers and water levels often fluctuate due to varying recharge and pumping rates. Due to their shallow and unconfined nature, alluvial aquifers are susceptible to contamination and pollution. On a local scale, the alluvium happens at the banks of Godavari, Girna, Tapi and different rivers draining the Deccan Volcanic Province. The alluvium incorporates pebble beds, sand and silt derived primarily from traps (G.S.I. 1976). The alluvium within the downstream component incorporates pebbles/gravels and coarse to fine sand with intercalated clay lenses. The alluvium in this area is composed of sand and gravel. The groundwater from this aquifer is being extensively exploited and utilized for irrigation. The water in the aquifer is predominantly

under unconfirmed conditions. However, locally confined to semi-confined conditions does exist depending upon the presence or absence of clay lenses in alluvial aquifers or the presence or absence of red beds in the basaltic aquifers.

Groundwater Balance

The calculations of the groundwater balance were done to acquire an idea of the quantitative changes in the chemical components of an aquifer system. The rainfall-infiltration approach can be used to compute the groundwater balance of an aquifer system, and this approach just approximates the recharge potential by taking a percentage of the volume of precipitation into account. The groundwater balance is calculated using the following equation:

Groundwater Recharge = Area X rainfall infiltration X average annual rainfall

Area of Jam River Basin = 636 Sq. Km

Rainfall infiltration = 10% (maximum allowable limit)

Average annual rainfall = 789 mm (average of 2020 and 2021)

Thus,

Groundwater Recharge = 636 X 0.10 X 0.789 = 50.18 M. cu. m.

Socio-Economic Environment

The area of study, as a whole, depicts a typical rural environment. The area's population primarily works in agriculture. However, over the past 20 years, a significant shift in agricultural techniques has been noted. The area has benefited from the formation of numerous agricultural businesses due to shifting land use and cropping patterns, which has improved the socio-economic status of the community.

General Development Scenario

The research area included 94 villages. This region is close to significant holy sites like Nashik, Trimbakeshwar and Shirdi. All of this draws' tourists to the region. The top side is part of the Bhojapur Dam's command area. The Mhalungi River's Bhojapur dam is one of the greatest surface water supply projects in the Jam basin. This project aims to provide water to Sinnar and Samgamaner talukas water shortage areas. The Nandur Madhameshwar right canal regulates a portion of the bottom side (Pathare village), and the lower canal of the Jam River basin is also supplied by public lift irrigation systems and private canals. The Jam River supports the region's agricultural industry. The irrigation has transformed the area's agriculture patterns and altered the local economy. Agriculture is a farmer's key occupation, with dairy and poultry production as supplements. All of these activities are supported by a strong network of cooperative societies. Since Samruddhi Mahamarg (Nagpur-Mumbai) passes through this region, the highway will be beneficial for local development.

Land Use Land Cover (LULC)

The land is the most fundamental and significant natural resource for all spheres of human activity. Therefore, knowledge of land usage is crucial for managing land resources and planning for space, especially in irrigated areas. The manner in which we use our land resources, however, is what matters most in defining the quality of our environment (Bhattacharya et al., 1989).

The quality of the soil and groundwater can be significantly impacted by land usage. Every year, the Government of Maharashtra publishes the District Statistical Abstracts, which include the land use statistics for all the villages in the district. Vink (1975) defined land use as all forms of ongoing or infrequent human interactions with the complex natural and artificial resources that make up land to fulfil his physical, spiritual, or needs.

By using the supervise image classification on a Landsat OLI/TIRS 2021 picture of the study area, ERDAS IMAGINE does the land use and land cover analysis (Fig. 7). According to the LULC classification, agricultural land makes up the majority of the study area, followed by wasteland, fallow land, built-up areas, water bodies and vegetation. The agricultural area in Fig. 7 is shown in yellow colour, and the total area occupied by agriculture is 403.92 sq. km (63.44%). The South section of the research area is surrounded by a hilly region, and the wasteland is shown by dark brown colour.

The total area occupied by wasteland is 122.50 sq. km (19.24%). Fallow land is shown by grey colour. The total area occupied by fallow land is 49.98 sq. km (7.85%). The built-up area is shown in red colour. The total area occupied by built-up is 28.13 sq. km (4.42%). The blue colour indicates the Jam River-related water bodies. The total area occupied by water bodies is 18.91sq.km (2.97%). Dark green represents vegetation. The total area occupied by vegetation is 13.24 sq. km, which is 2.08%, as shown in Table 2.4.

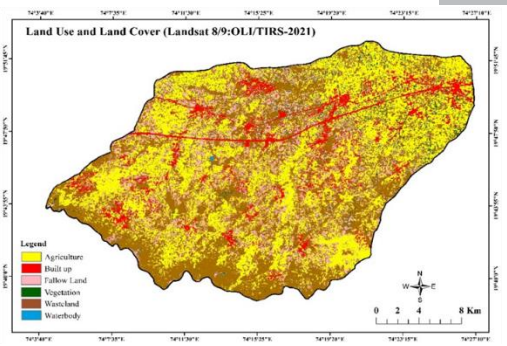

Table 3: Land Use and Land Cover 2021

LULC Classes	**Area (sq. km)**	**% Area**
Agriculture	403.92	63.44
Built up	28.13	4.42
Fallow Land	49.98	7.85
Vegetation	13.24	2.08
Wasteland	122.50	19.24
Waterbody	18.91	2.97
Total	**636.67**	**100.00**

Major Crops in Jam Basin

The major crops grown in the region are influenced by various factors, including soil and groundwater properties, local climate, soil type, irrigation system, and financial benefits. The hilly terrain, rough geology, and water scarcity during summers have led farmers to rely on traditional agricultural methods. However, mechanized farming techniques are increasingly being adopted in irrigated areas due to a shortage of available labour. In non-irrigated areas, farmers continue to use metal ploughs and animal-powered equipment.

Farming is the primary source of employment in the area, and once natural resources are degraded, remediation becomes time-consuming. The Nandur Madhameshwar dam right canal provides complete irrigation to the north-eastern region, while the Bhojapur dam canal slightly irrigates the south-west region. Both irrigation systems have contributed to changes in the cropping pattern. The main kharif crops cultivated in the region are Soybean, Bajra, Groundnut, and Maize. Wheat and Jowar are significant rabi crops. Sugarcane is the predominant cash crop grown in the heavily irrigated downstream region, playing a vital role in the local economy. Additionally, crops such as tomato, cabbage, onion, brinjal and ladyfingers are grown. In non-irrigated areas, pulses like grams, mung, tur and black gram are cultivated. Over the past decade, horticultural initiatives have focused on cultivating crops like pomegranate, guava and citrus fruits. (Note: The information provided is based on the data from the Agriculture Department of Sinnar, Sangamner, and Kopargaon Tehsil.)

