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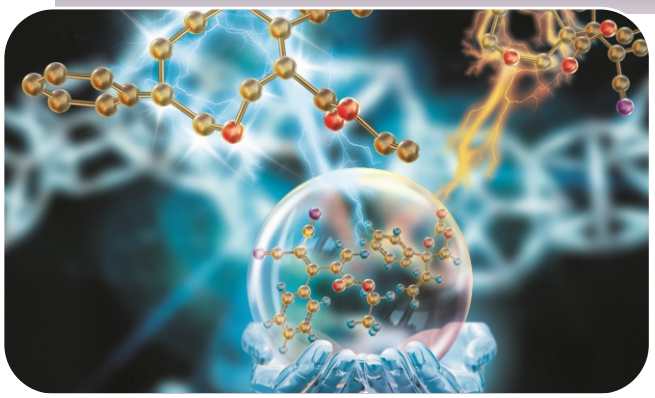
SAM-QUEST

Journal of Emerging Innovations



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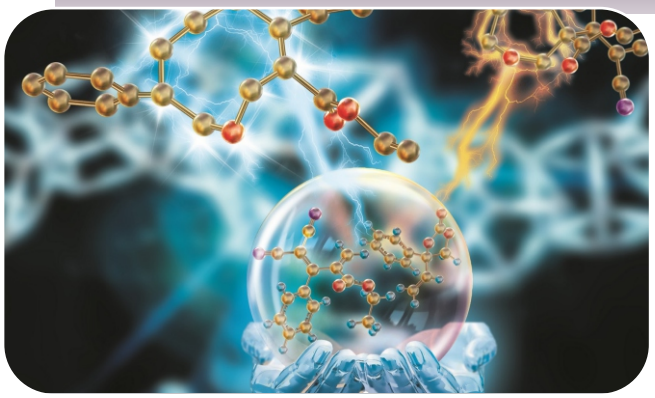

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SAM QUEST
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Pioneering in Higher Education

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SAM Group of Institutions, established by the Late Shri I S Saluja over six decades ago, is a prestigious educational institution working under the aegis of Shri Guru Hargovind Society in Central India. Our vision is to offer quality education to students, which has led to the successful establishment and management of ten colleges. Our society has been continuously expanding its range of educational institutions in various fields such as Commerce & Management, Engineering & Technology, Computer Applications, Science, Agriculture, Paramedical Sciences, Pharmacy, Nursing, Social Sciences, Arts, Humanities, and Ayurveda, with modern facilities and state-of-the-art infrastructure. We are proud of the range of national and international awards we have received including Best Group for Placement, Best Girls College, Best Group for Girls Education, Best Educational Group, Best Educational Group in the Healthcare sector, Best Group for Infrastructure and Campus, Best Nursing College, and Best Upcoming University. In 2019, SAM Group embarked on a dream project, SAM Global University, which is approved by Madhya Pradesh Niji Vishwavidhyalaya (Sthapana Avam Sanchalan) Adhiniyam 2007. The University is located at Raisen district of Madhya Pradesh, India, marking a significant milestone in group's history.

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SAM QUEST
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Editorial

Pioneering the Future of Research and Innovation

Editorial Team
SAM Global University, Raisen- 464 551, Madhya Pradesh, India
Received: 10/Jun/ 2024; **Accepted**: 15/Jun/2024; **Published**: 25/Jun/2024.

Welcome to the inaugural issue of the SAM QUEST- Journal of Emerging Innovations. It is with great excitement and anticipation that we launch this platform, dedicated to showcasing groundbreaking research and pioneering ideas that are shaping the future. Our mission is to foster a dynamic and inclusive environment where diverse fields of study converge, and the analysis or interpretation of the data leads to innovative solutions and advancements that address the complex challenges of our time.

The Genesis of SAM QUEST- Journal of Emerging Innovations

The idea behind the SAM QUEST- Journal of Emerging Innovations was born from a recognition of the rapidly evolving landscape of research and technology. As new discoveries and technological advancements emerge at an unprecedented pace, there is a growing need for a multidisciplinary platform that can disseminate these innovations. Our journal aims to bridge gap between various fields, promoting interdisciplinary collaboration & research, and cross-pollination of ideas.

The Need for Innovation

Innovation is the lifeblood of progress. In a world facing multifaceted challenges such as climate change, global health crises, and technological disruptions, the need for innovative solutions has never been more pressing. Traditional disciplinary boundaries can often hinder the development of comprehensive solutions. By bringing together researchers, scholars, and practitioners from diverse backgrounds, SAM QUEST- Journal of Emerging Innovations seeks to break down these barriers and foster a holistic approach to problem-solving.

A Platform for Diverse Voices

In this first issue, we are proud to present a collection of articles that exemplify the spirit of innovation and collaboration. Our contributors have explored a wide range of topics, from cutting-edge developments in artificial intelligence and biotechnology to novel approaches in environmental sustainability and social sciences. Each article represents a step forward in its respective field, contributing to a larger conversation about the future of research and innovation.

Highlights of the Inaugural Issue

1. Technological Breakthroughs

Explore the latest advancements in AI and machine learning, including their applications in healthcare, finance, and education. Our featured articles delve into the ethical considerations and future directions of these transformative technologies. Discover innovations in biotechnology that are revolutionizing medical treatments and diagnostics. From gene editing to personalized medicine, our contributors highlight the potential of these technologies to improve health outcomes.

2. Environmental and Sustainability Innovations

Read about the newest research in renewable energy sources, energy storage, and sustainable practices that are paving the way for a greener future. Our authors address the critical issue of climate change, presenting innovative strategies for mitigation and adaptation that span multiple disciplines.

3. Social and Economic Innovations

Investigate the role of innovation in economic resilience and sustainable development. Articles in this section explore new economic models, financial technologies, and strategies for inclusive growth. Learn about groundbreaking social innovations aimed at addressing societal challenges such as inequality, education, and public health.

Encouraging Collaboration and Innovation

At SAM QUEST- Journal of Emerging Innovations, we believe that collaboration is key to fostering innovation. We encourage submissions that not only present original research but also highlight the collaborative processes and interdisciplinary approaches that lead to these discoveries. By sharing experiences and methodologies, we aim to provide valuable insights and guidance for researchers embarking on similar journeys.

Supporting Emerging Scholars

The SAM QUEST- Journal of Emerging Innovations are particularly committed to supporting emerging scholars and early-career researchers. The future of research and innovation lies in the hands of the next generation of thinkers and leaders. By providing a platform for these voices, we aim to nurture their development and integrate fresh perspectives into the academic discourse.

Looking Ahead

As we embark on this exciting journey, we are aware of the challenges and opportunities that lie ahead. We are committed to maintaining the highest standards of academic excellence and integrity. We will continually strive to ensure that SAM QUEST- Journal of Emerging Innovations remains a dynamic and inclusive space for all researchers. We invite you, our readers, to join us in this endeavor. Your engagement, feedback, and contributions are vital to the success of the SAM QUEST- Journal of Emerging Innovations. Together, we can create a vibrant community dedicated to advancing knowledge and driving positive change.

Conclusion

In closing, I would like to extend my heartfelt gratitude to the authors, reviewers, editorial board members, and the entire SAM QUEST- Journal of Emerging Innovations team for their hard work and dedication in making this first issue a reality. Your commitment to excellence and collaboration is truly inspiring. Welcome to the SAM QUEST- Journal of Emerging Innovations. We look forward to embarking on this journey with you, and to the many discoveries and innovations that lie ahead.

Lastly, on behalf of the editorial committee for the SAM QUEST- Journal of Emerging Innovations we extend our heartiest appreciation to all the contributors, editorial board members, editorial advisory board. All the members of the editorial board are also thankful to the management of the university (Hon'ble Chairman, Vice Chairman sir), Hon'ble Chancellor madam, Vice Chancellor for all the support. Special thanks to Dean Academics for his interest and efforts in making this journal a reality. Efforts of the Deputy Registrar (Academics) are also acknowledged for his contributions in shaping the journal in its present form. We also thank all Deans, HoDs, and faculty members for their help

Editorial Team

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Review

The Concept of Ophthalmic Inserts as Drug Delivery Systems: An Insight

Shweta Gogate*, Shantanu Namdev, Nikhil Kushwah
School of Pharmacy, SAM Global University, Raisen- 464 551, Madhya Pradesh, India
*Corresponding Email: gogateshweta@yahoo.com
Received: 10/Jun/ 2024; **Accepted**: 15/Jun/2024; **Published**: 25/Jun/2024.

Abstract: Ophthalmic drug delivery is an extremely interesting and highly challenging endeavor facing pharmaceutical scientists. As an isolated organ, it is difficult to study the eye from a drug delivery point of view. The anatomy, physiology, and biochemistry of the eye render this organ exquisitely impervious to foreign substances. In recent scenarios, most eye diseases are treated with topical application of eye drops. However, these conventional eye drops have two major problems. One is it needs frequent administration and another is the formation of crystalline deposits on the cornea due to its pH-dependent solubility which is very low. Also, conventional drug delivery systems such as solutions, emulsions, and eye drops deliver the appropriate amount of drug but due to barriers such as lacrimal drainage, tear flow, etc. cause the drug to drain from the ocular surface. To provide the solution to the above problems many novel formulations have been developed. Ocular insert is one of them. Ocular inserts are defined as sterile, thin, multilayered, drug-impregnated, solid, or semisolid consistency devices placed into the cul-de-sac or conjunctival sac, whose size and shape are specially designed for ophthalmic application. They are made of various techniques that make them soluble, erodible, and insoluble. The review study emphasizes on advantages of ocular inserts over conventional dosage forms. The study includes the physiology of the eye and various preparation, and evaluation methods of ocular inserts.

Keywords: Conventional, Cul-de-sac, Eye, Ocular drug delivery, Ocular inserts, Novel

Introduction

Topical application of drugs to the eye is the well-established route of administration for the treatment of various eye diseases like dryness, conjunctiva, eye flu, etc. (Dhanapal and Ratna 2012). For illness of the eye, topical administration is usually ideal over systemic administration, before reaching the anatomical barrier of the cornea, any drug molecule administered by the ocular route that crosses the precorneal barriers. The protective mechanisms of the eye such as blinking, baseline and reflex lacrimation, and drainage decrease the bioavailability of drugs and also help to remove rapidly foreign substances like dust particles and bacteria, including drugs from the surface of the eye. There are most commonly available ophthalmic preparations such as drops and ointments about 70% of the eye dosage formulations in the market. But these preparations when instilled into the eye are rapidly drained away from the ocular surface due to blinking tear flow and lachrymal nasal drainage of the eye. With conventional ophthalmic solution normal dropper is used which delivers about 50-75µl per drop and a portion of these drops rapidly drain until the eye is back to normal i.e., with a resident volume of 7µl. Due to this drug loss in front of the eye, very small drugs are available to enter the cornea and inner tissue of the eye. Actual corneal permeability of the drug is relatively low and very small corneal contact time (about 1-2

min) in humans for an instilled solution is usually less than 10%. Therefore, only a small amount of the drug actually penetrates the cornea and reaches intraocular tissue.

1. Anatomy of the Human Eye

The adult eyeball is often referred to as a spherical globe, with its largest diameter being 24 mm anteroposteriorly (Sharma et al. 1974). Sclera is a white outer protective coat i.e. white of the eye. The cornea is the transparent, curved structure at the front of the eye and has poor penetration of drugs. Iris is a colored part of the eye. The pupil is the black part of the eye in the middle of the iris. The lenses are transparent discs immediately behind the iris and pupil. Aqueous humor is the transparent fluid that circulates behind the cornea and in front of the lenses. Vitreous is the material (like transparent jelly) that fills the eyeball between the lens and retina. The retina is a light-sensitive layer of millions of nerve cells that line the back of the eyeball (Fig. 1). Choroid is a large network of blood vessels that transport oxygen and other nutrients to the retinal pigment cells (Kurade et al. 2015).

The eyes are constantly cleansed and lubricated by the lacrimal apparatus which consists of four structures: lacrimal glands, lacrimal canals, lacrimal sac, and nasolacrimal duct. The lacrimal fluid secreted by the lacrimal glands is emptied on the surface of the conjunctiva of the upper eyelid at a turnover rate of 16% per minute. It washes over the eyeball and is swept up by the blinking action of the eyelids.

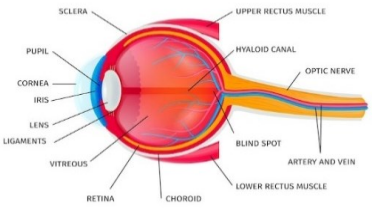

Fig. 1. Basic anatomy of the human eye.

2. Disorders of the Human Eye

Cataract

The term cataract refers to any cloudiness or opacity of the normally transparent crystalline lens of the eye. A cataract may or may not cause a loss of vision, depending on the size of the opacity, its density, and its location. Severe cataracts are a major cause of treatable blindness throughout the world.

Conjunctivitis

Conjunctivitis is an inflammation of the conjunctiva, the transparent mucous membrane lining the inside of the eyelids, and the white of the eyeball. Normally the white, or sclera, is clearly visible through the conjunctiva, but when the conjunctiva is inflamed, its normally invisible blood vessels become engorged, making the eye appear red. Conjunctivitis may be caused by many types of infectious agents, such as viruses or bacteria, as well as by toxic, chemical, and allergenic irritants.

Macular Degeneration

Macular degeneration, also called “age-related macular degeneration” (AMD), is the most common cause of blindness and vision impairment among the elderly. AMD damages the macula, a small part of the eye's light-sensitive retina (the layer of tissue that sends signals for vision to the brain). Because the macula is responsible for seeing sharp details directly in the center of the field of vision, damage caused by AMD may interfere with a person's ability to see straight ahead (necessary for driving and distance viewing, like TV watching) and for fine, detailed vision (newsprint reading, sewing, crafts, and repairs).

Night Blindness

Impairment of the vision in dim light is called night blindness, or nyctalopia. It may be due to vitamin A deficiency because that vitamin plays a major role in the cells of the eye sensitive to dim light. Night blindness is also a manifestation of various eye disorders such as glaucoma and optic nerve disease. It is often the earliest symptom of retinitis pigmentosa, a chronic and progressive inflammation of the retina.

Keratoconjunctivitis Sicca (KCS)

Dry eye syndrome, also known as Keratoconjunctivitis Sicca (KCS), is a disorder of the tear film that occurs due to tear deficiency or excessive tear evaporation; it causes damage to the interpalpebral ocular surface and is associated with a variety of symptoms reflecting ocular discomfort.

Dry eye symptoms may be a manifestation of a systemic disease; therefore, timely detection may lead to the recognition of a life-threatening

condition. Also, patients with dry eye are prone to potentially blinding infections, such as bacterial keratitis, and also at an increased risk of complications following common procedures such as laser refractive surgery.

3. Types of Ophthalmic Dosage Forms

Ophthalmic Solutions

The solution in the form of eye drops is one of the most frequent dosage forms used in the eye. The drug in the solution remains active as it enters the eye surface after passing through the cornea or conjunctiva. The main disadvantage of solutions is their less retention time in the eye, reduced bioavailability as 75% of the solution is removed through nasolacrimal fluid, unsteadiness of the drug, and a need for preservatives. The demerits of the eye can be shortened by using a viscosity-enhancing agent in the solution as it increases the retention time.

Ophthalmic Suspensions

Suspensions may be defined as a dosage form containing small divided insoluble drug particles dispersed in an aqueous vehicle having a suspending and dispersing agent. The retention time of the suspension is longer in comparison to the solution because of the ability of the particle to remain in the cul-de-sac. The dissolution rate of particles of suspension is inversely proportional to the particle size. Therefore, for suspension, a suitable particle size should be selected for the delivery of the drug into the eye for better dissolution which would be less than 10μm (Gurtler and Gurney 1995).

Sol-gel System

It is a newer concept of producing a gel from solutions by increasing the amount of viscosity-enhancing agent in the solution. As a result, the viscosity of the drug solution increases which results in gels leading to increased contact time and bioavailability and less drainage from the cornea. Many concepts have been discovered for the formation of in-situ gels these systems show their activation by changes in pH, temperature, or by Ion activation. The viscous solution or gels may result in increased contact time in the eye surface for the absorption of the drug but it can irritate the eye (Gurtler and Gurney 1995).

Ophthalmic Ointments

Ophthalmic ointments are semi-solid dosage forms containing mineral oil and white petroleum jelly as the base whose concentration varies according to the consistency needed for the ointment and the melting temperature. Drug loading in ointments is greater than in the case of solution. Due to the high consistency and viscosity of ointments, it can affect the vision of the eye which is the main disadvantage of ointments. So its application is only limited to the nights before sleeping. Only moisture-sensitive drugs can be delivered by base ingredients due to their anhydrous nature. Ointments are mostly preferred by pediatric patients. The main advantages of ophthalmic ointments are greater contact time and increased absorption of total drug (Gurtler and Gurney 1995).