Review of Literature

The following literature review summarizes some of the important results on the environmental setting, which has been the focus of countless studies over the years.

Mukherji and Shah (2005) studied groundwater irrigation, climate and poverty in India, discovering that it can be a potent instrument for enhancing rural people's quality of life. However, they also pointed out that groundwater usage without restrictions can result in environmental harm and other issues.

Shaikh et al. (2011) investigated the influence of climate change on groundwater availability for agriculture in Bangladesh and discovered that rising temperatures and shifting precipitation patterns are likely to limit groundwater recharge while increasing the demand for irrigation water. They also proposed that adaptation strategies such as rainwater gathering and enhanced irrigation technologies will be required to deal with these changes.

Deshmukh K. K. (2012 a) Studied the chemical characteristics of the soils and their classification from the Sangamner area, Ahmednagar district, Maharashtra and found that the higher values of pH in the central and downstream part of the area, which is indicative of the development of salinity/sodicity in the area. Higher EC values in the downstream region indicate slow groundwater movement and low flushing rates. The soils in the research area were created from basaltic and alluvium lithology under semi-arid climatic conditions, which are known for more significant CaCO3 precipitation and accumulation. During the rainy season, the soils are quickly saturated. The issue is made worse by the water table's depth being reduced as a result of careless irrigation and canal seepage. Thus, it is crucial to pay close attention to soil protection, especially in the irrigation region. To prevent further deterioration, farmers might be provided with regular education and training programs about the chemical makeup and quality of the soil.

Deshmukh K. K. (2012 b) Studied the soil fertility status in the Sangamner area, Ahmednagar district, Maharashtra

and found that improper agriculture practices, intensive farming, monoculture type of cropping pattern and overirrigation are responsible for the deterioration of soil quality in the area. To overcome the adverse effect of this chemical cultivation, efforts should be made to exploit all the available resources of nutrients under the theme of integrated nutrient management (INM). Under this approach, the best available option lies in the complimentary use of biofertilizers and organic manures in a suitable combination.

Pavan et al. (2017) studied the soil fertility maps using GPS technology in Baragaon Nandur, taluka Rahuri, Ahmednagar village. They found that the soil there had very low to moderate levels of available nitrogen, very low to moderate levels of available phosphorus and high to very high levels of available potassium. Only 5.77 percent of the region was determined to be inadequate in exchangeable magnesium, while the exchangeable calcium was 100% sufficient. These maps will help the farming community in the study zone use macronutrients for various crops efficiently, reducing the need for expensive inputs and increasing crop quality, productivity and yield.

Zolekar Rajendra (2018) studied Darna watershed as a case study to explore the integrated approach of RS and GIS in characterising land suitability for agriculture. The GIS-based multi-criteria evaluation strategy was found to be more effective at identifying suitable land in hilly zones. Highly and somewhat appropriate pH levels for agricultural chemical environments were discovered in the area. It concluded that agricultural productivity is positively correlated with soil depth and adversely correlated with slope, according to a correlation study.

Jiao et al. (2019) conducted a review and observed how groundwater and agriculture interact in China. He discovered groundwater depletion is a significant problem in many locations due to overexploitation for irrigation. Additionally, they mentioned that better management techniques and more efficient water use could lessen this issue.

Ushasri et al. (2019) studied GPS-GIS-based soil fertility maps of Kolhapur District, India's Bhudargad Tehsil. They led to the following conclusions: the soils of the Bhudargad Tehsil were found to be moderately acidic to slightly alkaline in reactivity and normal in salt content, indicating that the soils are free from salinity, low to high in organic carbon content and the majority of samples had high levels of available phosphorus, while the available potassium content ranged from low to high in the soils of the tehsil. This implies that nitrogen is the key limiting component in the soils, and the available Sulphur levels in the soils were low to moderate. The maps created as a result of the study will be helpful for producing homogenous units and assisting farmers in selecting the quantity and kind of macronutrients to be used in order to maximize economic returns.

The literature evaluations cited in the comments are all concerned with the relationship between environmental setting and agriculture. The evaluations emphasize several common themes, such as the importance of nitrogen management, the effects of livestock

farming, the effects of irrigation methods and climate, the effects of cropping patterns and the need for coordinated approaches to maintain groundwater quality. The reviews also identify a number of research gaps and areas in which additional research is required, such as the need for more field studies, the socio-economic impacts of groundwater contamination and the effects of climate change on groundwater quality. Overall, the literature reviews provide a comprehensive overview of the current state of knowledge on the relationship between groundwater quality, climate and agriculture, as well as useful insights into the key issues and challenges that must be addressed in the future to protect resources and sustain agriculture.

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Global Burden of Diseases: Emerging NCDs Burden and Epidemiological Transition

[1]Dr. G. Sathyavathy

[2]Dr. P. Manimegalai

[3]Mrs. G. Umamakeswari.

[1]Associate Professor, Dept of Medical Surgical Nursing, Sri Manakula Vinayagar Nursing College, Kalitheerthalkuppam, Puducherry

[2]Associate Professor, Dept of Obstetrics and Gynecological Nursing, Sri Manakula Vinayagar Nursing College, Kalitheerthalkuppam, Puducherry

[3]Dept of Medical Surgical Nursing, Chettinadu University Health and Science, Chennai

Email: gsathyavathybablu@gmail.com

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Abstract

The Global Burden of Diseases (GBD) study provides a comprehensive analysis of health loss due to diseases, injuries, and risk factors across the globe. Historically, the primary contributors to GBD were infectious diseases, particularly in low- and middle-income countries. However, in recent decades, a significant shift has occurred, with non-communicable diseases (NCDs) such as cardiovascular diseases, diabetes, cancers, and chronic respiratory illnesses now accounting for approximately 70% of global deaths. This rising NCD burden is attributed to lifestyle changes, urbanization, increased life expectancy, and aging populations, leading to a global health challenge that affects both high- and low-income countries.

The epidemiological transition explains this shift from a predominance of communicable diseases to NCDs. The transition involves three stages: the age of pestilence and famine (high prevalence of infectious diseases), the age of receding pandemics (improved control of infections), and the age of degenerative and man-made diseases (increasing NCDs). As countries progress socioeconomically, lifestyle factors like unhealthy diets, physical inactivity, smoking, and alcohol use contribute significantly to the rise in NCDs. This shift is more pronounced in urban areas, where sedentary behavior and dietary changes are prevalent.

Addressing the emerging NCD burden requires a multi-faceted approach, including policy interventions, healthcare system strengthening, and community-based preventive strategies. Effective health policies must target both modifiable risk factors (e.g., smoking, diet) and provide robust healthcare infrastructure to manage chronic diseases. The GBD study's data on mortality and disability help policymakers prioritize healthcare resources, plan interventions, and evaluate progress. Understanding the epidemiological transition and the increasing burden of NCDs is essential for implementing sustainable health strategies aimed at improving population health outcomes globally.

Keywords: Global, Non-Communicable Diseases, epidemiological, Expectancy.

Introduction:

The Global Burden of Diseases (GBD) is a systematic, data-driven effort to measure the impact of health problems worldwide. It evaluates the loss of health due to diseases, injuries, and risk factors using key metrics like Disability-Adjusted Life Years (DALYs)**,** Years of Life Lost (YLL)**,** and Years Lived with Disability (YLD)**.** Initiated by the World Health Organization (WHO) and expanded by the Institute for Health Metrics and Evaluation (IHME), GBD provides critical insights into both mortality and morbidity trends. The data informs health policies and helps prioritize resources, addressing shifting patterns from infectious diseases to non-communicable diseases (NCDs) globally.

Definitions

1. World Health Organization (WHO)

"The Global Burden of Disease (GBD) is a comprehensive, systematic effort to quantify the comparative magnitude of health loss due to diseases, injuries, and risk factors across different populations and time periods."

- World Health Organization (WHO), 2020.

"The Global Burden of Disease (GBD) is an ongoing, global project to assess the worldwide health loss from diseases, injuries, and risk factors, providing standardized and comparable data on mortality and morbidity to inform health policy." **- Institute for Health Metrics and Evaluation (IHME), 2021.**

Concept Of Global Burden of Disease (Gbd)

Global Burden of Disease (GBD): A systematic study that measures the impact of diseases, injuries, and risk factors globally, regionally, and nationally.

Purpose:

To quantify the overall health loss and identify major health challenges across populations, aiding in evidence-based health planning and policy-making.

Importance of GBD

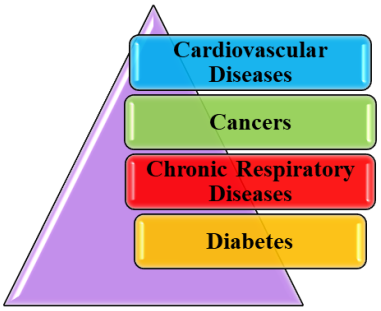
Informs Policy: Helps identify priority health issues and allocate resources effectively.

Global Comparisons: Allows for assessment of health trends and disparities across regions and time.

Risk Factor Analysis: Identifies key risk factors (e.g., smoking, high blood pressure) driving the burden of diseases.

Non-Communicable Diseases (NCDs)
Definition:
Non-communicable diseases (NCDs) are medical conditions or diseases that are not transmissible directly from one person to another.

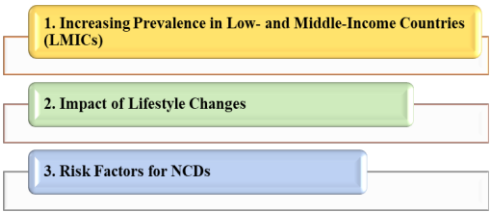
Types of NCDs:



1. Cardiovascular Diseases:
Includes heart attack, stroke, hypertension, and coronary artery disease.
2. Cancers:
Refers to a group of diseases characterized by uncontrolled cell growth (e.g., lung, breast, colorectal cancers).
3. Chronic Respiratory Diseases:
Includes chronic obstructive pulmonary disease (COPD) and asthma, affecting the airways and lungs.
4. Diabetes:
A metabolic disorder characterized by high blood sugar levels, involving insulin deficiency or resistance (Type 1 and Type 2 diabetes).
NCDs are major contributors to global mortality and morbidity, often linked to lifestyle factors such as smoking, unhealthy diet, physical inactivity, and alcohol use.

Global Trends in Non-Communicable Diseases (Ncds)

Non-communicable diseases (NCDs) are becoming a dominant health concern worldwide. These diseases include cardiovascular diseases, cancers, chronic respiratory conditions, and diabetes. The global trends show a significant increase in the prevalence of NCDs, particularly in low- and middle-income countries.



1. Increasing Prevalence in Low- and Middle-Income Countries (LMICs)
Historically, NCDs were more prevalent in high-income countries due to lifestyle factors such as sedentary behavior and high-calorie diets.
However, 80% of all NCD-related deaths now occur in LMICs, which often lack adequate healthcare infrastructure to manage these conditions.

2. Impact of Lifestyle Changes
The shift from rural to urban living has brought significant changes in lifestyle and behavior, increasing the risk of NCDs:
Urbanization: As more people move to cities, they adopt lifestyles characterized by reduced physical activity, exposure to air pollution, and easy access to processed foods.
Sedentary Behavior: The rise of technology and desk jobs has led to a decrease in physical activity, a major risk factor for obesity, diabetes, and heart diseases.
Unhealthy Diet: Increased consumption of high-calorie, low-nutrient foods (e.g.,

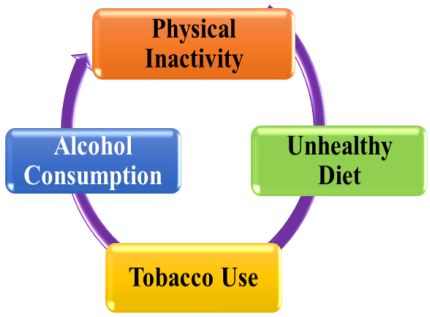
fast foods, sugary drinks) is linked to obesity and related conditions like type 2 diabetes.

3. Risk Factors for NCDs

NCD risk factors can be broadly categorized into modifiable and non-modifiable:

A. Modifiable Risk Factors

These behaviors and conditions can be changed or controlled to reduce the risk of NCDs.



1. Tobacco Use:

Smoking is a leading cause of lung cancer, chronic respiratory diseases, and heart disease.

Tobacco use is responsible for nearly 8 million deaths annually worldwide, with significant impacts in both high- and low-income settings**.**

2. Unhealthy Diet:

Diets high in saturated fats, sugar, and salt contribute to obesity, hypertension, and cardiovascular diseases.

Low intake of fruits, vegetables, and fiber is linked to increased risks of digestive cancers and diabetes.

3. Physical Inactivity:

Lack of regular exercise is a major risk factor for obesity, type 2 diabetes, and cardiovascular diseases.

WHO guidelines recommend at least 150 minutes of moderate-intensity exercise per week, yet many people fail to meet this target.

4. Alcohol Consumption:

Excessive alcohol use is associated with liver diseases, cancers, and cardio vascular issues.

Alcohol abuse contributes to risky behaviours, accidents, and a significant social and economic burden.