Ophthalmic Emulsions

Ophthalmic dosage forms have the advantage of delivering poorly water-soluble drugs. The emulsion consists of a phase oil phase or a non-aqueous phase in which the drug is dissolved or an aqueous phase which is made miscible using an emulsifying agent. The emulsion is of two types-o/w types or w/o type, out of which w/o type which water in the external phase is less irritating to the eye and can be bearable by the patient than o/w type emulsion (Kumar et al. 2011).

a. Ocular Inserts

Ophthalmic inserts are sterile preparations with a solid or a semisolid consistency, and whose size and shape are specially designed for ophthalmic application. Ocular inserts can overcome the disadvantages reported with traditional ophthalmic systems like eye drops, suspensions, and ointments. The composition of ocuserts includes polymeric support in which drug(s), are incorporated in the form of dispersion or a solution. For topical or systemic therapy in the eye, ocuserts can be used. The main purpose of the use of ophthalmic inserts is to enhance the retention time of the active form of the drug in the eye to ensure a sustained release suit. In comparison with other liquid formulations the ocuserts have numerous benefits Because of the prolonged retention time of the device and a controlled release, an efficient concentration of drug in the eye can achieved for an extended time. Dosing frequency can also be reduced and the risk of systemic adverse effects is decreased.

b. Classification of Ophthalmic Inserts

Depending on solubility ophthalmic inserts are classified as below:

Insoluble Inserts

This category of inserts includes diffusion and osmotic systems in which a drug reservoir is placed between the rate-controlling polymers to supply the drug in a controlled manner. In the reservoir system, the drug is dispersed or dissolved in a polymer in the form of a liquid, a gel, a colloid, a semisolid, or a solid matrix. The polymer that is used as a carrier may be hydrophobic, hydrophilic, organic, inorganic, naturally occurring, or synthetic material in nature (Rathore et al. 2010, Bloomfield et al. 1978). In this drug release depends on diffusion or osmosis.

Soluble Inserts

This type of insert belongs to the oldest class of ocular inserts. The main advantage of these inserts is that as they are completely soluble there is no need for removal from the site of application. The therapeutic agents are preferably absorbed by soaking the insert in a solution containing the drug, drying and rehydrating it before use on the eye. The amount of drug loaded will depend upon the amount of binding agent, the concentration of the drug solution into which the composite is soaked, as well as the duration of soaking (Bloomfield et al. 1978).

Bio-erodible Inserts

The bio-erodible inserts consist of homogeneous dispersion of a drug with or without a coating of hydrophobic coating which is considerably not permeable to the drug. As the name indicates bio-erodible polymers are used in the formulation of these inserts. The bio-erodible materials that are suitable for ophthalmic use are poly (orthoesters) and poly (orthocarbonates), etc. The drug release of these systems depends on the contact of the device with tear fluid showing an apparent bioerosion of the matrix (Bloomfield et al. 1978). It is of three types SODI (Soluble Ocular Delivery Inserts), Lacrisertis, and mini disc.

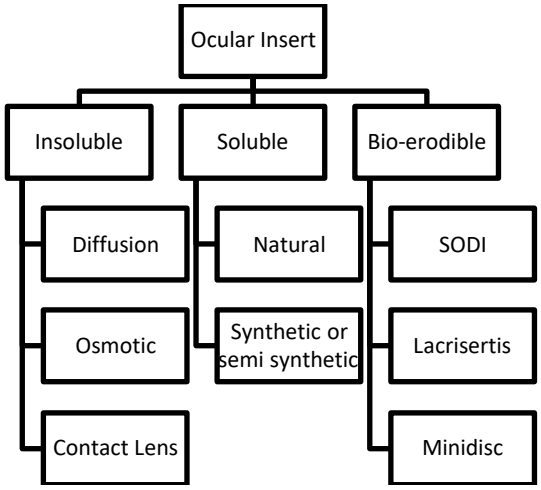

Fig. 2. Classification based on solubility ophthalmic inserts.

c. Mechanism of Drug Release

In the case of a controlled drug delivery system, the release of the drugs into the eye based on Diffusion, Osmosis, Bio-erosion

Diffusion

In this mechanism, the release of drugs through the membrane into the tear fluid occurs continuously in a controlled manner. Drug release takes place through diffusion into the pores. The controlled release can be regulated by the gradual dissolution of the solid dispersed drug within the matrix, due to which inward diffusion of an aqueous solution occurs. When the device is inserted into the eye, water from the tear fluid starts penetrating the matrix, then swelling of polymer with chain relaxation begins, and then drug diffusion takes place.

Osmosis

In osmosis, the insert is composed of a transverse elastic impermeable membrane. The interior parts of the inserts are divided into two compartments. In the first compartment, there is a solute that cannot cross the semi-permeable membrane and the second compartment supplies a reservoir for the drug which again is in liquid or gel form. When the insert comes into contact with the aqueous environment of the eye, water diffuses into the first compartment and enlarges the elastic membrane to open out the first compartment and contract the second compartment so that the drug is forced through the drug release (Dave et al. 2012).

Bio-erosion

In bio-erosion, the body of the insert is made from the matrix of a bio-erodible material in which the drug is present in a dispersed form. The contact of the insert with tear fluid results in the controlled release of the drug from the matrix, it may or may not be dispersed uniformly throughout the matrix, but the controlled release property of the drug can be achieved. These devices maintain constant surface geometry and that drug is poorly water-soluble.

d. **Advantages and Disadvantages of Ocular Insert**

The various advantages and disadvantages have been compiled in Table 1.

Table 1. Advantages and disadvantages of ocular insert. Source: Venkata et al. 2011, Karthikeyan et al. 2014.

Advantages	Disadvantages
Releasing of the drug slow and constant rate.	One of the main disadvantages of ocular inserts is their 'solidity', i.e., they are felt by the patients as an extraneous body in the eye. This may cause physical and psychological barriers to user acceptance and compliance.
Reduction of systemic absorption (which occurs freely with eye drops via the nasolacrimal duct and nasal mucosa)	Difficulty in the placement of ocular inserts.
Better patient compliance, resulting from a reduced frequency of administration and a lower incidence of visual and systemic side effects	Interference with the vision.
Increased shelf life for aqueous solutions	Unwanted migration of the insert to the upper fornix.
Increasing contact time and thus improving the bioavailability.	Leakage may occur
Increase ocular residence and prolong drug activity.	The occasional inadvertent loss during sleep or sometimes

e. Formulation Methods of Ocular Inserts (Ocuserts)

Solvent Casting Method

In this method number of batches are prepared of different ratios of drug and polymer. The polymer is dissolved in a suitable solvent. Into this solution plasticizer is added following continuous stirring and the accurately weighed amount of drug is added to the above solution and a uniform dispersion is obtained. The solution is transferred into a petri dish. The dried film was cut into definite sizes. The ocular inserts are stored in an airtight container (Dave et al. 2012, Karthikeyan et al. 2014).

Glass Substrate Technique

In this method the polymer like chitosan is soaked in 1%v/v Acetic acid solution for 24hrs, to get a clear solution. The solution is filtered. The required amount of drug is added and vortexed for 15 minutes to dissolve the complex in the polymer solution. A plasticizer is added to the above solution. The viscous solution is obtained and kept aside for 30 minutes until air bubbles are removed The rate-controlling films are formed and allowed to dry at room temperature for 24 hrs. The dried films are cut to form ocusert in definite shape and size Then, the matrix is sandwiched between the rate-controlling membranes using gum which is non-toxic, non-irritating, and water-insoluble. They are wrapped in aluminum foil separately and stored in a desiccator (Karthikeyan et al. 2014).

Melt Extrusion Technique

The drug and the polymer are passed through a sieve having a mesh size of 60#, weighed, and blended. In this mixture, the plasticizer is added. The blend is then discharged to the container of the Melt flow rate apparatus and extruded. The extrudate was cut into appropriate sizes and packed in polyethylene Aluminum foil, heat sealed, and sterilized by gamma radiation (Karthikeyan et al. 2014, Pandey et al. 2011).

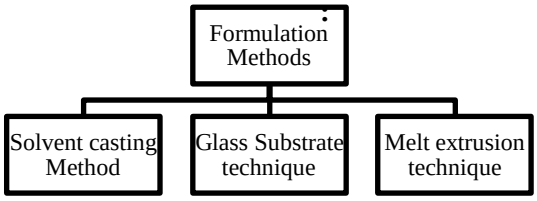

Fig. 3. Different formulation methods of Ocular Inserts (Ocuserts).

f. Evaluation Parameters of Ocuserts

Ocular inserts are evaluated based on various evaluation parameters like weight, thickness, content uniformity, percentage moisture loss, swelling index, percentage moisture absorption, in vivo drug release, in vitro drug release, surface pH, accelerated stability studies, folding endurance, etc.

Uniformity of Weight

All the prepared films are weighed separately and the weight of each film is noted. Then the average weight of the film is calculated. The standard deviation is calculated from the mean value (Karthikeyan et al. 2014).

Uniformity of Thickness

Thickness was determined by the use of Vernier-caliper/micro-meter gauze. Thickness was measured at five different points of each insert and the mean value was calculated (Born et al. 1997).

Percentage Moisture Absorption

This test is carried out to check the stability of ocular inserts. For the calculation of the percentage moisture absorption of the ocular inserts, the inserts are weighed and placed in desiccators containing 100 ml of saturated solution of aluminum chloride, and humidity is maintained at 79.5%. After three days' inserts were taken out and weighed properly. The percentage moisture absorption was calculated by using the formula (Abhilash et al. 2005):

$$\text{Percentage Moisture Absorption} = \text{Final Weight} - \frac{\text{Initial Weight}}{\text{Initial Weight}} \times 100$$

Swelling Index

A small amount of film is cut and weighed initially and then it is soaked in pH 7.4 tear fluid for 1 hour. After 1 hour, the film is reweighed. The swelling index is calculated by following formula (Abhilash et al. 2005, Mueller et al. 1956).

$$\text{Swelling Index} = \frac{\text{Initial Weight}}{\text{Final Weight}} \times 100$$

Drug Content Uniformity

A small amount of inserts is cut and dipped in 7 ml of tear fluid. Then it is taken in a centrifuge tube centrifuged for 15 min and analyzed in UV spectrometry. The concentration of a drug is calculated using a standard plot (Abhilash et al. 2005, Mueller et al. 1956).

Percentage Moisture Loss

This parameter checks the adherence of the film in the dry condition. Inserts were weighed and kept in a desiccator containing calcium chloride and after three days they were weighed again. Then by formula moisture loss was calculated (Abhilash et al. 2005):

$$\text{Percentage Moisture Loss} = \text{Initial Weight} - \frac{\text{Final Weight}}{\text{Initial Weight}} \times 100$$

Surface pH

Insert is placed in a closed Petri plate in distilled water for half an hour. After this, the swelling of the insert occurred. A swollen insert is then placed in a digital pH meter to determine surface pH (Abhilash et al. 2005, Mueller et al. 1956).

Folding Endurance

Folding endurance for ocular insert determined the number of folds that occurred in the film till its breakage. The folding endurance test was repeated using other sets of ocular inserts (Abhilash et al. 2005).

***In vitro* Diffusion Studies**

In vitro, drug release study of ocuserts is done by using Franz diffusion cell. It is an instrument used to study the permeability study of drugs. It consists of two compartments, one is the donor compartment in which dosage form i.e. ocusert is added and another is the receptor compartment which is filled with 7.4 tear fluid to simulate the tear fluid in the eye. Both compartments are separated by a membrane which may be semi semi-permeable dialysis membrane or egg membrane. The instrument is started, and RPM and temperature are adjusted. Ocusert is placed in the donor compartment and tear fluid in the receptor compartment. 1ml sample is withdrawn after a fixed time interval and after making a suitable dilution sample is analyzed in a UV spectrophotometer. The sample is withdrawn until a constant absorbance is not obtained. Drug release is calculated (Shafie and Rady 2012, Charoo et al. 2003).

Accelerated Stability Studies

In this study, ocuserts are placed in a square petri dish and film of them is taken out and kept at 3 different temperatures i.e. 400^{o}C, 500^{o}C, and 600^{o}C, and the time taken for the degradation is checked (Charoo et al. 2003).

g. Currently Available Ocular Inserts (Rathore et al. 2010)

S. No.	Name	Company	Uses
1.	Soluble ocular drug insert	Alza Corporation	Glaucoma, Dry eye treatment
2.	Collagen Shields	Bausch and Lomb Pharmaceuticals	Dry eye Syndrome
3.	Minidisc	Alza Corporation	Dry eye syndrome
4.	Lacrisert	Merck and Co. Inc	Dry eye syndrome
5.	Bioadhesive ophthalmic eye inserts	Sigma Aldrich Corporation	Treatment of Glaucoma
6.	Ocuserts	Alza Corporation	Dry eye syndrome

h. Conclusion

It's evident that drug delivery to the eye shows significant and important complications. Conventional dosage form needs frequent administration every 4 hours and formation of crystalline deposits on the cornea due to its pH-dependent solubility which is very low. The purpose of preparing an ocular insert is to increase the bioavailability of the drug. Inserts are available in different forms depending on their composition and applications. Ocuserts reduced the number of dose administrations thus improving patient compliance. It increases contact time and thus improves bioavailability. Systemic side effects can be decreased, hence reducing adverse effects. The use of preservatives is prohibited thus reducing the risk of sensitivity reactions (Lambert and Guilatt 2005, Lee and Robinson 1976). Ocular inserts are prepared with a different method and can be evaluated with different parameters. Ocuserts are novel approaches in the era of ocular drug delivery compliance with ethical standards.

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Review

A Comprehensive Review On Health Challenges in Rheumatology and Musculoskeletal Disorders

Murtuza Zaki*, Zaid Shamshee
School of Pharmacy, SAM Global University, Raisen- 464 551, Madhya Pradesh, India
*Corresponding Email: zakimurtuza5272@gmail.com
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Abstract: Rheumatoid arthritis (RA) is a systemic poly-articular chronic autoimmune joint disease that mainly damages the hands and feet, and affects 0.5% to 1.0% of the population worldwide. The deformation of skeletal muscles is observed in an arthritic patient. The present review is a discussion on rheumatoid arthritis that includes etiology, pathology and pathogenesis, signs and symptoms, clinical complications, diagnosis, treatment, and therapy. The targets to treat rheumatoid arthritis are interleukins, tumor necrosis factor-alpha, sialoprotein I, and several other factors. Different biomarkers are used for diverse types of rheumatoid arthritis and the mechanism also varies. Recent trends in the management of rheumatoid arthritis are the main concern of this article.

Keywords: Autoimmune Disorder, Interleukins, Rheumatoid arthritis

Introduction

Rheumatoid arthritis (RA) is a chronic autoimmune disorder that causes inflammation in the joints and surrounding tissue. It is characterized by symmetrical joint involvement, meaning that if one joint is affected, the opposite joint is also usually affected. The inflammation caused by RA can lead to swelling, stiffness, and pain in the affected joints, and it can also cause fatigue and overall weakness. RA is a progressive disease, which means that it can get worse over time. RA affects approximately 1% of the global population and is two to three times more common in women than in men. It can occur at any age, but it most commonly develops in people between the ages of 40 and 60. RA is a systemic disease, meaning that it can affect the whole body, not just the joints. It can cause inflammation in other organs, such as the eyes, lungs, and heart, and it can also cause vasculitis, which is inflammation of the blood vessels. The cause of RA is not fully understood, but it is thought to be the result of a combination of genetic and environmental factors. People with a family history of RA are more likely to develop the disease, and certain genetic markers have been identified as being associated with an increased risk of developing RA. Environmental factors that may contribute to the development of RA include infections, smoking, and exposure to certain toxins.

The diagnosis of RA is typically made based on a combination of clinical symptoms, laboratory tests, and imaging studies. The most common symptoms of RA are joint pain, stiffness, and swelling, but RA can also cause fever, weight loss, and fatigue. Laboratory tests that may be used to help diagnose RA include blood tests to measure inflammation, such as the erythrocyte sedimentation rate (ESR) and the C-reactive protein (CRP) level, and tests to measure autoantibodies, such as rheumatoid factor (RF) and anti-cyclic citrullinated peptide (anti-CCP) antibodies. Imaging studies, such as X-rays and magnetic resonance imaging (MRI), may also be used to help diagnose RA and to monitor the progression of the disease.

The goals of treatment for RA are to reduce inflammation, improve physical function, and prevent joint damage. The mainstay of treatment for RA is pharmacotherapy, which includes non-steroidal anti-inflammatory drugs (NSAIDs), disease-modifying anti-rheumatic

drugs (DMARDs), and biologic. In addition to pharmacotherapy, other treatment options for RA include lifestyle modifications, such as getting enough rest, exercising regularly, and managing stress, and physical therapy, which can help improve physical function and reduce pain. Surgery may also be an option for people with RA who have severe joint damage or deformity. RA is a chronic disease that can significantly impact the quality of life of people who have it. RA can be a challenging disease to manage, but with appropriate treatment and self-management, people with RA can lead full and active lives.

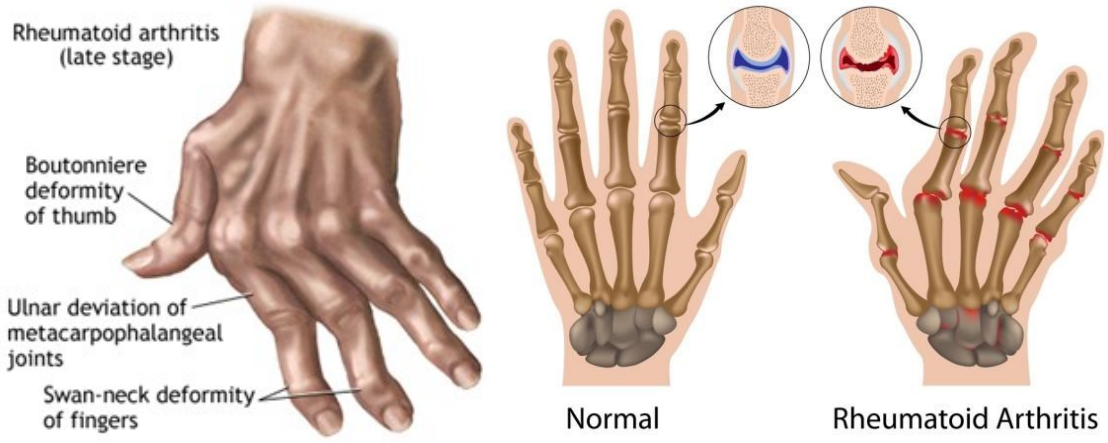

Fig. 1. Symptoms of Rheumatoid arthritis.

Pharmacology

Rheumatoid arthritis (RA) can progress if left untreated, and remission is rare. Therefore, medication is essential in managing RA symptoms and progression. Once diagnosed, it is recommended to begin therapy promptly. Optimal RA management typically involves a combination of medications and other therapies. Currently, there are five main categories of medications: analgesics, nonsteroidal anti-inflammatory drugs (NSAIDs), glucocorticoids, and biologic and non-biologic disease-modifying anti-rheumatic drugs (DMARDs). Biologic medications are recommended if DMARDs are ineffective. Abatacept is the second most commonly used biologic medication and is often combined with methotrexate (MTX). According to some studies, tocilizumab is the most effective biologic medication when used alone. Although rituximab is equally as effective as anti-TNF, it is rarely used as the first biological therapy due to safety concerns. Combination therapies are frequently used. Specific components of the immune system, such as cytokines, B-cells, T-cell activating agents, and antigen-presenting cells (APCs), can now be targeted for RA treatment (Sarkar 2022, Radu and Bungau, 2021).

Causes

The exact cause of rheumatoid arthritis (RA) is not fully understood, but it is thought to be the result of a combination of genetic and environmental factors. RA is an autoimmune disorder, which means that the immune system mistakenly attacks the body's own tissues. In the case of RA, the immune system attacks the synovium, the lining of the joints, leading to inflammation and the characteristic symptoms of RA, such as joint pain, stiffness, and swelling. Some of the factors that are thought to be involved in the development of RA include (Sailaja 2014).

Genetic Susceptibility

There is a strong genetic component to the development of rheumatoid arthritis (RA). Studies have shown that certain genetic variations or mutations are associated with an increased risk of developing RA. One of the most significant genetic factors in RA is the human leukocyte antigen (HLA) system. HLA genes code for proteins that help the immune system recognize foreign substances and distinguish them from the body's own tissues. In people with RA, certain HLA genes, such as HLA-DRB1, have been linked to an increased risk of developing the disease. Other genes that have been associated with RA include the PTPN22 gene, which plays a role

in regulating the immune system, and the STAT4 gene, which is involved in the signaling pathways that control inflammation. However, having a genetic predisposition to RA does not necessarily mean that a person will develop the disease. Environmental factors, such as smoking or exposure to certain chemicals, may interact with genetic factors to trigger the development of RA. Furthermore, some people may develop RA without any known genetic risk factors (Bullock et al. 2019).

Environmental Factors

Smoking: It is correct that smoking is the strongest known environmental risk factor for RA. This association has been known for over a decade and has been further characterized in recent studies. The risk of RA increases with the amount and duration of cigarette use, with the heaviest smokers having a two-fold increase in risk compared to those who have never smoked. Additionally, an individual remains at increased risk even after cessation for 20 years or more. The risk of RA from smoking is further modified by the number of shared epitope copies, suggesting gene-environment interaction. The shared epitope, a specific sequence of amino acids on the HLA-DRB1 allele, is the strongest known genetic risk factor for RA. Smokers who carry two copies of the shared epitope have a 21-fold higher risk of developing ACPA-positive RA compared to non-smokers who do not carry the shared epitope. This greatly elevated risk is attributed to the gene-environment interaction between smoking and the shared epitope. Smokers may induce citrullination, and carriers of the shared epitope may be genetically predisposed to developing antibodies against citrulline. It is important to note that the risk of RA from smoking is specifically associated with an increased risk of ACPA-positive and not ACPA-negative RA. Furthermore, the gene-environment interaction between smoking and the shared epitope has been observed in several European cohorts, but not in North American cohorts (Bullock et al. 2019).

Immunity: The pathogenesis of RA is complex and involves multiple immune cells, including B-cells, T-cells, and macrophages. B-cells are essential in the development of RA as they produce antibodies against self-antigens such as rheumatoid factors (RFs) and anti-citrullinated protein antibodies (ACPA), which are found in the synovial fluid and serum of RA patients. These antibodies are believed to play a role in the destruction of joint tissue by activating complement and recruiting inflammatory cells to the synovium. In addition, B-cells also secrete pro-inflammatory cytokines such as interleukin-6 (IL-6), which promote the survival and activation of T-cells and macrophages. T-cells are also crucial in RA pathogenesis as they activate macrophages and fibroblasts, leading to the production of pro-inflammatory cytokines such as tumor necrosis factor-alpha (TNF-α) and interleukin-1 (IL-1), which contribute to the destruction of joint tissue. CD4+ T-cells, particularly Th1 and Th17 subsets, are the main T-cell populations involved in RA pathogenesis. Th1 cells produce interferon-gamma (IFN-γ), which activates macrophages, while Th17 cells produce IL-17, which stimulates the production of pro-inflammatory cytokines and chemokines.

Macrophages are critical effector cells in RA pathogenesis as they produce pro-inflammatory cytokines and chemokines that contribute to joint inflammation and destruction. In the early stages of RA, macrophages are present in the synovium and produce pro-inflammatory cytokines such as TNF-α, IL-1, and IL-6, which promote the recruitment and activation of other immune cells. Activated macrophages also produce matrix metalloproteinases (MMPs), which degrade the extracellular matrix and lead to cartilage and bone destruction. In summary, immune cells, particularly B-cells, T-cells, and macrophages, play critical roles in RA pathogenesis by producing pro-inflammatory cytokines and antibodies against self-antigens. Understanding the complex interactions between these cells is essential for developing effective therapies to treat RA.

B-Lymphocytes: In RA patients, both checkpoints are usually defective, leading to the large production of autoreactive mature naïve B-cells. As shown in a previous study, untreated RA patients show a 3.4-fold increase in autoreactive B-cells in the peripheral blood compared to non-RA patients. Such a defect can be caused by a mutation in the PTPN22 gene that disrupts the BCR signaling pathway

in the central B-cell tolerance checkpoint (Armitage et al. 2021). The impairment of such tolerance checkpoints in RA patients cannot be effectively treated with drugs that reduce inflammation and alleviate other clinical presentations due to the irreversible genetic defect. The impaired peripheral tolerance checkpoint is also evident as shown by the elevated levels of mature naive B-cells that express both polyreactive and human epithelial (HEP-2)-reactive antibodies in RA patients (Yap et al. 2018). The peripheral checkpoint dysfunction results in defects in Treg as well as B-cell resistance to suppression and apoptosis (Kinnunen et al. 2013). BAFF is increased in the presence of cytokines and chemokines, as well as through TLR activation in RA patients. Such an increase in BAFF expression further prolongs the survival and maturation of autoreactive B-cells, hence sustaining the inflammation and exacerbating the autoimmune conditions (Yap et al. 2018).

Macrophages: Macrophages play a crucial role in the pathogenesis of RA and are a promising target for therapeutic intervention. While macrophages normally reside in tissues in a resting state, they become activated in an inflamed joint and secrete pro-inflammatory cytokines and enzymes that contribute to joint destruction. Additionally, macrophages act as antigen-presenting cells and are involved in T-cell activation, leading to the production of pro-inflammatory mediators. Targeting macrophages is effective in treating RA by inhibiting inflammation and bone erosion. One approach is to switch the macrophage phenotype from pro-inflammatory (M1) to anti-inflammatory (M2) using various agents. Other therapeutic strategies include using siRNA, anti-TNF, and nanosystems. These approaches have the potential to be developed into effective anti-rheumatic drugs.

Hormonal Factors

Hormonal changes, such as those that occur during menopause, have been linked to an increased risk of developing RA.

Estrogen: In summary, estrogens have complex interactions with the immune system that can be pro- or anti-inflammatory depending on the cell type and concentrations involved. Estrogens support immunoglobulin class switching in B cells and would be expected to have a deleterious effect on autoimmune diseases characterized by autoantibody production. Estrogens generally exert inhibitory effects on pro-inflammatory TH1 cells, while they may inhibit pro-inflammatory TH17 cells via ERα or have the opposite effect via ERβ. At high concentrations such as seen in pregnancy, estrogens induce the secretion of IL-10 and suppress TNFα production in T cells, supporting an anti-inflammatory cytokine milieu. Estrogens have also been found to have a range of direct anti-inflammatory actions on T cells, including the stimulation of apoptosis of human RA synoviocytes and the reduction of the production of inflammatory cytokines in rats with collagen-induced arthritis. The FOXP3 locus possesses sex steroid response elements enabling direct binding of hormones and subsequent modulation of FOXP3 activation. In mouse models of RA, exogenous estrogen administration has been shown to ameliorate postpartum flare and retard disease development in collagen-induced arthritis.

Menopause: A consistent finding is the increased risk of RA in early menopause. In the large Nurses' Health Study cohort, menopause at <44 years increased the risk of seronegative RA [hazard ratio (HR) 2.4, 95% CI 1.5–4.0]. Menopause has also been associated with the development of ACPA in first-degree relatives of patients with RA.

Androgen: In men with RA, low serum levels of testosterone were found to be strongly predictive of seronegative disease (OR 0.31, 95% CI 0.12–0.85) but not significantly predictive of seropositive disease. Men with untreated hypogonadism have been found to be at increased risk of a range of autoimmune diseases, including RA (HR 1.31, 95% CI 1.22–1.44), as are men with Klinefelter syndrome (RR 3.3, 95% CI 2.0–5.2).

Other Factors

Other factors that may contribute to the development of RA include obesity, stress, and certain medications. It is likely that different mechanisms contribute to the development of RA in different people, and further research is needed to fully understand the causes of this complex disease.

Types

There are several different types of rheumatoid arthritis (RA), including

Classic RA: This is the most common type of RA, characterized by symmetrical joint involvement (affecting the same joints on both sides of the body), morning stiffness, and fatigue.

Seropositive RA: "Seropositive RA is the most common type of RA," says Beth Wallace, M.D., assistant professor in internal medicine at the University of Michigan in Ann Arbor and a staff rheumatologist at the VA Ann Arbor Healthcare Center. According to the Hospital for Special Surgery, approximately 80% of people with RA are seropositive. Both types of RA result in very similar joint symptoms and distribution, and the exact level of anti-CCP and RF antibodies isn't all that important when determining how RA affects joints, says Jon Tyler Giles, M.D., associate professor of medicine in the division of rheumatology at Columbia University Vagelos College of Physicians and Surgeons in New York City. "It doesn't tell us how much inflammation you have, or how swollen the joints are going to be," he explains. Some people can have high levels of these antibodies but feel better than someone with very low levels. However, the presence of anti-CCP and RF antibodies can help doctors get a better idea of a patient's prognosis and how to approach treatment, Dr. Giles says. "People who are seropositive are more likely to not have the disease remit [or improve] on its own, especially if you have a high level of those antibodies," Dr. Giles says. "You are also more likely to have more damage to your joints over time" (Wragg 2011). People with seropositive RA also tend to not respond as well to treatment, says Dr. Wallace. The same medications are used to treat both types of RA, but seropositive RA may not respond as quickly and may ultimately require more aggressive treatment. Dr. Wallace also notes that seropositive RA is more often associated with extra-articular complications, meaning that systemic inflammation can cause problems beyond just the joints. Research has linked seropositive RA to complications such as cardiovascular disease, lung disease, and eye inflammation.

Seronegative RA: The absence of anti-CCP and RF antibodies in the blood means someone has seronegative RA, which is associated with less joint symptoms beyond the joints and a higher likelihood of being responsive to treatment, as well as less progression of bone erosion. However, a proper diagnosis and appropriate treatment are still necessary to prevent long-term joint damage. While the absence of these antibodies can make an RA diagnosis less certain, other information such as symptoms, joint exams, imaging tests, and other blood tests can still be used to diagnose seronegative RA. There may also be other distinct antibodies in people with RA that can help with diagnosis and treatment, although they have not yet been identified.

Juvenile RA: JIA, or juvenile idiopathic arthritis, describes multiple types of autoimmune, inflammatory arthritis in children. There are six types, some of which look very much like RA. The pattern of joint involvement and course of disease is very similar to RA, and similarly to RA, JIA shows up in patterns of flares and remission. It also has systemic effects on the body.

Oligoarticular JIA affects four or fewer joints, typically the large ones, while polyarticular (also known as polyarthritis) JIA affects five or more joints, often on both sides of the body, and may affect both large and small joints. Both are similar to RA, but polyarticular JIA is most similar and is the equivalent of childhood-onset RA, according to Dr. Giles. Blood testing for RF factor is done when a child has polyarticular RA.

While treatments for polyarticular JIA may involve the same immune-modulating medications as adult RA, and long-term joint damage can occur if it's not treated, it's common to grow out of JIA. However, it is possible to be diagnosed with true RA when you're young, but it's quite rare, and most of these causes involve diagnosis in adolescence, not younger than that.

This type of RA affects children and adolescents under the age of 16. It has many of the same features as adult RA, but the course of the disease may be different.

Symptoms

The symptoms of rheumatoid arthritis (RA) vary widely from person to person, and the severity of the disease can also vary widely. Some people with RA may experience only mild symptoms, while others may have severe

and disabling symptoms. The most common symptoms of RA are joint pain, stiffness, and swelling.

Joint pain and stiffness are often worse in the morning or after a period of inactivity, and they may improve with movement. The joints most commonly affected by RA are the small joints in the hands and feet, but RA can also affect other joints, such as the wrists, elbows, shoulders, knees, and ankles. RA is a symmetrical disorder, meaning that if one joint is affected, the opposite joint is also usually affected.

- Pain or aching in more than one joint.
- Stiffness in more than one joint.
- Tenderness and swelling in more than one joint.
- The same symptoms on both sides of the body (such as in both hands or both knees)
- Weight loss.
- Fever.
- Fatigue or tiredness.
- Weakness

Epidemiology

Rheumatoid arthritis (RA) affects approximately 1% of the global population. It is more common in women than in men, with a female-to-male ratio of 2:1. RA can occur at any age, but it most commonly develops in people between the ages of 40 and 60. RA is more common in certain ethnic groups, with higher rates of the disease observed in people of European descent compared to people of African or Asian descent. RA is also more common in people who smoke and in people who have a family history of the disease.

RA is a leading cause of disability worldwide, with the severity of the disease varying widely from person to person. Some people with RA may experience only mild symptoms, while others may have severe and disabling symptoms. RA can also cause inflammation in other organs, such as the eyes, lungs, and heart, and it can also cause vasculitis, which is inflammation of the blood vessels.

Effective treatment for RA can improve symptoms and prevent joint damage, but the disease is not curable. RA is a progressive disease, which means that it can get worse over time, and it is important for people with RA to receive ongoing medical care to manage their symptoms and prevent complications (Radu and Bungau 2021).

Pathogenesis

There are two major subtypes of rheumatoid arthritis (RA) based on the presence or absence of anti-citrullinated protein antibodies (ACPAs), which are detectable in approximately 67% of RA patients and serve as a valuable diagnostic tool for early, undifferentiated arthritis and predicting disease progression. Citrullination, which is catalyzed by the enzyme peptidyl-arginine-deiminase (PAD), converts arginine to citrulline through post-translational modification. The ACPA-positive subset of RA has a more aggressive clinical phenotype compared to the ACPA-negative subset, which has different genetic associations and immune cell responses to citrullinated antigens. Additionally, the ACPA-negative subset may have a less effective treatment response to methotrexate (MTX) or rituximab, highlighting the need for further research into potential pathophysiological differences between the two subsets. This review will focus on the ACPA-positive subset of RA and categorize the progression of RA into distinct stages, although it is important to note that these stages may occur sequentially or simultaneously.

RA pathophysiology is not yet fully understood, but several hypotheses have been proposed. The pre-RA phase suggests that immunological processes may occur many years before joint inflammation symptoms are noticed. Epigenetic modifications and environmental factors may lead to modified self-antigens such as IgG, type 2 collagen, and vimentin, which can be converted to citrulline by peptidyl arginine deiminases. Joint disorders such as synovial hyperplasia or synovial infections can also trigger cytokine release that may cause joint inflammation and modified self-antigens. Due to the HLA-DR1 and HLA-DR4 susceptibility genes, the immune system may no longer recognize citrullinated proteins as self-structures, and antigens are taken up by APCs to initiate an immune response. $CD4_+$ helper T cells are activated in the lymph node, and B cells get activated through costimulation. B cells undergo somatic hypermutation or class-switch recombination and differentiate into

plasma cells that produce autoantibodies. RF and ACPA are the most studied autoantibodies involved in RA, with ACPA being more specific for RA and forming immune complexes with citrullinated proteins that accumulate in the synovial fluid (Wragg 2011, Radu and Bungau 2021).

Diagnosis

Laboratory Technique

Rheumatoid factor (RF) and anti-citrullinated peptide antibodies (ACPA) are both laboratory tests used in the diagnosis of rheumatoid arthritis (RA). A positive result for either test can support a diagnosis of RA, and having both tests positive increases the specificity of the diagnosis. However, as you mentioned, up to 50% of patients with RA may have negative results on both tests when initially evaluated, and up to 20% of patients may remain negative during follow-up. This is why a diagnosis of RA is not solely based on laboratory testing, and a thorough clinical evaluation by a rheumatologist is important. Once a diagnosis of RA is established, there is generally no need for serial testing of these serologies for disease prognosis. However, these tests may be repeated periodically to monitor disease activity and response to treatment. It's important to note that a diagnosis of RA should not be based solely on serologic testing, and a thorough clinical evaluation by a rheumatologist is necessary to confirm the diagnosis and determine the most appropriate treatment plan.