B. Non-Modifiable Risk Factors

These are inherent factors that cannot be changed but still influence the risk of developing NCDs.

1. Age:

The risk of NCDs increases with age, as physiological changes and cumulative exposure to risk factors take a toll on health.

The global population is aging, contributing to a higher burden of NCDs.

2. Gender:

Some NCDs have gender-specific prevalence (e.g., men have higher rates of cardiovascular diseases, while women are more affected by osteoporosis).

3. Genetics:

Family history and genetic predisposition increase the likelihood of certain NCDs, such as breast cancer, diabetes, and hypertension.

Prevention And Control of Non-Communicable Diseases (Ncds)

1. Primary, Secondary, and Tertiary Prevention Strategies

A. Primary Prevention

Health Education: Raising awareness about the importance of healthy diets, physical activity, and avoiding tobacco and excessive alcohol consumption.

Vaccination:

Preventing infections that may lead to certain cancers, such as human papilloma virus (HPV) vaccination to prevent cervical cancer.

Promotion of Healthy Lifestyles: Encouraging physical activity, healthy eating, and the cessation of smoking.

Environmental and Policy Interventions:
Creating environments that make healthy choices easier, such as urban planning that promotes walking and cycling, or food policies that reduce sugar and salt in processed foods.

Screening and Counselling:
Providing counselling on healthy behaviours in schools, workplaces, and community settings.

B. Secondary Prevention
Screening Programs:
Early detection of diseases such as hypertension, diabetes, and cancer through regular screenings.

Health Check-ups:
Regular check-ups in healthcare settings for early diagnosis of NCDs, especially for individuals with risk factors.

Behavioural Interventions:
Providing education and support for individuals who are at risk of developing an NCD (e.g., those with pre-diabetes or a family history of heart disease).

C. Tertiary Prevention
Treatment and Rehabilitation: Ensuring access to medical treatment for conditions like diabetes, heart disease, and chronic respiratory diseases. This includes the use of medications, surgeries, and rehabilitation programs to manage symptoms and prevent complications.

Management of Comorbidities: Providing integrated care for patients with multiple NCDs (e.g., managing diabetes and hypertension together to reduce cardiovascular risk).

Palliative Care:
For individuals with advanced NCDs, palliative care can improve the quality of life by addressing pain and other symptoms of the disease.

Psychosocial Support:
Offering counselling and support groups for individuals living with chronic conditions to help them manage the emotional and social aspects of the disease.

2. Role of Healthcare Systems and Policies
A. WHO's Global Action Plan for NCDs
1. **Policy Development:**
Encouraging countries to implement national policies that prioritize NCD prevention and control.

2. Reducing Risk Factors:
Tobacco Control:
Implementing smoking cessation programs, public smoking bans, and taxes on tobacco products.

Promotion of Physical Activity: Policies that create spaces for physical activity and encourage walking or cycling.

Healthy Diet Promotion:
Reducing the intake of salt, sugar, and fats through food labelling, taxation on sugary drinks, and public health campaigns.

3. Universal Health Coverage:
Ensuring that all individuals have access to essential health services, including NCD prevention, diagnosis, treatment, and rehabilitation.
Strengthening health systems to handle the growing burden of NCDs.

4. Monitoring and Surveillance:
Establishing robust systems to monitor the prevalence and trends of NCDs and their risk factors, facilitating data-driven policies and interventions.

B. National Healthcare Policies
National Tobacco Control Programs: Policies to curb tobacco use, such as public smoking bans and anti-smoking campaigns.
Nutritional Guidelines: Governments can introduce guidelines for healthy eating, regulate food marketing, and provide subsidies for fruits and vegetables.
Screening and Early Detection Programs

3. Case Study: NCD Trend in India
Here is an analysis of the NCD trend in India:

A. Prevalence of NCDs in India
Cardiovascular Diseases: Heart disease and stroke are among the leading causes of death in India. Urbanization, dietary changes, and physical inactivity have contributed to high rates of hypertension, high cholesterol, and heart disease.

Diabetes: India has one of the highest numbers of people with diabetes, particularly type 2 diabetes, which is strongly associated with obesity, sedentary lifestyle, and unhealthy diets.

Cancer: The incidence of cancers such as breast cancer, cervical cancer, and lung cancer is increasing, especially in urban areas where lifestyle factors like smoking and alcohol use are prevalent.

Chronic Respiratory Diseases: India has high levels of air pollution, contributing to respiratory diseases such as COPD and asthma. Indoor air pollution from cooking with biomass fuels is also a significant contributor.

B. Risk Factors
Modifiable Factors:
Poor diet (high in salt, sugar, and fats), tobacco use, alcohol consumption, and sedentary lifestyle are major contributors to the rise of NCDs.

Non-Modifiable Factors:
India has a large aging population, and genetic predispositions, especially for diabetes and heart disease, contribute to the growing NCD burden.

C. Healthcare Challenges
India faces a shortage of healthcare infrastructure, especially in rural areas, limiting access to NCD prevention, diagnosis, and treatment.

High Out-of-Pocket Expenditure: Many people cannot afford the medical treatment for NCDs, leading to delayed diagnosis and worse outcomes.

Lack of Public Awareness: Despite significant efforts, awareness about NCD prevention, early detection, and management remains low in many parts of the country.

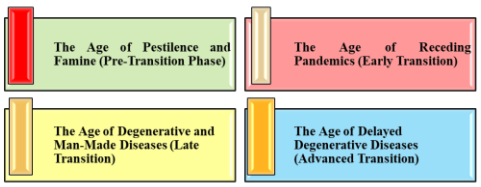
D. Government and Policy Responses
National Program for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases, and Stroke (NPCDCS): Aims to increase awareness, improve early detection, and provide access to treatment for NCDs.

Tobacco Control:
The government has implemented strong anti-smoking laws, tobacco taxes, and public awareness campaigns.

Ayushman Bharat Scheme:
A national health insurance program aimed at providing financial protection to the poor for health services, including treatment for NCDs.

Epidemiological Transition
The epidemiological transition refers to the shift in a population's disease and health patterns as a country or region develops. This transition is marked by a move from a high burden of infectious diseases and malnutrition (common in early stages of development) to a higher burden of non-communicable diseases (NCDs) and degenerative diseases, as societies industrialize and urbanize.
The concept was first introduced by epidemiologist Abdel Omran in 1971, and it describes how health challenges evolve as societies progress through different stages of economic and social development.