Erythrocyte sedimentation rate (ESR) and serum C-reactive protein (CRP) are both markers of systemic inflammation and are commonly elevated in patients with RA. These tests may be repeated after the initial evaluation and diagnosis to assess and monitor disease activity and inflammation throughout the disease. In general, both ESR and CRP levels correlate with disease activity in RA, with higher levels indicating more active disease. However, it’s important to note that these tests are not specific to RA and can be elevated in a variety of other inflammatory conditions. Therefore, while ESR and CRP testing can be helpful in the diagnosis and management of RA, they should be used in conjunction with other clinical and laboratory assessments to determine disease activity and response to treatment.

Tests

Antinuclear antibody (ANA) testing is a laboratory test that is often used to help diagnose autoimmune diseases, including systemic lupus erythematosus (SLE) and other systemic rheumatic diseases. A negative ANA result can help exclude SLE and other autoimmune conditions, although a negative result does not rule out RA. On the other hand, a positive ANA test is not specific to any one disease and can be seen in a variety of conditions, including RA. Therefore, a positive ANA test alone is not sufficient to make a diagnosis of SLE or other autoimmune diseases. If a patient has a positive ANA test, further testing for specific autoantibodies, such as anti-double-stranded DNA and anti-Smith antibodies, may be performed to help differentiate between SLE and other rheumatic diseases. These autoantibodies are more specific for SLE than ANA, but they can also be seen in other conditions. It's important to note that the diagnosis of RA is primarily based on clinical features, and ANA testing is not routinely performed in patients with suspected RA unless there is a concern for overlap with another autoimmune disease.

A complete blood count (CBC) with differential and platelet count, as well as tests of liver and kidney function, serum uric acid, and a urinalysis, are commonly performed as part of the initial evaluation of a patient with suspected RA. The CBC may show anemia and thrombocytosis, which can be consistent with chronic inflammation in RA. Abnormalities in liver and kidney function tests could indicate the presence of comorbid conditions that may impact therapeutic choices or drug dosing. Elevated serum uric acid levels may prompt additional investigations to exclude gout, another form of arthritis that can cause joint pain and inflammation. In rare cases, polyarticular gout can be mistaken for RA, so it's important to consider this possibility in patients with hyperuricemia and joint symptoms.

Overall, these laboratory tests can provide important information to help diagnose and manage RA, as well as identify potential comorbidities that may impact treatment decisions. However, it's important to interpret these tests in the context of the patient's overall clinical presentation and to consider other factors that may contribute to abnormal

results. Radiographs of the hands, wrists, and feet are often obtained during the initial evaluation of a patient with suspected RA primarily to establish a baseline for monitoring disease progression. However, characteristic joint erosions may be observed on radiographs in some patients presenting with symptoms for the first time, which can aid in diagnosis and provide prognostic information. Radiographs can also help differentiate RA from other disorders that may present with similar symptoms, such as psoriatic arthritis, spondyloarthropathy, gout, or chondrocalcinosis. In these cases, radiographic changes that are more characteristic of these conditions may point to an alternative diagnosis. It's important to note that radiographic changes may not be present in the early stages of RA and that joint erosions can develop over time. Therefore, radiographs may not be sufficient to establish a definitive diagnosis of RA, and other clinical and laboratory findings should also be considered. Overall, radiographs can provide valuable information for monitoring disease progression and identifying alternative diagnoses, but their interpretation should be considered in the context of the patient's overall clinical presentation.

Studies

It is important to note that these serologic studies for infection are only necessary in patients with a very short duration of symptoms and who are seronegative for ACPA and RF. In most cases of RA, these tests are not necessary and would not be informative for the diagnosis or management of the disease. The decision to perform these tests should be based on the individual patient's clinical presentation and risk factors for these infections. Synovial fluid analysis is an important diagnostic tool that can help distinguish between different types of arthritis and guide appropriate treatment. It involves withdrawing synovial fluid from a joint using a needle and analyzing it in a laboratory. The results of synovial fluid analysis, including cell count, differential, crystal search, and Gram stain and culture, can help identify the cause of joint inflammation, such as infection, gout, or pseudo gout. That is correct. MRI and ultrasound may be useful in establishing the presence of synovitis in patients with normal radiographs and uncertainty regarding either the diagnosis or the presence of inflammatory changes. MRI and ultrasound are more sensitive than radiography at detecting changes resulting from synovitis. However, they do not have an established role in the routine evaluation of patients with polyarthritis. Abnormalities observed in imaging studies should be considered consistent with, but not diagnostic of, RA as each can be observed in other conditions.

Treatment

Biological Targeted Therapy

TNF Inhibitor: Indeed, TNF inhibitors are effective in the treatment of several inflammatory conditions, including RA, Crohn's disease, psoriatic arthritis, ankylosing spondylitis, and others. However, the use of TNF inhibitors is associated with an increased risk of infections, including serious and sometimes life-threatening infections, such as tuberculosis and sepsis. Therefore, patients receiving anti-TNF therapy should be carefully monitored for signs of infection and treated promptly if an infection is suspected. In addition, TNF inhibitors should be avoided in patients with active infections, including chronic hepatitis B or C, and in patients with a history of malignancy or congestive heart failure. Close communication and collaboration between the patient and their healthcare provider is crucial to ensure the safe and effective use of TNF inhibitors.

IL-1 Inhibition: Anakinra is an alternative treatment option for RA that targets the pro-inflammatory activity of IL-1, and it has been shown to reduce symptoms and slow the progression of structural damage in people with moderate to severe RA in clinical trials. However, it has a short half-life and needs to be given subcutaneously every day, which may be inconvenient for some patients. Additionally, it has lower response rates than TNF inhibitors and is therefore typically only provided to individuals who are intolerant to TNF inhibitors.

T Cell Co-stimulation: Abatacept is a chimeric human protein that targets T cell activation by binding to antigen-presenting cells and preventing them from engaging with the T cell receptor. It is given intravenously once a month after a loading regimen of three administrations separated by two weeks.

Clinical trials have shown that it can improve the signs and symptoms of RA, and it was approved by the FDA for use in adult patients with RA in 2005 and in children aged 6 and above in 2008. Abatacept can be used alone or in combination with other DMARDs. While T cell activation is viewed as a critical event in the onset and course of RA, T cell-directed biological therapies for RA have been disappointing due to their lack of efficacy and high toxicity. Nevertheless, a variety of T cell-targeted therapeutic options, including biological therapies that target specific populations of activated T cells and pharmacological drugs that modify T cells precisely, have emerged as potential treatments for RA (Sarkar 2022, Wragg 2011).

B-Cell Directed Therapy: Rituximab is a B-cell-targeted therapy that has been studied due to a better understanding of the role of B cells in the inflammatory process of RA. It depletes peripheral B cells quickly and specifically without harming plasma cells and has been shown to improve clinical signs and symptoms while reducing the progression of radiographic disease in multiple clinical trials. It is administered intravenously as part of a treatment regimen that includes several doses spaced weeks apart, and retreatment is usually given every 6-9 months. The most commonly reported adverse events in clinical studies are infusion-related symptoms, such as rigors, fever, pruritus, chills, and urticarial rash, with or without accompanying hypotension. The FDA has approved rituximab for use in combination with methotrexate for adult patients who have had a poor response to anti-TNF therapy. Rituximab therapy has not been associated with an increased risk of infection when compared to placebo, and it has shown no detrimental effects on IgG levels.

Inhibitor of Janus-activated Kinase (JAK): JAK inhibitors have been shown to improve the signs and symptoms of RA and reduce radiographic progression in clinical trials. There are currently several JAK inhibitors approved by the FDA for the treatment of RA, including tofacitinib, baricitinib, and upadacitinib. These drugs are taken orally and have been shown to be effective in reducing inflammation and improving physical function in patients with moderate to severe RA who have had an inadequate response to methotrexate or other conventional DMARDs. However, JAK inhibitors have also been associated with some adverse effects, such as an increased risk of infections, including serious infections, and an increased risk of blood clots. It is important for patients taking JAK inhibitors to be monitored closely for these potential adverse effects.

Biosimilar: Biosimilar have been shown to be as safe and effective as their reference products in numerous clinical trials for the treatment of RA. They have the potential to offer lower-cost alternatives to expensive biologic therapies, allowing more patients to access these treatments. However, it is important to note that biosimilars are not identical to their reference products and may have subtle differences that could impact their safety and efficacy. Therefore, rigorous regulatory and clinical testing is required to ensure their safety and efficacy before they are approved for use in patients. In addition, patients switching from reference products to biosimilars should be closely monitored to ensure that there are no adverse effects or changes in efficacy.

Combinational Therapy in RA

Combination therapy is an important approach in the management of RA, as it can improve disease activity and delay radiographic progression. Most combination therapies still include MTX as a key component, but alternative combinations have also been successfully used. Triple therapy (MTX, HCQ, and SSZ) and COBRA therapy (MTX, SSZ, and prednisolone) are two well-established combination regimens. Biologic medications have also been shown to be effective when used in combination with MTX. A comprehensive study found that early combination therapy is most effective in achieving clinical remission and improving radiographic results in individuals with early, active RA. However, not all DMARD combinations have been properly examined, and there is a lack of data on head-to-head comparisons of different therapeutic combinations.

Epigenetic Therapy in RA

DNMT inhibitors (e.g. azacitidine, decitabine) inhibit DNA methyl transferases, which are enzymes responsible for adding methyl groups

to DNA, leading to gene silencing. HDAC inhibitors (e.g. vorinostat, romidepsin) block the activity of histone deacetylases, which are enzymes responsible for removing acetyl groups from histones, leading to gene silencing. By inhibiting these enzymes, epigenetic treatments can potentially reverse abnormal epigenetic changes that contribute to the development of RA. However, more research is needed to determine their effectiveness and safety in treating RA.

New Perspective in the Treatment of RA

Indeed, the ongoing research on RA promises to bring significant advancements to the field, including the development of new molecular targets and therapeutic drugs. Additionally, a personalized approach based on genetic studies combined with evidence-based therapy may improve the treatment outcomes for RA patients, particularly those who are unresponsive to existing treatments. The use of MSCs as a potential therapeutic approach is also an exciting development in the field, offering a new way to manage the symptoms of RA. While there are still unmet needs in the treatment of RA, the advancements made over the past few decades provide hope for improved quality of life and better outcomes for RA patients in the future.

Complication

It is a progressive disease, which means that it can get worse over time. If left untreated, RA can cause several complications, including:

Joint Damage: The inflammation caused by RA can lead to joint damage, which can cause deformities and difficulty with movement.

Disability: RA can cause significant disability, especially in people with severe joint damage or deformities.

Extra-articular Manifestations: RA can cause inflammation in other organs, such as the eyes, lungs, and heart, and it can also cause vasculitis, which is inflammation of the blood vessels.

Osteoporosis: RA can cause bone loss, leading to osteoporosis, which is a condition that makes bones weak and prone to fractures.

Infections: People with RA are at an increased risk of infections due to the use of immunosuppressive medications and the presence of underlying inflammation.

Cardiovascular Disease: RA has been linked to an increased risk of cardiovascular disease, including heart attack and stroke.

Conclusion

It is a leading cause of disability and can affect people of all ages, although it is most commonly diagnosed in middle-aged adults. RA can cause joint damage and other serious complications, including fatigue, anemia, and an increased risk of infections and cardiovascular disease. The exact cause of RA is unknown, but it is thought to be triggered by a combination of genetic, environmental, and hormonal factors. It is diagnosed through a combination of physical examination, laboratory tests, imaging studies, and referral to a rheumatologist. Treatment for RA typically involves a combination of medications and lifestyle changes to reduce inflammation, relieve pain, and prevent joint damage. The goal of treatment is to control the symptoms of RA and improve the patient's quality of life.

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Review

Revolutionary Changes by Using Artificial Intelligence (AI) in Green Human Resource Management (GHRM)

Rekha Bisht[1*], Bimla Dhariyal[2]
[1]School of Sciences, SAM Global University, Raisen- 464 551, Madhya Pradesh, India
[2]Wyndham Hotels & Resorts, Rmada, Udaipur- 313 001, Rajasthan, India
**Corresponding Email: bisht.rekha 82@gmail.com, bdhariyal@gmail.com*
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Abstract: Artificial Intelligence (AI), in its broadest sense, is intelligence exhibited by machines, particularly computer systems. It is a field of research in computer science that develops and studies methods and software that enable machines to perceive their environment and use learning and intelligence to take actions that maximize their chances of achieving defined goals. Today we can do many things with the machine. As in the present scenario, everybody is moving towards building smart and environmentally friendly organizations, Green HRM is playing a fundamental role in the integration of corporate environmental management into human resource management. As the economy is moving towards the new era of the Industrial Revolution. Its main focus is profit maximization to business sustainability for which initiating and adopting green HRM practices has become necessary. The AI-green HRM integration has the potential to create a powerful synergy that can help organizations become more sustainable. For example, AI can be used to analyze data and identify areas of an organization where energy and resources being wasted are. This information can then be used to develop and implement more sustainable practices. This paper aims to explore the integration of artificial intelligence in GHRM's recruitment process, elucidate the rationale behind its adoption, and identify associated drawbacks. The methodology employed for this research involves a comprehensive literature review comprising conceptual papers, peer-reviewed journals, and articles.

Keywords: Artificial intelligence, Decision-making, Human resources management, Recruitment, Revolution, Sustainable

Introduction

Green artificial intelligence is an AI that uses lower computational costs to help reduce carbon emissions. It combines the immense value of artificial intelligence with the green values we need to lower carbon emissions and protect our planet from further climate change.
In the ever-changing environment of modern technology, Artificial Intelligence (AI) stands out as a flexible tool with the potential to transform the way we process information analyze data, and use the insights produced from it to improve decision-making. Artificial intelligence (AI) is defined as the science and engineering of creating intelligent machines, AI revolutionizes diverse fields by simulating human cognitive processes. From automating routine tasks to enabling complex decision-making. Integrating artificial intelligence (AI) into various sectors has undoubtedly revolutionized how businesses operate, bringing about unprecedented efficiency and productivity. However, this rapid advancement raises significant concerns regarding privacy, security, and ethical considerations. As Organizations continue to leverage AI technologies for data analysis, customer service, and decision-making processes, collecting and utilizing vast amounts of data pose inherent risks to individuals.
In the contemporary digital age, companies aspire to excel in innovation global competitiveness, and modern equipment and software. AI technologies have been changing HR processes and systems lately. Optimize

operational efficiency by minimizing workforce while maximizing productivity and profitability. Consequently, companies must invest resources in training new and seasoned employees to adeptly operate HR information systems (HRIS) and utilize AI features, including machine learning, natural language processing, and predictive analytics, more frequently to improve insights, efficiency, and experiences. However, concerns around transparency, ethics, and workforce impacts arise with the integration of AI into HRIS. This research aims to provide a comprehensive look at AI's current and potential future applications in HRIS, exploring this emerging trend's benefits, challenges, and responsibilities.

The concept of "Artificial Intelligence (AI)" is relatively new within the realm of information technology, coinciding with the evolution of "green human resources" practices aimed at environmental preservation and sustainability alongside fostering corporate growth and efficiency gains. Termed as "green HRM," these strategies aim to promote the efficient utilization of environmentally friendly resources within corporate infrastructure while advancing sustainability goals. In addition to serving as a comprehensive platform for various human resource functions such as recruitment, selection, training, development, compensation, and performance management, defined as "an adaptable, rational agent that perceives its environment and takes actions to maximize its chances of achieving a particular goal," AI promises to alleviate employee workloads. Streamline processes, and conduct data analysis, among other capabilities. Human resource departments across developed and developing nations increasingly leverage AI technologies to streamline recruitment, employee engagement, and talent management processes. This adoption has led to significant cost reductions, enhanced candidate selection precision, and, most notably, reduced turnaround time for recruitment procedures.

Understanding Information and Data

This section delves into the nuances of these concepts, highlighting the distinctions between data and information and their implications. While data refers to raw facts and figures, information represents processed data that provides insights and reduces uncertainty.

The collection and utilization of data by organizations for AI training and decision-making purposes present opportunities and challenges, particularly concerning privacy and security. In order to address these concerns, robust privacy policies and regulations are necessary to ensure transparency, accountability, and individual control over their data algorithms can sift through historical data, current market trends, and even external factors like economic indicators or weather patterns to predict future demand with high accuracy. This predictive capability enables businesses to plan better, reduce waste, and allocate resources more efficiently.

Organizations must prioritize data protection measures, such as encryption and access controls, to safeguard against cyber threats and unauthorized access. Moreover, transparency in AI usage, including how algorithms are trained, and decisions are made, is essential for building trust and ensuring ethical AI practices.

Review of Literature

Artificial Intelligence (AI) is not a new concept anymore for developing or developed economies. AI is the science and engineering of making intelligent machines, especially intelligent computer programs (Me Carthy 1988). Geetha and Bhanu Sree Reddy (2018) investigate the influence of artificial intelligence (AI) on hiring practices. Their study aims to explore AI's impact on recruitment processes within businesses. The researchers utilize secondary data from various sources such as websites, journals, and newspapers to analyze alternative approaches for employing individuals through AI. In recent decades, computer science has covered many fields related to this like Machine Learning (ML) it's the process of teaching machines how to learn from experience, examining large data sets, and finding hidden patterns, reviving the Artificial Intelligence. Machine language, which is at the crossroads of information technology, statistics, math, etc. for decision–making under conditions of uncertainly shows that artificial intelligence in the sense of a learning machine it's an insoluble task in the sense that a learning machine it's an insoluble task in the coming decades like " while the " Deep Blue"

computer of IBM won the world chess Champion Garri Kasparov, it was not really an artificial intelligence included as a method of choice within the AI for a range of applications and extended to different scientific fields like psychology, genomics, astrophysics, etc. (IBM 2019).

Numerous studies suggest that AI augmentation can significantly benefit HR processes and systems. Advantages include faster processing and response times, reduced HR staff workload, data-driven strategic decision-making, enhanced employee engagement, cost savings from automating high-volume administrative tasks, and improved candidate experience (Votto et al. 2021, Makarius and Srinivasan 2017). Through secondary data analysis, the study evaluates the application and scope of AI in various facets of human resource management. AI has changed the pattern of work and decision-making abilities for many organizations with its smart technological approach such as genetic algorithms, neural networks, data mining, text mining, sentiment analysis, and interactive voice recognition applications (Lauterbach 2019, Strohmeier and Piazza 2015). It improves the decision-making ability and cost-effectiveness of the organizations by making decisions on real-time data (Kaya and Kahraman 2011, Rana and Sharma, 2017, Meeker and Elliot 1996). However, the question arises: What is artificial intelligence? Is it a tool, an application, software, a methodology, or a thought? AI cannot be defined in terms of a written definition, but various researchers defined artificial intelligence in technical & sociological terms. The research investigates how AI reshapes various management functions, including HR, marketing, finance, and manufacturing.

The study concludes that HR managers can leverage AI technology across diverse HR activities such as recruitment, selection, training, development, compensation, and rewards management. Data privacy of employee information is a top concern, as is cyber security (Khan et al. 2020). This paper aims to synthesize and extend current knowledge by examining the trajectory of AI integration in HRIS. Beyond screening, sourcing, and recruiting, the study examines HR operations such as performance management systems, training, learning, and development, highlighting the transformative potential of AI & ML technology.

Research Methodology

This paper adopts a descriptive approach to study the integration of Artificial Intelligence (AI) in the recruitment process within Green Human Resources Management (GHRM). Research is conducted based on secondary data collected through various articles journal publications, newspapers, theses, websites, case studies, reports, and magazines. Artificial Intelligence has played a major role in all sectors of society, majorly Human resource management or HRM. Human resource management has grown in various areas and now it is also contributing to pollution control of society. The research involves qualitative and quantitative data collection and analysis to develop a holistic understanding of the topic. To gather qualitative data, the study uses a qualitative descriptive design that involves semi-structured interviews with HR executives & technology leaders at organizations that have implemented AI capabilities in their HRIS.

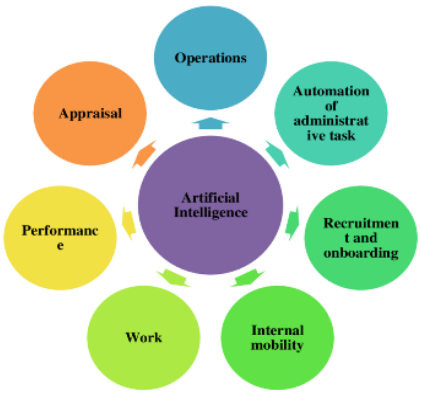

Fig. 1. Model showing the relationship of AI with Green HRM

In this model, it is clear that artificial intelligence is helpful in various areas of the Green HRM and is directly supporting all the HR practices. Organizational interests are best served by a system that attends to the employee's ability, motivation, and opportunity.

A model was prepared by Appelbaum et al. (2000) which clearly defines that the entire HR study depends on the ability of selecting,

training, and remuneration based on an individual's profile and experience. This model is a revised version of the above-mentioned model in relation to the current scenario.

Understanding HR Activities in Recent Trends

Fig. 2. HR Trends of 2024.

An Alternative framework using constructs of quality, commitment audit is said to be used for the growth of human resource management, in which this area is widely acceptable. In this case, remuneration, benefits, extra bonuses, motivation, and commitment are the most effective tools for employees that upgrade the performance of every firm.

The Role of AI in Adopting Green HRM

AI can help HR professionals make data-driven decisions about which candidates are most likely to succeed in a given role by analyzing factors such as employee tenure, performance ratings, and engagement levels.

Artificial Intelligence (AI) has significantly transformed operations within the Green Human Resources department, substantially benefiting organizations. By organizing data sets and aligning candidate profiles with job requirements, AI streamlines processes, reduces operational costs, and enhances overall efficiency. Artificial Intelligence (AI) is indispensable in addressing the growing demands of a rapidly expanding population and evolving customer needs. In Human Resource Information Systems (HRIS) artificial intelligence (AI) finds multifaceted applications across various pivotal functions. Recruiting and Hiring represent a domain where AI significantly enhances efficiency and precision.

Collecting and tagging data, assessing and analyzing data for manufacturing and service industries. Natural language processing is a form of AI whereby individuals can speak with machines and get their work done; for example, the virtual personal assistant Alexa (Amazon Echo), and call center agents. AI technology is adopted and implemented by organizations to improve their processes and services. These AI technologies are not only changing human effort but also generating more opportunities to leverage human skills. AI is not limited to manufacturing or service organizations but is also implemented to improve organizational efficiency and effectiveness. Companies are employing AI tools and techniques for various administrative and HRM functions including recruitment, training and development, performance, appraisal, career development, and talent retention.

AI plays a great role in turning imagination into reality. With its smart and digitally equipped applications.

Conclusion

This study delved into the extensive current applications and future potential of incorporating artificial intelligence capabilities into human resource information systems. Artificial Intelligence (AI) has significantly impacted human resource management (HRM) practices and operations. Nowadays, every company is moving forward by constructing innovative and ecologically friendly firms; Green HRM plays a critical role in integrating corporate environmental management with human resource management.

AI is helping companies to perform effectively and efficiently. AI helps to do automation of work because this category of jobs is also changing in the market. More brain jobs are demanded in the market as compared to muscle jobs GRHM can help organizations contribute to sustainable development by promoting environmentally-conscious behavior among employees, implementing environmentally- friendly policies, and incorporating sustainability into recruitment and hiring practices. Although this research synthesized relevant literature and market trends, it primarily relied on scholarly sources

over direct data collection. This can not only reduce the organization's environmental impact, but also improve employee engagement and satisfaction, and potentially gain a competitive advantage in the marketplace. Addressing the challenges posed by AI in green HRM requires the development of new machine learning algorithms, pattern recognition techniques, user-friendly platforms, and enhanced system security. Evidently, "Artificial Intelligence is poised to shape the future of Human Resources (HR)" in the years to come, offering transformative possibilities for recruitment and HR management practices.

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Research

Cybersecurity in the Era of Make in India: Challenges for Engineering Project Management

Ashish Kumar Rohit[1*], Mukesh Saini[2]
[1]School of Business Administration, SAM Global University, Raisen- 464 551, Madhya Pradesh, India
[2]School of Electrical & Electronics Engineering, SAM Global University, Raisen- 464 551, Madhya Pradesh, India
[*]Corresponding Email: *ashishrohit619@outlook.com, sainimukesh16@gmail.com*
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Abstract: The rapid digitalization of engineering project management has brought about unprecedented efficiency and connectivity, but it has also exposed critical infrastructure and sensitive data to a growing array of cyber threats. This research delves into the multifaceted cybersecurity challenges faced by engineering projects in an increasingly interconnected world. The study examines the evolving threat landscape, including sophisticated malware, ransomware attacks, insider threats, and state-sponsored cyber espionage targeting engineering firms and their projects. Through a comprehensive analysis of recent cyber incidents and their impact on engineering projects, this research identifies critical vulnerabilities in project management software, communication systems, and industrial control networks. The study also investigates the unique cybersecurity risks associated with emerging technologies such as Building Information Modeling (BIM), Internet of Things (IoT) devices, and cloud-based collaboration platforms commonly used in modern engineering projects. To address these challenges, the research proposes a robust cybersecurity framework tailored specifically for engineering project management. This framework integrates best practices from established cybersecurity standards with industry-specific requirements, emphasizing a risk-based approach to security. The proposed model encompasses strategies for secure project data management, supply chain risk mitigation, and resilient system design. Furthermore, the study explores the human factor in cybersecurity, highlighting the importance of cultivating a security-aware culture within engineering teams and implementing comprehensive training programs. The research concludes by outlining future directions for enhancing cybersecurity in engineering project management, including the potential application of artificial intelligence and machine learning for threat detection and response.

Keywords: Artificial intelligence, Cybersecurity, Cyber resilience, Internet of Things, Project management security, Supply chain risk management

Introduction

A. Background on Engineering Project Management

Engineering project management has undergone a significant transformation in recent decades, evolving from traditional paper-based processes to highly digitalized workflows. This shift has been driven by the need for increased efficiency, better collaboration, and more accurate data management in increasingly complex engineering projects. Modern engineering project management encompasses a wide array of digital tools and platforms, including project management software, Building Information Modeling (BIM) systems, computer-aided design (CAD) tools, and cloud-based collaboration platforms. These technologies have revolutionized how engineering projects are planned, executed, and monitored, enabling real-

time data sharing, remote collaboration, and advanced analytics for decision-making.

B. The Growing Importance of Cybersecurity in Engineering

As engineering projects become more digitally integrated, the importance of cybersecurity has grown exponentially. The convergence of Information Technology (IT) and Operational Technology (OT) in engineering environments has created a complex ecosystem where traditional security measures are often insufficient. Critical infrastructure projects, industrial facilities, and sensitive design data have become attractive targets for cyber threats, ranging from state-sponsored actors to criminal organizations. Recent high-profile incidents, such as the Colonial Pipeline ransomware attack and the SolarWinds supply chain compromise, have highlighted the vulnerabilities in engineering and industrial systems. These events underscore the critical need for robust cybersecurity measures tailored specifically to the unique challenges of engineering project management.

C. Research Objectives and Scope

This research paper aims to address the pressing need for enhanced cybersecurity in engineering project management through the following objectives:

1. To conduct a comprehensive analysis of the current cybersecurity threat landscape specific to engineering projects, including an examination of emerging risks associated with new technologies such as IoT devices, cloud computing, and AI-driven systems.
2. To assess the multifaceted impact of cyber-attacks on engineering projects, considering not only immediate financial losses but also long-term operational disruptions, reputational damage, and legal implications.
3. To propose a robust, adaptable cybersecurity framework designed to address the unique challenges of engineering project management, integrating best practices from established security standards with industry-specific requirements.
4. To explore strategies for cultivating a security-aware culture within engineering teams and implementing effective training programs to address the human factor in cybersecurity.
5. To investigate the potential applications of advanced technologies, such as artificial intelligence and machine learning, in enhancing threat detection and response capabilities for engineering projects.

The scope of this research encompasses various sectors of engineering, including civil, mechanical, electrical, and software engineering projects. It will focus on both large-scale infrastructure projects and smaller, specialized engineering initiatives. The study will draw upon recent case studies, industry reports, and expert interviews to provide a comprehensive view of the current state of cybersecurity in engineering project management and to identify emerging trends and best practices.

By addressing these objectives, this research aims to contribute valuable insights and practical recommendations to the field of engineering project management, enhancing the security posture of engineering projects in an increasingly interconnected and vulnerable digital landscape.

Literature Review

A. Current State of Cybersecurity in Engineering Project Management

The current state of cybersecurity in engineering project management reflects a landscape of growing complexity and increasing threats. Patel et al. (2023) highlight that while digital transformation has enhanced project efficiency, it has also expanded the attack surface for cyber threats. Their study reveals that many engineering firms struggle to keep pace with evolving cybersecurity challenges, often relying on outdated security measures ill-suited for modern, interconnected project environments.

Johnson and Lee (2022) conducted a survey of 500 engineering project managers, finding that only 37% felt their organizations were adequately prepared to handle sophisticated cyber-attacks. The research identified key vulnerabilities in areas such as supply chain management, remote access systems, and industrial control networks. Similarly, Zhang et al. (2024) emphasize the growing risks associated with the integration of IT and OT systems in engineering projects, noting that traditional IT security approaches often fail to address the unique requirements of operational technology environments.

B. Common Cybersecurity Frameworks and Standards

Several cybersecurity frameworks and standards have been adapted or developed for engineering contexts. The National Institute of Standards and Technology (NIST) Cybersecurity Framework, as discussed by Brown and Smith (2021), provides a flexible approach that many engineering firms have begun to adopt. However, they note that significant customization is often required to address industry-specific challenges.

The ISO/IEC 27001 standard, analyzed by Chen et al. (2023), offers a comprehensive information security management system applicable to engineering projects. Their research indicates that while ISO 27001 certification can enhance overall security posture, it may not fully address the real-time operational security needs of dynamic engineering environments.

Specifically, for industrial control systems, the IEC 62443 series of standards has gained prominence. Rodriguez and Kim (2022) examine its application in engineering project management, highlighting its strengths in addressing the convergence of IT and OT security. However, they also identify gaps in areas such as cloud security and emerging IoT technologies.

C. Recent Cyber Incidents in Engineering Projects

Several high-profile cyber incidents have underscored the vulnerabilities in engineering project management systems. The 2021 Colonial Pipeline ransomware attack, analyzed by Thompson et al. (2022), exposed critical weaknesses in industrial control systems and demonstrated the far-reaching consequences of cyber-attacks on engineering infrastructure.

In the realm of intellectual property theft, Wang and Davis (2023) document a series of state-sponsored cyber espionage campaigns targeting engineering firms involved in advanced technology projects. Their research reveals sophisticated attack vectors exploiting vulnerabilities in project management software and collaboration tools.

Hassan et al. (2024) present a case study of a major European construction firm that suffered a significant data breach due to compromised Building Information Modeling (BIM) systems. The incident highlighted the need for enhanced security measures in collaborative engineering platforms and led to substantial financial and reputational damage.

A particularly concerning trend, identified by Morales and Singh (2023), is the rise of supply chain attacks targeting engineering projects. Their analysis of the solar winds incident and its impact on engineering firms underscores the complex interdependencies in modern project ecosystems and the potential for cascading security failures.

These recent incidents collectively demonstrate the evolving sophistication of cyber threats facing engineering projects and the urgent need for more robust, adaptive security frameworks. They also highlight gaps in current security practices, particularly in areas such as third-party risk management, secure software development, and incident response preparedness in engineering contexts.

This literature review reveals a clear need for further research into tailored cybersecurity solutions for engineering project management, addressing the unique challenges posed by the integration of advanced technologies and the increasing interconnectedness of engineering systems.

Methodology

A. Research Design

This study employs a mixed methods approach, combining quantitative and qualitative research techniques to provide a comprehensive understanding of cybersecurity challenges in engineering project management. The research design is structured in three phases:

1. Exploratory phase: A thorough literature review and expert interviews to identify key themes and challenges.
2. Descriptive phase: A large-scale survey to quantify the prevalence and impact of cybersecurity issues in engineering projects.
3. Explanatory phase: Depth case studies to provide context and detailed insights into specific cybersecurity incidents and mitigation strategies.

This design allows for a holistic examination of the topic, leveraging the strengths of both quantitative and qualitative methodologies to address the research objectives.

B. Data Collection Methods

The study utilizes multiple data collection methods to ensure a comprehensive dataset:
1. Literature Review: A systematic review of academic journals, industry reports, and technical publications to establish the current state of knowledge and identify research gaps.
2. Expert Interviews: Semi-structured interviews with 1520 cybersecurity professionals and engineering project managers to gain insights into emerging threats and best practices.
3. Survey: An online questionnaire distributed to a sample of 500 engineering firms across various sectors (civil, mechanical, electrical, etc.) to gather quantitative data on cybersecurity practices, incidents, and challenges.
4. Case Studies: Detailed examination of 57 recent cybersecurity incidents in engineering projects, including document analysis and interviews with key stakeholders.
5. Archival Data: Collection and analysis of publicly available cybersecurity incident reports and regulatory filings related to engineering projects.

C. Analysis Techniques

The collected data will be analyzed using a combination of quantitative and qualitative techniques:
1. Statistical Analysis: Descriptive and inferential statistics will be applied to the survey data to identify patterns, correlations, and significant factors influencing cybersecurity in engineering projects. This may include regression analysis to determine relationships between variables such as project size, cybersecurity investment, and incident frequency.
2. Thematic Analysis: Qualitative data from interviews and case studies will be coded and analyzed to identify recurring themes, challenges, and strategies related to cybersecurity in engineering project management.

3. Content Analysis: A systematic examination of archival data and incident reports to quantify and categorize types of cyber threats, vulnerabilities, and impact on engineering projects.
4. Comparative Analysis: Cross-case analysis of the selected case studies to identify common factors, successful mitigation strategies, and lessons learned across different engineering sectors and project types.
5. Triangulation: Integration of findings from different data sources and analysis methods to enhance the validity and reliability of the research conclusions.
6. Framework Development: Synthesis of the analyzed data to propose a robust cybersecurity framework tailored for engineering project management, which will be validated through expert feedback.

This methodology is designed to provide a comprehensive and nuanced understanding of cybersecurity challenges in engineering project management, balancing breadth through the survey and depth through case studies and expert insights. The mixed methods approach allows for both quantification of key issues and a rich, contextual understanding of complex cybersecurity dynamics in engineering projects.