Stages of Epidemiological Transition



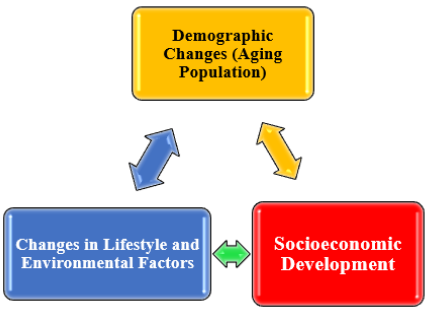
1. The Age of Pestilence and Famine (Pre-Transition Phase)
Characteristics: This stage is typically found in pre-industrial societies, where the population faces high mortality rates due to infectious diseases, malnutrition, and poor sanitation.

2. The Age of Receding Pandemics (Early Transition)
Characteristics: As societies begin to develop, there is a reduction in mortality rates due to improved public health measures, better nutrition, and the control of infectious diseases. Advances in medicine, vaccination programs, and sanitation practices help control pandemics.

3. The Age of Degenerative and Man-Made Diseases (Late Transition)
Characteristics: As the country industrializes and urbanizes further, there is a shift toward non-communicable diseases. This stage is marked by an increase in diseases like cardiovascular diseases, cancer, diabetes, and respiratory diseases.

4. The Age of Delayed Degenerative Diseases (Advanced Transition)
Characteristics: In highly developed countries, the onset of degenerative diseases such as heart disease and cancer are delayed due to medical advancements, better healthcare systems, and improved public health measures. However, the population still faces a high burden of NCDs, but these diseases occur at older ages.

Factors Driving the Epidemiological Transition



1. Demographic Changes (Aging Population)

As healthcare improves and life expectancy increases, populations are aging. This demographic shift results in a higher proportion of elderly people, who are more likely to suffer from chronic non-communicable diseases such as cardiovascular disease, diabetes, arthritis, and Alzheimer's disease.

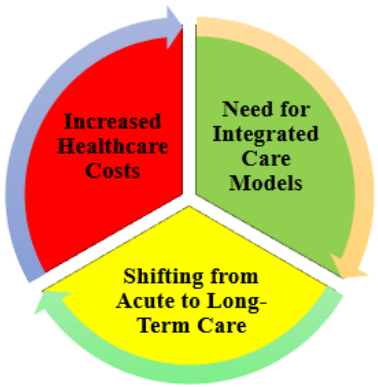
2. Socioeconomic Development

- Economic Growth
- Urbanization
- Technological Advances

3. Changes in Lifestyle and Environmental Factors

- Dietary Changes
- Physical Inactivity
- Tobacco and Alcohol Use
- Environmental Pollution

Impact on Health Systems



1. Increased Healthcare Costs

NCDs are long-term conditions that often require ongoing treatment, monitoring, and management. Chronic diseases like diabetes and hypertension require regular medications, lifestyle interventions, and frequent visits to healthcare providers.

Healthcare costs for the elderly population are disproportionately high due to the accumulation of multiple chronic conditions. This results in higher national healthcare expenditure as countries transition to an aging society.

2. Need for Integrated Care Models

The complexity of managing multiple chronic conditions requires healthcare systems to evolve towards more integrated care models. Integrated care aims to coordinate services across different healthcare providers (e.g., hospitals, clinics, primary care physicians) to ensure comprehensive management of NCDs.

3. Shifting from Acute to Long-Term Care

As the epidemiological transition occurs, healthcare systems must shift focus from acute care (treating short-term, infectious diseases) to long-term care that focuses on managing and preventing chronic diseases.

Primary care providers play a more critical role in NCD prevention, early detection, and ongoing management. This requires health promotion and chronic disease management programs at the primary care level.

Conclusion

The global burden of diseases reflects a significant shift towards non-communicable diseases as the leading cause of death, particularly in low- and middle-income countries. This shift, driven by aging populations, socioeconomic development, and changing lifestyles, marks the epidemiological transition. Healthcare systems must adapt to manage the growing prevalence of NCDs through prevention, early diagnosis, and long-term care. Effective policies and integrated care models are essential to reduce the burden of chronic diseases, lower healthcare costs, and improve

health outcomes globally. Addressing these challenges is crucial for sustainable healthcare development.

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ADVANCES IN SCIENCE AND TECHNOLOGY

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Gymnema Sylvestre (Gurmar) For Diabetes Mellitus: A Review

Miss. Asavari Sambhaji Bhosale

B Pharm [final year], Dr. shivajirao kadam college of pharmacy kasabe digraj, sangli, Maharashtra.

Email: asavaribhosale8230@gmail.com

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Abstract

From ancient times, plants have been an exemplary source of medicine. India has about 45000 plant species and among them, several thousands have been claimed to possess medicinal property. there are about 800 plants which have been reported to show antidiabetic potential. the present review provides in depth information about the potential and bioactive compounds present in *Gymnema sylvestre* (Gurmar)

Keywords: *Gymnema sylvestre, Diabetes,* hypoglycemic activity, gymnemic acid

Introduction:

Diabetes mellitus, one of the most common endocrine metabolic disorders has caused significant morbidity and mortality due to microvascular (retinopathy, neuropathy, and nephropathy) and macrovascular (heart attack, stroke, and peripheral vascular disease) complication.[1]. Currently available therapies for diabetes includes insulin and various oral antidiabetic agents like sulfonylureas, biguanides, and glinides. the hypoglycemic effect of these plant used as antidiabetic remedies has been confirmed, and the mechanism of hypoglycemic activity of this plant has been studied.[2]

Different types of diabetes mellitus can be classified under following two categories:

Type 1: is insulin dependent diabetes mellitus in which the body does not produces any insulin. it accounts for 5-10 %of diabetes.[3]

Type 2: is a non-insulin dependent diabetes mellitus, in which the body does not produces enough or improper use of secreted insulin is most common form of disease, accounting for 90-95 % of diabetes.[4]

Type 3: gestational diabetes, it can be form due to hormonal changes during pregnancy leading to insulin resistance [5]

Symptoms of diabetes mellitus:

1. Increased thirst
2. Slow healing cuts and sores
3. Fatigue
4. Blurred vision
5. Frequents urination

6. Unexplained weight loss [6]

Treatments of diabetic mellitus:

- Patient education concerning the disease
- Physical exercise
- Diet and
- Hypoglycemic agents

As a very common chronic disease, diabeties is becoming the third killer of health of mankind along with cancer, cardiovascular and cerebrovascular diseases of its high prevalence, morbidity and mortality. Thus, medicinal plants have an ever-emerging role to play in treatment or management of lifelong prolonging disease like diabeties mellitus.[7]

***Gymnema sylvestre*:**

Gymnema sylvestre is perennial woodyvine native to asia (inciuding the arabian peninsula), Africa and Australia it has been used in ayurvedic medicine common names include gymnema, Australian cowplant, and peripioca of the woods, and hindi term gurmar, which means 'sugar destroyer '. The leaves and extract contain gymnemic acid the major bioactive constituents that interact with taste receptor on the tongue to temporarily suppress the taste

Fig .1 Gymnema sylvestre [8]

Scientific classification:

Kingdom: plantae

Clade : angiosperm

Clade : eudicots

Clade : asterides

Order : gentianales

Family : apocynaceae

Genus : G*ymnema*

Species : *sylvestre*

Table no:1: Scientific classification of G.Sylvestre [9]

Gymnema benefits:

1. It has anti-inflammatory action
2. Lower the sugar craving
3. Increases the insulin production
4. Lowers the sugar absorption
5. Block the lipid absorption
6. Reduce blood pressure
7. Help in weight loss [10]

Side effects of *gymnema*:

It is generally considered safe for use, there are risks associated with this popular herbal supplements. It includes symptoms of hypoglycemia

- Headache
- Dizziness
- Nausea [10]

Contraindications:

There are situations in which the supplements should be avoided due to the lack of safety research. this incule the use of *G.sylvestre* :

- During pregnancy or breastfeeding
- In children and infants

- In peoples with diabetes
- Before surgery [10]

Origin and historical facts:

Origin: *Gymnema sylvestre* is native to the tropical forests of India, Africa, and Australia.

Historical usage: traditionally used in ayurvedic medicine for over 2000 years, gymnema sylvestre was primarily employed to treat diabetes.

The plants name gurmar translates to sugar destroyer reflecting its ability to suppress the taste of sweetness and manage blood sugar level

Medicinal uses: besides its role in managing diabetes, it has been used to treat various ailments including malaria, snake bites and digestive issues.

It has also been explored for its potential to support weight loss and lower cholesterol.[11]

Key characteristics:

Diabeties mellituis: known as a sugar killer for its ability to reduce sugar level in urine.

Urinary system: profuse urination with high sugar content, causing significant weakness.

Skin: burning sensation all over the body and the presence of diabetic carbuncles.

Thirst: extreme thirst, often seen in diabetic patients.

Sexual weakness: notable decrease in sexual power.[12]

Modalities:

Aggravation: symptoms are worsened by excessive sugar intake and physical exertion.

Amelioration: symptoms are improved by hydration and rest.

Relationship with another drug:

Compare: similar remedies include syzygium jambolanum, which is also used for its anti-diabetic properties and lycopodium, which addresses digestive and urinary issues.[12]

Dose:

Potency of choice: typically used in mother tincture 3x and 6 potencies, depending on the patient's symptoms and response to treatment.[12]

Microscopic characteristics:

1. Petiole:

Transverse section of petiole is horse shoe shaped. The epidermis is barrel shaped single layered, thick walled covered with uniseriate, multicellular, non-glandular trichomes. The cortex is collenchymatous and vascular bundles are amphicribal and three in number. Well-developed phloem consists of sieve tubes, companion cells and phloem parenchyma. The xylem consists of vessels, tracheids and tracheidal fibres. The starch grains are polygonal, simple or compound in two or many groups. The rosette crystals of calcium oxalate are present more towards the centre [13-15].

2. Lamina:

The epidermal cells of lamina are square shaped with outer convex wall and thin cuticle. When viewed transversally, epidermal cell surface is interrupted with trichomes, which are uniseriate, multicellular with 2 to 5 celled, present in abundance on both the surfaces. Single layered closely arranged palisade cells are present just below the adaxial epidermis. Vascular bundles are amphicribal and the mesophyll is 3-5 celled thick [13-15].

3. Stem:

The transverse section of stem is circular in outline. The epidermis is barrel shaped and thick walled. Trichomes are multicellular, uniseriate and 185-485 µ long and 9-25 µ broad. The cork is 3 to 5 layered thick, and cortical cells are latterly elongated and collenchymous. The phloem well developed consists of large sieve plates, companion cells and phloem parenchyma. The xylem is in the form of a continuous cylinder transverse by narrow medullary rays. The endodermis is conspicuous and the pericycle is broad [13-14].

4. Powder:

The powdered material is slight yellowish green in colour, bitter in taste with pleasant aromatic odour. On microscopic examination, it shows thick walled, uniseriate multicellular trichomes, anomocytic stomata, idioblast with rosette crystals of calcium oxalate, starch grains, remnants of collenchymatous and parenchymatous cells; vessels, tracheids, tracheidal fibres, bast fibres and sieve plates [9, 13-14].

5. Identification Tests:

When powder is treated separately with 1 N aqueous NaOH and 50% KOH, shows green fluorescence under UV 254 nm and orange colour with 50% HNO3 in daylight. General identification tests for G. sylvestre hydro-alcoholic extracts are as given below: The dilute solution suppresses the sweet taste buds, it gives copious foam appearance when shaken with water and on addition of dilute acid, it forms a voluminous precipitate [9, 15-16].

6. Purity test:

G. sylvestre depicts the following characteristics: 1) Maximum moisture content should not more than 6 percent, 2) Total ash content should not more than 12 percent, 3) Heavy metal content in leaves or leaves extract should not more than 40 ppm and in the final dosage form, it should not more than 10 ppm [13,17].

7. Phytochemistry:

The leaves of *G. sylvestre* contain triterpene saponins belonging to oleanane and dammarene classes. Oleanane saponins are gymnemic acids and gymnemasaponins, while dammarene saponins are gymnemasides [18-21].

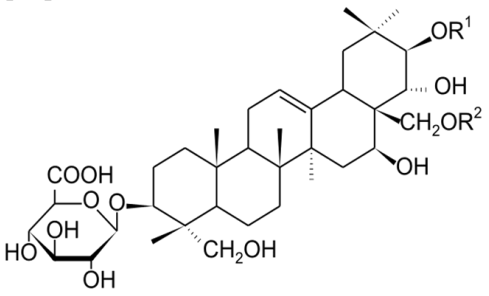
The leaves also contain resins, albumin, chlorophyll, carbohydrates, tartaric acid, formic acid, butyric acid, anthraquinone derivatives, inositole alkaloids, organic acid (5.5%), parabin, calcium oxalate (7.3%), lignin (4.8%), cellulose (22%) The gymnemic acids contain several acylated (tiglolyl, methylbutyroyl etc.) derivatives of deacylgymnemic acid (DAGA) which is a 3-O-β-glucouronide of gymnemagenin (3β, 16β, 21β, 22α, 23, 28-hexahydroxy-olean-12-ene). The individual gymnemic acids (saponins) include gymnemic acids I-VII, gymnemosides A-F, gymnemasaponins. The presence of gymnemic acids, (+) quercitol, lupeol, (-) amyrin, stigma sterol etc. have been reported from G. sylvestre. A new flavonol glycoside namely kaempferol 3-O-beta-D-glucopyranosyl-(1-->4)- alpha-Lrhamnopyranosyl-(1-->6)-beta-D-galactopyranoside has also been found in aerial parts of *G. sylvestre* [22-25].