The Evolving Threat Landscape in Engineering Projects

A. Types of Cyber Threats Targeting Engineering Projects

1. Malware and Ransomware

i. Increasing sophistication of malware targeting engineering systems
ii. Rise of ransomware attacks on critical infrastructure projects
iii. Examples: WannaCry impact on manufacturing, Not Petya disrupting global engineering firms
iv. Potential for operational shutdown and data loss in engineering projects

2. Industrial Espionage

i. State Sponsored and corporate espionage targeting intellectual property
ii. Advanced Persistent Threats (APTs) focusing on long-term data exfiltration
iii. Theft of design plans, proprietary technologies, and strategic information
iv. Impact on competitive advantage and national security in engineering sectors

3. Insider Threats

i. Disgruntled employees or contractors with privileged access
ii. Unintentional insider threats due to lack of security awareness, Potential for sabotage, data theft, or unauthorized system access

iii. Challenges in balancing security with necessary access for project collaboration

4. Supply Chain Attacks

i. Exploitation of vulnerabilities in third-party vendors and suppliers.
ii. Compromise of software updates or hardware components.
iii. Example, Solar Winds attack impacting engineering and infrastructure sectors
iv. Cascading effects through interconnected project ecosystems

B. Vulnerabilities in Engineering Project Management Systems

1. Project management software

i. Security flaws in popular project management tools.
ii. Inadequate access controls and authentication mechanisms.
iii. Vulnerabilities in cloud-based project management platforms.
iv. Risks associated with sharing sensitive project data across multiple stakeholders.

2. Communication Systems

i. Insecure communication channels used for project coordination
ii. Vulnerabilities in email systems and instant messaging platforms
iii. Risks of eavesdropping and man-in-the-middle attacks
iv. Challenges in securing remote communication for distributed engineering teams

3. Industrial Control Systems (ICS)

i. Legacy systems with limited security features in industrial environments
ii. Convergence of IT and OT creating new attack vectors
iii. Vulnerabilities in SCADA systems and PLCs
iv. Potential for physical damage and safety risks through cyber attacks

4. Building Information Modeling (BIM) Platforms

i. Security challenges in collaborative BIM environments
ii. Data integrity and confidentiality risks in shared models
iii. Vulnerabilities in BIM software and associated plugins
iv. Potential for manipulation of design data leading to structural or safety issues

Impact of Cyber Attacks on Engineering Projects

A. Financial Consequences

Cyber-attacks can have severe financial implications on engineering projects. Direct costs often include expenses related to the immediate response to the attack, such as hiring cybersecurity experts, implementing emergency measures to contain the breach, and restoring affected systems. Indirect costs can be even more substantial, encompassing lost revenue due to project delays, penalties for not meeting contractual obligations, and increased insurance premiums. Additionally, there may be long-term financial impacts, such as investments in improved cybersecurity measures to prevent future attacks and potential loss of future contracts due to damaged trust.

B. Operational Disruptions

Operational disruptions caused by cyber-attacks can halt engineering projects in their tracks. These disruptions can manifest in various forms, including the loss of critical data, disruption of communication channels, and compromise of essential project management tools. Such disruptions can lead to delays in project timelines, increased labor costs due to overtime required to make up for lost time, and inefficient resource allocation. The inability to access key data and tools can significantly impair decision-making processes, further exacerbating the project's operational challenges.

C. Reputational Damage

The reputational damage resulting from a cyber-attack can be devastating for engineering firms. Clients and stakeholders may lose confidence in the firm’s ability to protect sensitive information and deliver projects securely. Negative publicity can spread quickly, leading to a tarnished brand image and the potential loss of current and future business opportunities. In highly competitive industries, reputation is paramount, and any

perceived vulnerability can give competitors an edge, further impacting the firm's market position and profitability.

D. Legal and Regulatory Implications

Legal and regulatory implications of cyber-attacks on engineering projects are becoming increasingly significant as governments worldwide tighten cybersecurity regulations. Engineering firms may face hefty fines and legal action if they are found to have neglected cybersecurity measures. Regulatory bodies may impose strict compliance requirements, necessitating substantial investments in cybersecurity infrastructure and ongoing audits. Failure to comply with these regulations can result in legal battles, further financial strain, and mandatory disclosures that can damage a firm's reputation and client relationships.

In conclusion, cyber-attacks pose multifaceted challenges to engineering project management. The financial consequences, operational disruptions, reputational damage, and legal and regulatory implications highlight the critical need for robust cybersecurity strategies. Engineering firms must prioritize cybersecurity to mitigate these risks and ensure the successful and secure completion of their projects.

Emerging Technologies and Associated Risks

A. Internet of Things (IoT) in Engineering

The Internet of Things (IoT) revolutionizes engineering by integrating sensors, software, and other technologies to connect and exchange data between devices and systems. This connectivity enhances monitoring, control, and automation in various engineering fields. For instance, IoT enables predictive maintenance in industrial equipment, thereby reducing downtime and costs. However, IoT adoption also brings potential cyber risks. The vast number of interconnected devices creates numerous entry points for cyber-attacks, resulting in data breaches and intellectual property theft. Therefore, robust cybersecurity measures are critical to mitigate these risks, ensuring device integrity and data security [citation:1] [citation:5].

B. Cloud-Based Collaboration Platforms

Cloud-based collaboration platforms, such as Microsoft Teams and Google Workspace, have become indispensable in engineering for facilitating remote work and cross-functional teamwork. These platforms offer real-time document sharing, communication tools, and project management features that enhance productivity and streamline workflows. However, the reliance on cloud services introduces risks related to data confidentiality, integrity, and availability. Unauthorized access, data loss, and compliance with data protection regulations are primary concerns. Effective risk management strategies, including encryption, multi-factor authentication, and regular security assessments, are essential to protect sensitive information and ensure seamless collaboration [citation:9] [citation:8].

C. Artificial Intelligence and Machine Learning Applications

Artificial Intelligence (AI) and Machine Learning (ML) are transforming engineering by enabling advanced data analysis, design optimization, and automation of complex processes. Applications include predictive analytics, intelligent control systems, and enhanced decision-making capabilities. While AI/ML offers significant benefits, they also pose risks related to algorithmic bias, transparency, and accountability. Algorithms may inadvertently perpetuate biases present in training data, leading to unfair outcomes. Additionally, the "black box" nature of some AI models complicates understanding and trust in AI-driven decisions. Establishing ethical guidelines, enhancing algorithm transparency, and implementing robust validation processes are necessary to address these challenges and ensure responsible AI/ML deployment in engineering [citation:6] [citation:8]. By carefully considering the associated risks of these emerging technologies, engineering professionals can harness their potential while safeguarding against vulnerabilities, ultimately driving innovation and progress in the field [citation:1] [citation:5] [citation:9] [citation:6] [citation:8].

Proposing a Robust Cybersecurity Framework for Engineering Project Management

A. Risk Assessment and Management

1. Continuous threat modeling: Implement an ongoing process to identify and evaluate potential threats specific to engineering projects.
2. Asset inventory and classification: Maintain a detailed inventory of all project assets, including digital and physical components, classifying them based on criticality and sensitivity.
3. Vulnerability scanning: Regularly conduct automated and manual vulnerability assessments of project systems and infrastructure.
4. Risk prioritization matrix: Develop a matrix to prioritize risks based on likelihood and potential impact, guiding resource allocation for mitigation efforts.
5. Regulatory compliance mapping: Ensure alignment with relevant industry standards and regulations (e.g., NIST, ISO 27001, IEC 62443).

B. Security by Design Principles

1. Secure SDLC integration: Incorporate security considerations throughout the Software Development Life Cycle for project-related applications.
2. Least privilege architecture: Design systems with the principle of least privilege, minimizing unnecessary access and potential attack surfaces.
3. Segmentation and isolation: Implement network segmentation and isolate critical systems to contain potential breaches.
4. Secure configuration management: Establish and maintain secure baseline configurations for all project-related hardware and software.

C. Access Control and Identity Management

1. Multi-factor authentication (MFA): Enforce MFA for all user accounts, especially for privileged access.
2. Role-based access control (RBAC): Implement granular RBAC aligned with project roles and responsibilities.
3. Just-in-time access: Utilize temporary, time-bound access for contractors and third-party vendors.
4. Privileged access management (PAM): Deploy PAM solutions to monitor and control high-level access to critical systems.

D. Data Protection and Privacy

1. Data classification scheme: Develop a comprehensive data classification system tailored to engineering project needs.
2. Data Loss Prevention (DLP): Implement DLP tools to prevent unauthorized data exfiltration.
3. Privacy-enhancing technologies: Utilize techniques like data masking and tokenization to protect sensitive information.
4. Secure data sharing protocols: Establish secure methods for sharing project data with stakeholders and partners.

E. Incident Response and Recovery

1. Incident response plan: Develop a detailed, engineering-specific incident response plan with clearly defined roles and procedures.
2. Cybersecurity incident response team (CSIRT): Establish a dedicated CSIRT with expertise in engineering systems and processes.
3. Tabletop exercises: Regularly conduct scenario-based exercises to test and improve incident response capabilities.
4. Forensic readiness: Maintain forensic capabilities to investigate and analyze security incidents effectively.

F. Supply Chain Security

1. Vendor risk assessment: Conduct thorough security assessments of all third-party vendors and suppliers involved in the project.
2. Secure contracting: Include robust security requirements and SLAs in all vendor contracts.
3. Third-party access management: Implement strict controls and monitoring for vendor access to project systems and data.
4. Software supply chain security: Verify the integrity of all third-party software and components used in the project.
5. Collaborative incident response: Establish protocols for coordinated incident response with key suppliers and partners.

This framework aims to provide a comprehensive approach to cybersecurity in engineering project management, addressing the complex and interconnected nature of modern engineering projects. By implementing these measures, organizations can significantly enhance their security posture, protect sensitive data and intellectual property, and ensure the resilience of their projects against evolving cyber threats.

To be effective, this framework should be adaptable to the specific needs and context of each engineering project and should be regularly reviewed and updated to address new and emerging threats in the rapidly evolving cybersecurity landscape.

Implementation Strategies

A. Integrating Cybersecurity into the Project Lifecycle

1. Security requirements definition: Incorporate cybersecurity requirements into the initial project scoping and planning phases.
   - Develop cybersecurity requirements template specific to engineering projects.
   - Conduct threat modeling sessions during project initiation to identify potential risks.
2. Security-aware design phase: Embed security considerations into the design process.
   - Implement secure-by-design principles in system architecture.
   - Conduct regular security design reviews with cross-functional teams.
3. Secure development practices: Integrate security into the development and construction phases.
   - Implement secure coding practices and guidelines for software components.
   - Conduct regular code reviews and static analysis for vulnerability detection.
4. Security testing and validation: Incorporate security testing throughout the project execution.
   - Perform penetration testing and vulnerability assessments at key project milestones.
   - Conduct security acceptance testing before system deployment or handover.

B. Training and Awareness Programs

1. Role-based security training: Develop tailored training programs for different project roles.
   - Provide in-depth technical security training for IT and engineering staff.
   - Offer executive-level cybersecurity awareness sessions for project managers and leadership.
2. Simulated attack exercises: Conduct regular phishing simulations and tabletop exercises.
   - Use project-specific scenarios to increase relevance and engagement.
   - Analyze exercise results to identify areas for improvement in security awareness.
3. Continuous learning platforms: Implement ongoing cybersecurity education initiatives.
   - Utilize e-learning platforms with regularly updated content on emerging threats.
   - Encourage professional certifications in cybersecurity for key project personnel.
4. Security champions program: Establish a network of security-aware individuals across project teams.
   - Train selected team members as security champions to promote best practices.
   - Create a community of practice for sharing security insights and experiences.

C. Collaboration with Cybersecurity Experts

1. External security consultations: Engage cybersecurity firms for specialized expertise.
   - Conduct periodic third-party security assessments of project infrastructure.
   - Seek expert input on complex security challenges specific to engineering projects.
2. Academic partnerships: Collaborate with universities and research institutions.
   - Participate in cybersecurity research projects relevant to engineering domains.
   - Offer internships to cybersecurity students to bring fresh perspectives to project teams.
3. Industry information sharing: Participate in sector-specific cybersecurity information-sharing initiatives.
   - Join Information Sharing and Analysis Centers (ISACs) relevant to the engineering sector.
   - Contribute to and learn from industry-wide incident reports and threat intelligence.
4. Cybersecurity vendor engagement: Establish strategic partnerships with security solution providers.
   - Work closely with vendors to tailor solutions to engineering project needs.
   - Participate in beta testing programs for new security technologies.

D. Continuous Monitoring and Improvement

1. Security metrics and KPIs: Develop and track cybersecurity performance indicators.
   - Implement metrics such as vulnerability remediation time, security training completion rates, and incident response times.
   - Regularly report on security KPIs to project stakeholders and leadership.

2. Automated security monitoring: Implement continuous monitoring solutions for project systems.
   - Deploy Security Information and Event Management (SIEM) systems for real-time threat detection.
   - Utilize automated vulnerability scanning tools for continuous assessment of project infrastructure.
3. Incident analysis and lessons learned: Conduct thorough post-incident reviews.
   - Perform root cause analysis on all security incidents, near-misses, and exercises.
   - Implement a formal process for incorporating lessons learned into security practices.
4. Regular security audits: Conduct periodic internal and external security audits.
   - Perform annual comprehensive security audits of project management practices.
   - Engage third-party auditors for unbiased assessment of security posture.

By implementing these strategies, engineering organizations can effectively integrate cybersecurity into their project management processes, fostering a security-aware culture and maintaining resilience against evolving cyber threats. The key to success lies in viewing cybersecurity as an integral part of the project lifecycle rather than an add-on, and in continuously adapting and improving security measures in response to the changing threat landscape.

Case Studies

A. Successful implementation of cybersecurity measures in engineering projects

Global Engineering Firm Enhances Project Security

A multinational engineering firm specializing in large-scale infrastructure projects implemented a comprehensive cybersecurity framework across its global operations. The company, which we'll call "Global Engineer," recognized the increasing cyber risks to its projects and took proactive measures to enhance its security posture.

Key implementations:

1. Integrated Security Operations Center (SOC): Global Engineer established a 24/7 SOC to monitor and respond to security incidents across all its projects worldwide.
2. Zero Trust Architecture: The firm implemented a zero-trust model, requiring continuous authentication and authorization for all users and devices accessing project resources.
3. AI-powered threat detection: Advanced machine learning algorithms were deployed to identify anomalous behavior and potential threats in real-time.

Results

- 75% reduction in security incidents within the first year of implementation
- Successful thwarting of a sophisticated APT attack targeting proprietary design data
- Improved client confidence, leading to a 20% increase in high-security project contracts

Case Study 2: Cybersecurity in Smart City Project

A major European city embarked on a smart city initiative, integrating IoT devices and advanced data analytics into its urban infrastructure. The project team prioritized cybersecurity from the outset, recognizing the potential vulnerabilities in such a connected ecosystem.

Key measures:

1. Security-by-design approach: Cybersecurity requirements were embedded in all RFPs and vendor selections.
2. Segmented network architecture: The city's network was divided into isolated segments to contain potential breaches.
3. Robust IoT device management: A centralized system for monitoring, updating, and securing all IoT devices was implemented.

Outcomes:

- Successfully defended against multiple DDoS attacks targeting city services
- Maintained citizen trust through transparent security practices and zero data breaches
- Became a model for other smart city projects worldwide

These case studies illustrate both the successful implementation of cybersecurity measures and the valuable lessons learned from security incidents in engineering projects. They highlight the importance of proactive security planning, the need for continuous adaptation to evolving threats, and the critical role of cybersecurity in maintaining the integrity and success of modern

engineering projects. The lessons derived from these experiences can serve as guideposts for other organizations in the engineering sector as they navigate the complex landscape of cybersecurity challenges.

Future Directions in Cybersecurity for Engineering Projects

A. Emerging Trends in Cybersecurity for Engineering Projects

The landscape of cybersecurity is continuously evolving to address the increasing sophistication of cyber threats. One of the most significant emerging trends is the adoption of zero-trust architecture, which operates on the principle of "never trust, always verify." This approach requires strict verification for every user and device attempting to access resources, minimizing the risk of internal threats. Another trend is the increased use of blockchain technology for securing data transactions and ensuring transparency in engineering project management.

B. Potential Applications of AI and ML in Threat Detection and Response

Artificial Intelligence (AI) and Machine Learning (ML) are revolutionizing threat detection and response mechanisms in cybersecurity. These technologies enable the development of advanced anomaly detection systems that can identify unusual patterns and potential threats in real time. By analyzing vast amounts of data, AI and ML algorithms can predict and prevent cyber-attacks before they occur. Additionally, AI-driven automation in incident response helps in swiftly mitigating threats, reducing the response time significantly. The integration of AI and ML in cybersecurity tools also allows for continuous learning and adaptation, ensuring that the defense mechanisms evolve alongside emerging threats.

C. Regulatory Landscape and Compliance Requirements

The regulatory landscape for cybersecurity is becoming increasingly stringent, with new laws and standards being introduced globally to protect critical infrastructure and sensitive data. Engineering projects, especially those involving public utilities or national infrastructure, must comply with frameworks such as the General Data Protection Regulation (GDPR) in Europe, the Cybersecurity Information Sharing Act (CISA) in the United States, and other regional regulations. Compliance requires rigorous risk assessments, regular security audits, and adherence to best practices in data protection. Failure to meet these requirements can result in severe penalties, legal action, and damage to the organization's reputation.

In summary, the future of cybersecurity in engineering project management lies in adopting innovative technologies like zero-trust architectures, blockchain, AI, and ML, alongside ensuring compliance with evolving regulatory standards. These advancements are essential for protecting projects from the growing threat landscape and ensuring their successful and secure completion.

Conclusion

A. Summary of Key Findings

The research highlights the multifaceted nature of cybersecurity challenges in engineering project management. Key findings include the significant financial, operational, reputational, and legal impacts of cyber-attacks on engineering projects. Emerging trends such as zero-trust architecture and blockchain technology are pivotal in enhancing cybersecurity measures. The integration of AI and ML in threat detection and response is revolutionizing the way organizations defend against cyber threats. Additionally, the increasingly stringent regulatory landscape necessitates compliance with various national and international cybersecurity standards.

B. Implications for Engineering Project Management

For engineering project management, these findings underscore the urgent need for robust cybersecurity strategies. Engineering firms must prioritize cybersecurity to mitigate financial losses, operational disruptions, reputational damage, and legal repercussions. Implementing zero-trust architectures and blockchain technology can provide stronger security frameworks, while AI and ML can offer advanced threat detection and response capabilities. Compliance with regulatory requirements is not only a legal obligation but

also a critical component of risk management. By integrating these cybersecurity measures, engineering projects can achieve greater resilience against cyber threats and ensure the successful completion of their objectives.

C. Recommendations for Future Research

Future research should focus on several key areas to further strengthen cybersecurity in engineering project management. First, there is a need for more empirical studies on the effectiveness of emerging cybersecurity technologies, such as zero-trust architecture and blockchain, in real-world engineering projects. Second, exploring the potential of AI and ML in proactive threat intelligence and predictive analytics can provide deeper insights into preempting cyber-attacks. Third, research should examine the evolving regulatory landscape and its implications for global engineering firms, with a particular focus on harmonizing international standards. Finally, interdisciplinary studies that integrate cybersecurity with other aspects of project management, such as supply chain security and human factors, can offer a holistic approach to safeguarding engineering projects.

In conclusion, addressing cybersecurity challenges is critical for the success and sustainability of engineering projects. By leveraging emerging technologies and ensuring regulatory compliance, engineering firms can protect their projects from the ever-evolving threat landscape. Future research will play a crucial role in advancing our understanding and implementation of effective cybersecurity measures in engineering project management.

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Research

Monitoring the Performance of Reinforced Concrete Structures

Sanjeev Kumar Verma*, Hitesh Kodwani
School of Engineering and Technology, SAM Global University, Raisen- 464 551, Madhya Pradesh, India
Corresponding Email: deanacademic@samglobaluniversity.ac.in
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Abstract: Demolition of steel in concrete structures with reinforcement reduces the life and sturdiness of structures. Resulting in enormous costs for inspection and maintenance, corrosion of reinforcing steel causes most of the damage to the reinforced concrete structures. Consequently, standards in inspections of structures are required to assess their condition. However, interpreting test data is not easy, because outcomes are considerably influenced by the surrounding environment to which the structure is exposed. This paper describes the in-situ monitoring of various concrete structures in Bhopal city using different Non-destructive testing equipment for determining the performance and condition of concrete structures.

Keywords: Concrete, Condition, Corrosion, NDT, Performance

Introduction

Non-destructive testing methods (NDT) can be applied to old and new structures. For new structures, the principal applications are likely to be for quality control or the resolution of doubts about the quality of materials or construction. The testing of existing structures is usually related to an assessment of structural integrity or adequacy. In either case, if destructive testing alone is used, for instance, by removing cores for compression testing, the cost of coring and testing may only allow a relatively small number of tests to be carried out on a large structure which may be misleading. The process of SHM involves monitoring a structure over some time using appropriate sensors, extracting damage-sensitive features from the measurements given by the sensors, and analyzing these features to determine the current state of the structure. In the traditional methods, the material is broken down to determine mechanical properties, such as strength, toughness, and hardness. However, NDTs are performed in a manner that does not affect the future usefulness of the reinforced concrete (RC) structures. According to Somerville (1994), present performance and rate of deterioration are the significant parameters influencing and controlling the residual life of concrete structures. The rate of degradation and corrosion of steel in RC structures depends on the exposure conditions of the structure and the extent of maintenance. However, these severe environments can cause corrosion of reinforcement as long as the required amount of oxygen and moisture is available at the rebar level in concrete structures (Hussain and Ishida 2012). For monitoring and evaluating the condition of deteriorating structures better in-situ NDT inspection techniques are needed (Rens et al. 1997), these methods relate some physical and chemical properties of concrete structure to its strength, performance, and service life.

Failure of concrete structures due to carbonation or chloride ingress-induced corrosion of reinforcement may be a major problem causing significant loss of cash and time. Hence, there it's required to completely understand the basic causes of failure and monitor the condition of structures. Effective methods for in-situ monitoring are fundamental requirements for planning maintenance, repair, and removal of RC structures. Information

regarding conditions required the determination of parameters like the concrete cover, carbonation depth, chloride content, half-cell potential, and age of the structure. In the present research parameters such as concrete cover, carbonation depth, chloride content, and half-cell potential were determined by conducting in-situ testing over several structures for monitoring the condition and performance of concrete.

A brief review of similar work

In-situ performance degradation of concrete structures increases with age, and after a certain period repair and maintenance of structures is required. So, it is required to evaluate the present condition of structures through in-situ and laboratory experiments. In the last few decades, several similar attempts have been made to evaluate the condition of existing structures by performing in-situ and lab tests.

Several mechanical and physical properties of concrete structures are often referred to assess the condition and capacity of the structures. Pascale et al. (2003) carried out an experimental program involving both destructive and non-destructive techniques applied to various substantial blends, with 3D shape strength shifting from 30 to 150MPa, to characterize a connection among strength and boundaries. Tests performed are beat speed, bounce back hammer, pull-out, test entrance, miniature coring, and joined techniques. Almir and Protasio (2000) utilized NDT techniques to decide the compressive strength of cement and the connection between the deliberate mechanical or actual properties and the strength.

A few specialists performed various sorts of NDT tests, for example, mechanical, substance, electrochemical, and attractive techniques to assess the condition by joining the outcomes. Rens and Kim (2007) assessed a steel span utilizing a few NDT techniques, for example, visual investigation, hammer sounding, Schmidt hammer, UPV testing including tomographic imaging. Bhadauria and Gupta (2007) introduced contextual analysis of weakened water tanks arranged in the semitropical area of India. Boundaries estimated are substantial cover, carbonation profundity, chloride fixation, compressive strength, and so forth. NDT strategies utilized are, Cover-meter, Phenolphthalein marker test, Quantab test, Potentiometric Titration, Schist's sledge test, and UPV test. Amleh and Mirza (2004) performed the substantial cover test, half-cell Potential, consumption rate, electrical resistivity, chloride content at steel level (%), steel bar mass misfortune (%), retention, beat speed, compressive strength, carbonation profundity, Petro-realistic assessment, and penetrability test. Dias and Jayanandana (2003) performed nondestructive methods of visual examination, scrutiny of drawings, ultrasonic heartbeat speed estimations, Cover-meter overviews, and center testing for the condition evaluation of RC structures.

The proliferation of waves or impressions of various beams like X-beam, through substantial designs can be utilized to distinguish the decay level of substantial designs. Shiotani et al. (2009) utilized the Acoustic Discharge (AE) method to assess the primary state of a substantial scaffold. Cascante et al. (2008) introduced a philosophy for the ND assessment utilizing the multichannel investigation of surface waves (MASW). Nachiapan and Cho (2005) dissected erosion items utilizing X-beam diffraction and nuclear retention spectroscopy to track down minerals present in them. Akuthota et al. (2004) introduced the exploratory aftereffects of involving close-to-handle microwave NDT procedures for distinguishing disbond in an exceptionally pre-arranged carbon fiber built-up polymer (CFRP) supported mortar test. Gassman and Tawhed (2004) introduced the aftereffects of an NDE testing program performed to survey the harm in substantial extension by utilizing the Effect reverberation technique. Popovics et al. (1998) evaluated the uneven pressure wave estimation technique in concrete. This strategy gives important data on the condition of material, when admittance to only one side surface is conceivable, for example, for the instance of substantial asphalts.

Ultrasonic heartbeat speed is involved by numerous specialists for the appraisal of substantial properties by utilizing travel season of longitudinal waves over a known distance. Sharma and Mukherjee (2011) involved ultrasonic-directed waves for observing the movement of rebar erosion in chloride and oxide climates. Shah and Hirose (2010) introduced a trial examination of the substantial application of nonlinear ultrasonic testing methods. Ervin et al. (2009) made an

Ultrasonic Detecting Organization to survey support disintegration. Stergiopoulou et al. (2008) introduced a technique for NDT of metropolitan substantial foundations utilizing UPV estimations and applied it to substantial carports. UPV has been utilized as a sign of substantial quality.

Electrochemical techniques are utilized by numerous specialists to distinguish the disintegration level of designs. Sangoju et al. (2011) studied the consumption conduct of steel in broken Conventional Portland Concrete (OPC) and Portland Pozzolana Concrete (PPC) cement by estimating chloride particle vulnerability, absorptivity, half-cell potential, resistivity, all-out charge passed, and gravimetric weight reduction. Bola and Newtson (2005) chose five locales for field assessment of support erosion, porousness, chloride particle focus, half-cell potential, polarization obstruction, and pH esteem. Buddy et al. (2002) explored the rate and measure of consumption of steel in concrete. Tests performed for dissecting consumption are half-cell potential, potentiodynamic, sped-up electrolytic erosion tests, and sped-up carbonation tests. Costa and Appleton (2002) depicted a progression of contextual investigations of various sorts of substantial designs, exposed to a cruel marine climate that crumbled because of chloride-instigated erosion.

From the above conversation, it has been seen that a large percentage of the scientists and researchers perceived substantial concrete cover, carbonation depth, chloride content, half-cell potential, and period of designs as significant boundaries impacting the condition, solidness, and life of designed structures.

Experimental Study

In the current investigation several non-destructive field tests, shown in Table 1, were performed on different concrete structures to evaluate the performance and condition of structures.

Table 1. NDT Methods used in the present research.

S. No.	Parameter	NDT method	Principle
1.	Concrete cover	Cover meter	Electromagnetic induction
2.	Carbonation depth	Rainbow indicator	Carbonation reduces the pH of the concrete
3.	Chloride concentration	Rapid Chloride Test	The potential difference of unknown solution is compared with the potential difference of solutions with known chloride concentration
4.	Corrosion	Half-cell potential.	The electric potential of rebar's is measured relative to half-cell and indicates the probability of corrosion

(i) Concrete cover: Concrete cover to reinforcement acts as the first line of defense against physical and chemical attacks from the environment, and is measured and recorded with the help of a cover meter. The concrete cover of all the structures is plotted in Fig. 1

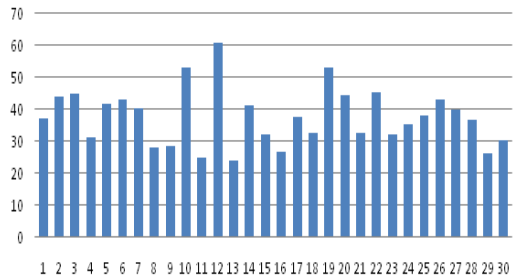

Fig. 1. Concrete cover.

(ii) Carbonation depth: Carbonation depth for concrete structures is determined by using rainbow indicator spray, a freshly broken piece of concrete or a newly cut core is sprayed and allowed to dry and the approximate pH of the paste is indicated by colors indicated on the spray. Carbonation depth and concrete cover are important parameters if Carbonation depth is close to or more than the concrete cover then corrosion starts and accelerates. Results are plotted in Fig. 2 and 3.

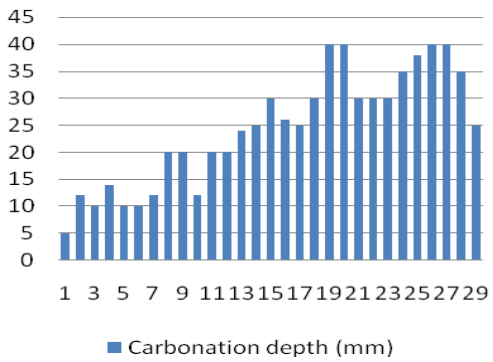

Fig. 2. Carbonation depth.

(iii) Chloride content: Rapid Chloride Test (RCT) can be used to determine chloride content from dust samples taken from a depth varying between 25-30 mm. The generally accepted threshold value is 0.2% of chloride ions by the weight of the concrete.

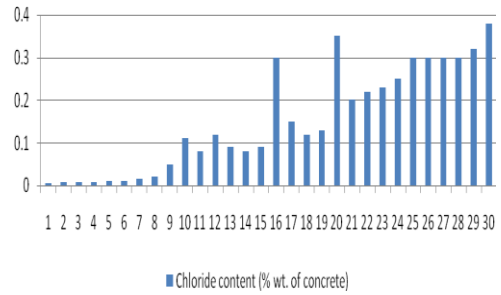

Fig. 4. Chloride content.

(iv) Half-Cell Potential: It is a widely used method for evaluating the corrosion state, it involves the measurement of the potential of embedded steel relative to a reference half-cell placed on a concrete cover. The half-cell consists of a metal rod immersed in a solution of its own ($Cu/CuSO_4$ or Ag/AgCl). The metal rod is connected with reinforcement steel by a voltmeter. The value of potential difference measured by half-cell indicates the percentage of Corrosion. In the present study, an Ag/AgCl half-cell is used to evaluate the percentage of corrosion according to Table 2.

Table 2. Presents criteria according to ASTM C876 for $Cu/CuSo_4$.

S. No.	Half Cell Potential (mV)	% chance of corrosion
1.	>-119	10
2.	-119 to -269	50
3.	<-269	90

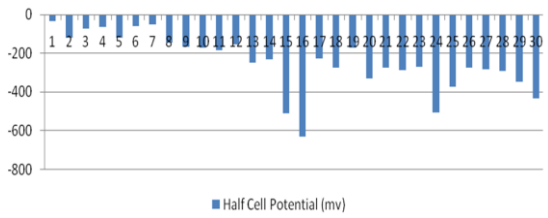

Fig. 5. Half Cell Potential Values.

(i) Age of structure: From the results it has been observed that an increase in the age of structure increases the probability of corrosion as it increases the carbonation depth and chloride content with age, as shown in Fig 6, 7and 8.

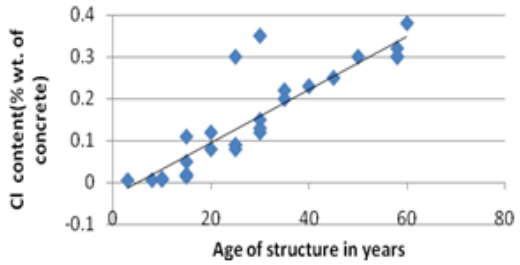

Fig. 6. Variation of Chloride content with age.

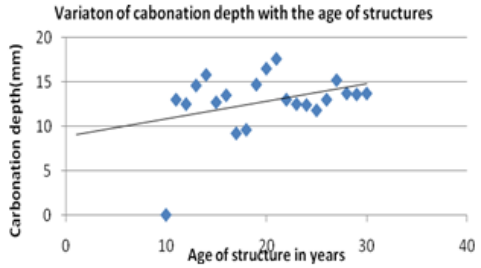

Fig. 7. Variation of Carbonation depth with age.

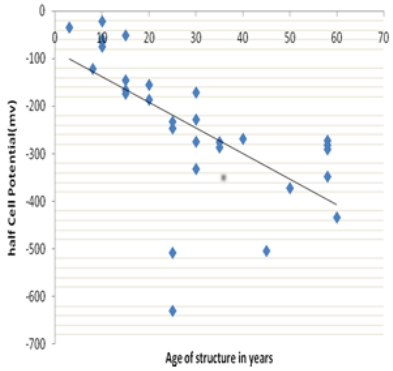

Fig. 8. Variation of Half Cell Potential with age.

Conclusion

This paper discussed the results of an in-situ survey conducted on a few structures of Bhopal city; it has been observed that with the increase in age of the structures the deterioration of concrete increases (Fig. 1-6). The age of the structure influences the condition and corrosion state of the structure. Parameters such as carbonation depth, concrete cover, chloride content, and half-cell potential are investigated *in situ* and field investigations indicate that carbonation depth, chloride content, and concrete cover have significant effects on rebar corrosion.

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Research

Nitrate Reductase Activity of Thermophilic Cyanobacteria *Mastigocladus* sp.

Vidhi Verma[1*] Meenakshi Banerjee[2]
[1]School of Sciences, SAM Global University, Raisen- 464 551, Madhya Pradesh, India
[2]Center for Applied Algal Research, Rice University, Houston, Texas, US
**Corresponding Email: vidhiverma2021@gmail.com, meenakshi.b.bhattacharjee@rice.edu*
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Abstract: The thermophilic cyanobacteria have adapted themselves to a wide array of ecological niches such as hot springs, volcanoes, etc. In cyanobacteria lipids, nucleic acids, and proteins are susceptible to heat and therefore there is no single factor that enables all thermophiles to grow at extreme temperatures. The lipid membranes of thermophiles have saturated and straight chains of fatty acids to provide the right degree of fluidity needed for membrane function. Some species contain Para crystalline surface layers which function as external protective barriers. Thermophilic cyanobacteria also have histone-like protein that protects DNA and have reverse gyrase which is responsible for positive supercoiling in DNA. Heat shock protein chaperons are also present which are likely to play a significant role in stabilizing and refolding proteins as they begin to denature. The study has unraveled a lot of significant data and opened many new avenues of research in the industrial use of extremophiles, which answer the fundamental questions of the existence of extremophilic organisms on Earth and their use in various biotechnological processes.

Keywords: Cyanobacteria, Nitrate reductase activity, Thermophiles

Introduction

Thermophilic cyanobacteria are the most studied extreme group in the world. Thermophilic microorganisms are found in the thermal waters of each continent except Antarctica. The inhabitants of these thermal environments are called thermophiles ("thermo" for heat, "phile" for lover—survive and thrive). 'A thermophile is an organism capable of living at a temperature at 'or' near the maximum for the taxonomic group of which it is a part.' (Brock 1986). These thermophiles are found in hot springs and hydrothermal vents of the world.