Three new oleanane type triterpene glycosides i.e. beta-O-benzoylsitakisogenin 3-O-beta-D-

glucopyranosyl (1-->3)-beta-D-glucuronopyranoside, the potassium salt of longiospinogenin 3-O-beta-D-glucopyranosyl (1-->3)-beta-D glucopyranoside and the potassium salt of 29- hydroxylongispinogenin 3-O-beta-D-glucopyranosyl (1-->3)-beta-D-glucopyranoside along with sodium salt of alternoside II were isolated from an ethanol extract of the leaves of *G. sylvestre* [26]. Four new triterpenoid saponins, gymnemasins A, B, C and D isolated from the leaves of *G. sylvestre* were identified as 3-O-[beta-D-glucopyranosyl(1-->3)-beta-Dglucopyranosyl]-22-O-tiglyol-gymnemanol,3-O-[beta-D-glucopyranosyl(1-->3)-beta-D-glucuro - nopyranosyl]- gymnemanol, 3-O-beta-D-glucuronopyranosyl-22-O-tigloyl-gymnemanol and 3- O-beta-D-glucopyranosyl-gymnemanol respectively. The aglycone, gymnemanol, which is a new compound, was characterized as 3 beta-16 beta-22 alpha-23-28-pentahydroxyolean-12-ene. Gymnestrogenin, a new pentahydroxytriterpene from the leaves of *G. sylvestre* has been reported [27, 28].

Mechanism of action of *G. Sylvester* (Gymnemic Acid):

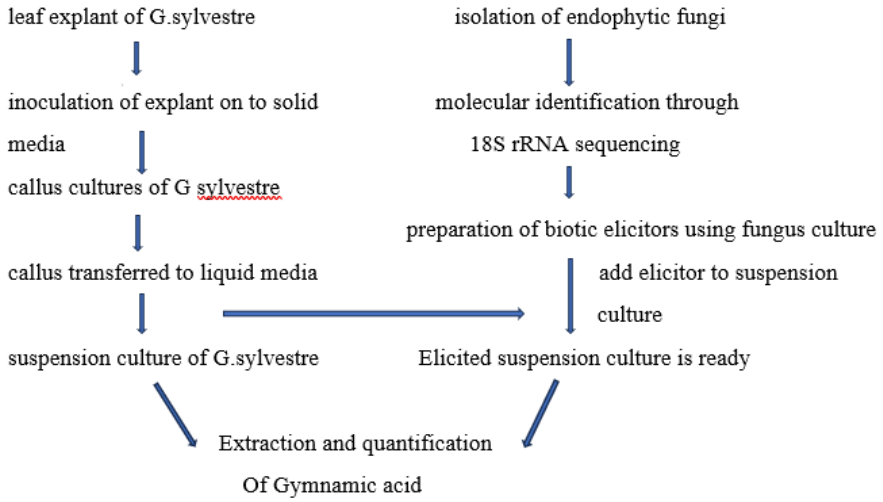
G. Sylvester leaves have been found to cause hypoglycemia in laboratory animals and shown a use in herbal medicine to treat diabetes mellitus in adults. When leaf extract of plant, administered to a diabetic patient, there is stimulation of the pancreas by virtue of which there is an increase in insulin release. These compounds have also been found to increase fecal excretion of cholesterol [29, 30]. There are some possible mechanisms by which the leaves extract of *G. Sylvester* or (Gymnemic acid) possess its hypoglycemic acid effects are: 1) It promotes regeneration of islet cells, 2) It increases secretion of insulin, 3) It causes inhibition of glucose absorption from intestine, 4) It increases utilization of glucose as it increase the activities of enzymes responsible for utilization of glucose by insulin-dependent pathways, an increase in phosphorylase activity, decrease in gluconeogenic enzymes and sorbitol dehydrogenase [2]. Uses Traditional Uses Susruta describes *G. sylvester*, as a destroyer of madhumeha (glycosuria) and other urinary disorder. It is also reported to be bitter, astringent, acrid, thermogenic, anti-inflammatory, anodyne, digestive, liver tonic emetic, diuretic, stomachic, stimulant, anthelmenthics, laxative, cardiotonic, expectorant, antipyretic and uterine tonic. It is useful in dyspepsia, constipation and jaundice, haemorrhoids, renal and vesicle calculi, cardiopathy, asthma, bronchitis, amenorrhoea, conjunctivitis and leucoderma [12, 31-32]. The drug is also used in the composition of ayurvedic preparations like Ayaskri, Varunadi kasaya, Varunadighrtam, Mahakalyanakaghrtam [33]



Structure: gymnemic acid

Referance:https://www.shutterstock.com/image-photo/gymnema-sylvestre-plant-leaves-flowers-beneficial-781421848

Extraction and quantification of gymnemic acid:



Marketed preparation of *Gymnema Sylvestre*:

Fig.2: Supplementry preparation

Fig.4: Gymnema sylvestre in liduid extract and tableted form
Referance: https://images.app.goo.gl/CLbzrizSRzkQdEjV9 (for fig 2,3,4)

Fig.3: Powdered form

Application of *G. sylvestre*:

1. Ethanobotanical uses:

There are over four hundred different tribal and other ethnic groups in India. Each tribal group is having their own tradition, folk language, beliefs and knowledge about the use of natural resources as medicines. The plant is reported to be useful in ethnobotanical surveys conducted by ethnobotanists. It has been documented that the Jungle Irulas inhabitants of Nagari Hills of the North Arcot District, Bombay and Gujarat from India have the habit of chewing a few green leaves of G. sylvestre in the morning in order to keep their urine clear and to reduce glycosuria. Bourgeois classes of Bombay and Gujarat also chew fresh leaves for the same effect. In Bombay and Madras, 'Vaids' are known to recommend the leaves in the treatment of furunculosis and madhumeha. The juice obtained from root is used to treat vomiting and in dysentery and plant paste is applied with mother milk to treat mouth ulcer. [7, 13, 34].

2. Pharmacological Uses:

Following the folk and traditional uses of the plant, it has been investigated scientifically to validate the potential of plant in cure of variety of ailments.

3. In General Pharmacological Activities:

The LD50 of ethanolic and water extract of *G. sylvestre* administered intraperitoneally in mice was found to be 375 mg/kg [35]. In an acute toxicity study in mice, no gross behavioral, neurologic, or autonomic effects were observed. The safety ratio (LD50/ED50) was 11 and 16 in normal and diabetic rats, respectively [36]. The pharmacological activities of *G. sylvestre* are desribed below:

Antiobesity Study:

G. Sylvestre helps to promote weight loss possibly through its ability to reduce cravings for sweets and control blood sugar levels. It has been reported that the gurmarin peptide block the ability to taste sweet or bitter flavors and thus reduces sweet cravings [37-38]. A standardized *G. sylvestre* extract in combination with niacin-bound chromium and hydroxycitric acid has been evaluated for antiobesity activity by monitoring changes in body weight, body mass index (BMI), appetite, lipid profiles, serum leptin and excretion of urinary fat metabolites. This study showed that the combination of *Gymnema Sylvestre* extract and hydroxycitric acid, niacin bound chromium can serve as an effective and safe weight loss formula that can facilitate a reduction in excess body weight and BMI while promoting healthy blood lipid levels [39].

Antidiabetic Activity:

The first scientific confirmation of *G. sylvestre* use in human diabetics came almost a century back when it was demonstrated that the leaves of *G. sylvestre* reduce urine glucose in diabetics [40]. In an animal study, Paliwal et al have investigated that gurmar leaf powder had positive and encouraging effects over blood glucose levels. No adverse effect was observed on the health status of the subjects and thus, it can thus be concluded that gurmar powder is effective in lowering the fasting as well as postprandial blood glucose levels [3]. Moreover, Sugihar et al have investigated the

antihyperglycemic action of a crude saponin fraction and five triterpeneglycosides derived from the methanol extracts of *G. sylvestre* [41]. Ankit Saneja et al Der Pharmacia Lettre 2010: 2 (1) 275-284

Hypolipidaemic Activity:

The administration of leaf extracts to hyperlipidaemic rats for two weeks have been found to show reduction in elevated serum triglyceride (TG), total cholesterol (TC), very low-density lipoprotein (VLDL) and low-density lipoprotein (LDL) – cholesterol in dose dependent manner. The efficiency of this drug was almost similar to that of a standard lipid lowering agent clifibrate [42, 4].

Antimicrobial Activity:

The ethanolic extract of *G. sylvestre* leaves showed good antimicrobial activity against Bacilluspumilis, *B. subtilis, Pseudomonas aeruginosa* and *Staphylococcus aureus* and no activity was found against *Proteus vulgaris* and *Escherichia coli* [43]. The aqueous and methanolic extract of *G. sylvestre* leaves also showed moderate activity against the three pathogenic *Salmonella* species (*Salmonella typhi, S. typhimurium and S. paratyphi*). Out of the two extracts used, aqueous extract showed higher activity against the *Salmonella* species [44]. *Ethanolic, Chloroform* and *Ethyl acetate* extracts of the aerial parts of *G. sylvestre* also reported to have antibacterial effects against *P. vulgaris, E. coli, P. aeroginosa, Klebsella pneumoniae* and *S. aureus* [45].

Anti-Inflammatory Activity:

The aqueous extract of G. sylvestre leaves was investigated for evaluation of anti-inflammatory activity in rats at a dose 200, 300 and 500 mg/kg in carrageenin-induced paw oedema and cotton pellet method. The aqueous extract at 300 mg/kg decreased the paw oedema volume by 48.5% within 4 h after administration, while the standard drug phenylbutazone decreased the paw oedema volume by 57.6% when compared with the paw oedema volume of control. The aqueous extract at the dose of 200 mg/kg and 300 mg/kg produced significant reduction in granuloma weight, when compared to control group [46].

4. Homoeopathic application:

Primary use: *Gymnema sylvestre* is prominently used as a remedy in cases where there is a profuse passage of sugar loaded urine. it is also employed in treating snake bites and alleviating symptoms related to excessive thirst, burning skin, and sexual weakness.

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About Editors

Dr. Prem Kumar Gautam

Dr. Prem Kumar Gautam did M.Sc. (1999) and Ph.D. (2003) in Botany from Dr. B. R. A. University, Agra (U.P.) with Genetics and Plant breeding as a subject of specialization. Presently, he is working as Associate Professor and Head at P.G. & Research Department of Botany, NTVS'S G.T. Patil College, Nandurbar (M.S.). He is enthusiastic teacher and research worker. He has published 01 Patent, 12 books, 16 research papers in national and international journals along with 06 Book chapters. He actively participated in more than 35 seminars and conferences, besides many training programmes. He guided 12 candidates for research projects for university academic degrees (M.Sc.). He is Ph.D. Guide in Botany, (One student was awarded Ph. D. Degree and now supervising five students pursuing their doctorates in various topics. He is a life member of many prestigious academic and scientific bodies and societies such as Hindustan agriculture research and development Society Agra, Botanical Survey of India (BSI).

Dr. Sunil M. Sangale

Dr. Sunil M. Sangale is Assistant professor at Department of Botany, Government Institute of Science Aurangabad - 431004(M.S.) India (MH) has published 32 research articles/ review articles/ book chapters and 03 books/edited books. He actively participated in more than 30 conferences. He has received four most prestigious awards of Regional, National and International repute. He have 15 year teaching experience at UG and PG Level. He is editorial board member of "Educreator Research Journal" (ERJ) – A Multidisciplinary Quarterly Print/online Peer Reviewed ISSN 2394-8550. He was completed one Minor Research project.

Dr. Janhavi A. Bhagwat

Dr. Janhavi Ameeya Bhagwat serves as an Assistant Professor inthe Department of Zoology at Ramniranjan Jhunjhunwala College of Arts, Science and Commerce (Empowered Autonomous). She has 17 years of teaching experience at the undergraduate level and 13 years at the postgraduate level. She has earned her Masters and Doctorate from University of Mumbai in the subject of Zoology. Dr. Bhagwat is a recognised Ph.D guide in Zoology at the University of Mumbai. She has been part of the editorial team of a college magazine for 14 years. She has published book chapters and research papers in reputed journals. She has completed two research projects from University of Mumbai and University Grants Commission(UGC).

Dr. Kulbhushan A. Sasane

Dr. Kulbhushan Ashru Sasane*Dr. Kulbhushan Ashru Sasane holds an M.Sc. degree from Ahmednagar College, Ahmednagar (2007) and a Ph.D. from the Institute of Chemical Technology, Mumbai (2013). He is a recipient of the CSIR-JRF (2009) and CSIR-NET (2008). With a robust academic career, Dr. Sasane has been an Assistant Professor at Rayat Shikshan Sanstha for the past four years, currently teaching at Abasaheb Marathe Arts and New Commerce Science College, Rajapur.With 16 years of research experience, Dr. Sasane has made significant contributions to the field, publishing articles in renowned international UGC CARE listed journals, including Syllent, Synthetic Communication, and Heterocyclic Letters. He boasts 9 years of teaching experience and is dedicated to fostering academic excellence in his students.

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