Geothermal springs of temperature between 45-100°C are almost exclusively inhabited by thermophilic prokaryotic microorganisms, photosynthetic flexi bacteria, and certain non-photosynthetic autotrophic and heterotrophic bacteria. (Pentecost 2003, Banerjee and Castenholz 2009, Norris and Castenholz 2007). The hot source of water contains most of the essential nutrients and permits a steady growth of cyanobacteria throughout the year. As the effluent moves away from the source of the spring the water cools thus setting up a temperature gradient (Banerjee et al., 2001, Banerjee and Verma 2008). Downstream as the temperature gradually decreases from 73°C to about 53°C, populations of unicellular and filamentous heterocystous cyanobacteria, form deep green to reddish brown mats (Bhattacharya 2001). Thermophilic cyanobacteria have adapted themselves to a wide array of ecological niches such as hot springs, volcanoes, etc. (Madigan and Brock 1977).

These algae withstand 'or' tolerate a very high temperature. (Castenholz 1977). Thermophilic cyanobacteria have become an experimental system for basic and applied research due to their unique properties (Whitton et al. 1990, Tomitani et al. 1999)

Natural geothermal areas are widely distributed around the globe, but they are primarily associated with tectonically active zones at which the movements of the Earth's crust occur (Castenholz 1969, 1977). Due to this localization of geothermal heat sources, hot springs are generally restricted to a few concentrated areas. The most important biotopes are terrestrial geothermal fields, with alkaline freshwater hot springs and solfatara, and marine environments with coastal, shallow, and deep hydrothermal systems. Hot environments display a complete range of pH, from acid to alkaline, depending on temperature, water availability, and gas and ion concentration (Kristjansson and Hreggvidsson 1995, Haverkamp et al. 2008).

Thermophilic cyanobacterium *Mastigocladus* is dominant in the thermal hot springs of every continent. Description of this cyanobacterium was first given by Ferdinand Cohn (1862) from Karlsbad Hot Spring (now Karlovy Vary in the Czech Republic). He pointed out the evolutionary and biogeochemical significance of organisms living in the hot spring. The organism forms tough mats and the morphology of this cyanobacterium is very simple. The cells of the main filament are long cylinder and barrel in shape with narrow branches at one side with an intercalary heterocyst. The cells of side branches are long cylinders. Hormogonia are absent in this organism (Jha et al. 1986, Bhattacharya 2001, Khumanthem et al. 2007).

Among all the thermophilic microorganisms *Mastigocladus* has a unique ability to adapt entire range of temperatures and perform oxygenic photosynthesis in addition to the ability to fix atmospheric nitrogen, especially at elevated temperatures (Fogg 1951, Stewart 1970, Miller et al. 2006**,** Khumanthem et al. 2007, Miller et al. 2009). In India, *Mastigocladus* was found in the thermal hot spring of Barkeshwar (West Bengal), Rajgir (Bihar) and it is also found in the thermal effluents of the Tarapur nuclear plant, near Maharashtra (Bhattacharya 2001).

Cyanobacteria are fundamentally important colonists of hot springs and hydrothermal vents. Their role in these extreme ecosystems is a result of their remarkable resistance to extreme temperature and high salinity whilst being capable of photosynthesis in adverse situations. Their production of compatible solutes makes them tolerate osmotic stresses resulting from desiccation, hot temperatures, and extreme salinity.

Although such initial research on thermophilic *Mastigocladus* there is a paucity of knowledge regarding the behavior of this organism when isolated from their natural environment to lab conditions. The study of this organism, therefore, is not only important because it is biologically and scientifically very interesting but also because there is a great lacuna of knowledge regarding the physiology of nitrate metabolism in this organism which is essential for its growth and survival in the niche it belongs. Almost nothing is known about the mechanism adopted by these organisms to perform nitrate reduction metabolism under extreme conditions. Keeping this in mind, this study is a sincere attempt to study thermophilic cyanobacteria, heterocystous *Mastigocladus* from the hot springs of Yellowstone National Park its nitrate metabolism.

Materials and Methods

Collection and Identification of the Microbes

The culture of *Mastigocladus* has been isolated from the thermal hot springs of Yellowstone National Park, the organism

was available in the Centre for Ecology and Evolutionary Biology, University of Oregon, USA. *Mastigocladus* was cultured, purified, identified, and made axenic by standard microbiological procedure by Professor (Dr.) Meenakshi Banerjee Head, Department of Biosciences, Barkatullah University Bhopal during her visit to that center in the USA in 2007, and brought to the laboratory of Algal Biotechnology for further work. Identification of the strains was made according to the standard literature like Desikacharya (1959), the latest edition of Bergey's Manual (2001). Now isolated cultures were a part of the culture collection of the Laboratory of Algal Biotechnology, Department of Bioscience, Barkatullah University, Bhopal (Madhya Pradesh).

Cultural Media and Culture Conditions

Out of several media tested *Mastigocladus* showed the best growth in Fogg's (N^-) medium where A_5 and FeEDTA were autoclaved separately.

Culture Vessels

The glassware used was either Borosil or Qualigens made. Cultures were maintained in culture tubes (15x1.5 cm) each containing 15ml medium in Erlenmeyer flasks of 100 ml or 250 ml capacity containing 20 ml or 100 ml medium respectively.

Sterilization of the Medium and Glassware

Culture medium and culture vessels were sterilized by wet-heat sterilization method in an autoclave at 15 lb/inch^2 pressure and a temperature of 121°C for 15-20 minutes.

Incubation and Maintenance of Enrichment Culture

The culture was incubated in an air-conditioned culture room and illuminated by three 40 W fluorescent tubes at 50 cm for 16 hours daily unless otherwise stated in the case of light-intensity experiments. The culture was shaken in an orbital shaking incubator as well as by hand. The cultures were sub-cultured at regular intervals and experiments were conducted on exponentially growing cultures only.

Nitrate Reductase Activity

The estimation of *in vivo* nitrate reductase activity was done by the following method of Camm and Stein (1974) as slightly modified by Kumar and Kumar.

Results

Figure 1 shows the graph of nitrate reductase activity of *Mastigocladus*. In *Mastigocladus* nitrate reductase activity was highest at 96 h (0.74 µg NO_2 µg Chl *a*/ ml^{-1}) after which there was a decline in the activity. The effect of temperatures has been studied on the strain. In *Mastigocladus* with increasing temperature an increase in nitrate reductase activity was observed, the activity was highest at 55±2ºC (0.84 µg NO_2 / µg Chl *a* ml^{-1}) at 96 h (4.3b), and the fold increase was found to be 1.13 over the control (25±2ºC) at 96 h.

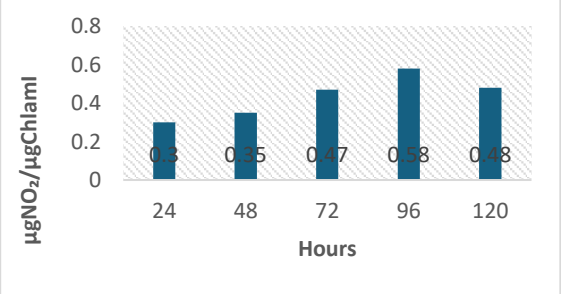

Fig. 1. Nitrate reductase of *Mastigocladus* (Fogg's N^-) under laboratory conditions. (Temperature 25ºC± 2ºC, Light Intensity 2500±200 Lux, pH- 8.2, Results mean ± SD n=3).

Discussion

It is observed in a present study that nitrate reductase activity high in *Mastigocladus*. In *Mastigocladus* nitrate reductase is the main nitrogen assimilating enzyme like nitrogenase activity. If nitrate is available, then *Mastigocladus* can choose between the energy-expensive nitrogenase and nitrate reductase. Studies on nitrate reductase activity showed that if provided with external sources of nitrogen, the extremophiles could metabolize it. Under extreme conditions, the morphology of the cyanobacteria changes remarkably, and this could cause enormous effects, changing the whole metabolism of the organism, especially at the biochemical level. Under

elevated temperature conditions as studied and like that found in nature the nitrate reductase activity increased in *Mastigocladus* (Fig. 1). This suggests that it can be the adaptation of the organisms for elevated temperature, at elevated temperature the surface area of the cell increases which provides a far greater area to capture light energy and hence increased photosynthesis resulting in increased reductant energy supply for the enzyme activities (Bhattacharya 2001). Nitrate assimilation depends upon the CO_2 fixation. The high nitrate reductase activity in the thermophile at normal temperature (25ºC±2ºC) as well as at elevated temperature showed the flexibility of the enzyme, in the organism.

The main results so far point to the importance of the thermophile *Mastigocladus* which is thermostable even when isolated under culture conditions and maintained in culture room. Such organisms therefore have tremendous applications in research requiring thermostability. This study paves the path for the future utilization of *Mastigocladus* in biofertilizers in regions of remarkably elevated temperature, biological research about the use of thermostable enzymes, and industrial and biotechnological applications.

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Research

Isolation and Characterization of Volatile Contents from *Ocimum basilicum*

Varun Jain[1*], Sohan Kumar[2], Ruchi Upadhyay[1]
[1]School of Sciences, SAM Global University, Raisen- 464 551, Madhya Pradesh, India
[2]Govt. PM Rise PG College, Vidisha- 464 001, Madhya Pradesh, India
**Corresponding Email: jainvarun27@gmail.com*
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Abstract: The essential oils of *O. basilicum* were obtained from a Clevenger apparatus distilled for 3 hr. Essential oils of *O. basilicum* were analyzed by GC and GC-MS. The yield of the essential oil obtained from *O. bascillum* (0.98% w/w). Methyl eugenol and eugenol were found to be major constituents of fresh leaves of O. *basilicum.*

Keywords: Essential oils, *Lamiaceae*, *Ocimum* species

Introduction

To expand the spectrum of antibacterial agents from natural resources, *Coleus aromaticus* belonging to the *Lamiaceae* family (Mint family) has been selected. The leaves of the green type of country borage are often eaten raw with bread and butter. The chopped leaves are also used as a substitute for sage (*Salvia officinalis* L.) in stuffing. *Coleus aromaticus* is used for seasoning meat dishes and in food products, while a decoction of its leaves is administered in cases of chronic cough and asthma. It is considered to be an antispasmodic, stimulant, and stomachic and is used for the treatment of headache, fever, epilepsy, and dyspepsia. It is used to treat conditions such as indigestion, diarrhea, nervous tension, insect bites, toothache, earache, rheumatism, whooping cough, and bronchitis. It is also known to be a very powerful painkiller, that stimulates the flow of bile aiding digestion. Mast cell stability properties of *C. aromaticus* leaves were checked in rat peritoneal mast cells. The essential oils from *Ocimum* contain many terpenes (linalool, citral, 1,8-cineole) and phenylpropanoids (e.g. methyl chavicol, eugenol) produced in specialized glandular trichomes (Warrier et al. 1995, CSIR 1992, Charles and Simon 1990, Gang et al. 2001). It is also a source of aroma compounds and essential oils containing biologically active constituents that possess insecticidal and nematicidal properties (Deshpande and Tipnis 1997). To the best of our knowledge, an investigation of the essential oil of *O. sanctum* and *O. basilicum* leaves of South India has not been reported to date. In the present study, the essential oils were isolated from fresh leaves and the volatile oil was analyzed by GC/MS method.

Materials and Methods:

Plant Materials The fresh leaves of *Ocimum basilicum* were collected from various areas of Vidisha (M.P). Specimens of *Ocimum basilicum* were deposited at the Pest control and ayurvedic Research Lab of SSSL Jain P.G College Vidisha (M.P). Isolation of the Volatile Oils is done by chopping the fresh leaves of *O. basilicum* and hydro distilled for 3h using a Clevenger-type apparatus. The essential oils were collected separately and stored in well-capped bottles prior to analysis. GC-MS Analysis GC-MS was carried out in SAIF CDRI Lucknow. The identification of the compounds was performed by comparing their retention indices and mass spectra with those reported and supplemented by Wiley and Quadlib 1607 GC-MS libraries.

Results and Discussion

The percentage of essential oil obtained was *O. basilicum* (0.98% w/w). The gas chromatograms of these three essential oils are given in Fig. 1. The essential oils of *O. basilicum* obtained from the Clevenger apparatus were found to be rich in methyl eugenol and eugenol. As shown in Table 1, essential oils constituents in both plant samples from Vidisha (M.P) were identified by *the* GC-MS method. The essential oil of *Ocimum basilicum* (L) was identified as three major constituents such as methyl eugenol (37.5%), eugenol (31.3%), and unknown (31.1%) (Table 1, Fig. 1, Fig. 2).

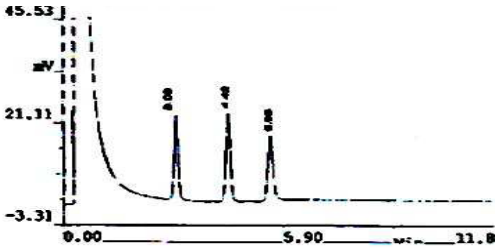

Fig. 1. Gas chromatograms of three essential oils.

Table 1. Chemical composition of essential oil from the fresh leaf of *Ocimum basilicum*.

S. No.	RT	% Area	Constituents	Methods
1	3.03	31.1	Unknown	GC-MS
2	4.42	37.5	Methyl Eugenol	GC-MS
3	5.55	31.3	Eugenol	GC-MS
Total		**99.9**		

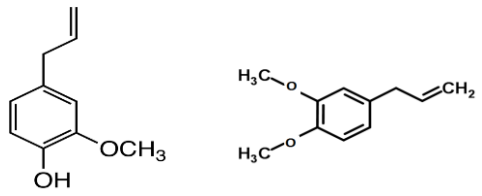

Fig. 2. Chemical structures of Methyl Eugenol and Eugenol.

Methyl Eugenol Eugenol

Methyl eugenol has been previously reported as the main constituent of the essential oils from *Ocimum selloi* and *Ocimum basilicum* (Ozcani and Chalchat, 2007, de Paula et al. 2007). In contrast, a trace amount of methyl eugenol has been reported from the essential oil of *Juniperus angosturana* (Adams et al. 2007, 2017), and a low content in the essential oil from *Pimenta dioica* berries (Park et al. 2007). There is currently concern as to the carcinogenic potential of methyl eugenol.

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Research

Qualitative and Quantitative Analysis of Photochemical and Study of the Effect of Phytoconstituents in Seed Germination

Sarvar Jahan
Department of Chemistry, School of Sciences, SAM Global University, Raisen- 464 551, Madhya Pradesh, India
Corresponding Email: sarvarjahan92@gmail.com
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Abstract: Ten distinct locally accessible plant sections were subjected to photochemical screening in methanol extract. Plants include a variety of phytoconstituents, including quinine, terpenoid, flavonoid, steroid, alkaloid, cardiac glycoside, glycoside, volatile oils, etc. The investigation into the role of phytoconstituents in the germination of Pisum sativum seeds indicated that these components had a cytotoxic impact on live cells, or the *Pisum sativum* seeds' ability to germinate. The plant extract's phytoconstituents had an impact on the growth and multiplication of cells. Therefore, these plants may be useful in the development of medications that target cancer cells as well as germs and other microorganisms.

Keywords: Cytotoxicity, Methanol extract, Photochemical screening, Phytoconstituents, Seed germination

Introduction

Medicinal plants are important species of plants that according to traditional medicinal practices and also from modern scientific studies are useful for medicinal purposes to alleviate diseases and make human health more invigorating. These plants are contemplated as rich sources of ingredients that can be used in the synthesis and production of drugs (Oladeji et al. 2019). Plants consist of various kinds of chemical constituents known as phytoconstituents (Mercy et al. 2017). Phytoconstituents Serve the plants by contributing some secondary functions like; helping in plant growth, safeguarding the plants by activating defense mechanisms, and imparting color, odor, and flavor to the plants (Molyneux et al. 2007). Natural products and their derivatives exhibit minimal side effects and improved efficacy than other synthetic counterparts (Batiha *et al*. 2020).

These plant-derived components like flavonoids, quinine, terpenoids, etc conduct certain biological functions that enhance therapeutic activities such as anti-carcinogenic, anti-mutagenic, anti-inflammatory, and antioxidant properties (Batiha et al. 2020). Photochemical screening is the scientific process of analyzing, examining, extracting, experimenting, and thus identifying different classes of phytoconstituents present in various parts of the base for the discovery of drugs, the active components could be further taken for investigation and research.

The process was qualitative which is termed phytochemical screening. The outcome of the research could be fruitful in developing potent drugs against various diseases.

Table 1. List of medicinal plants and uses.

Name	Part taken	Local name	Local uses
Allium cepa (ACB)	Bulb	Onion	Vegetable.
Curcuma longa (CLR)	Rhizome	Turmeric	Antiseptic, anti-diabetic and antibacterial agent (Maithalikarpagaselvi *et al*. 2020)
Ocimum sanctum (OSL)	Leaves	Tulsi	Antioxidant, Anti-inflammatory (Chaudhary *et al.* 2020)
Mentha arvensis (MAL*)*	Leaves	Mint	Antibacterial and antiseptic agent (Patil *et al.* 2016)
Allium sativum (ASB)	Bulb	Garlic	Antioxidant (Melania *et al*. 2019)
Zingiber officinale (ZOR)	Rhi-zome	Ginger	Treats cold, cough, in gastric problems (Arwande *et al*. 2018)
Acorus calamus (ACR)	Rhi-zome	Calamus	Treats throat and stomach problems (Nath & Yadav, 2016)
Zanthoxyllum armatum (ZAS)	Seeds	Timur	Used in intestinal problems (Bharti & Bhushan 2015)
Nyctanthes arbortristis (NAL)	Leaves	Parijat	Anti-diabetic (Haque *et al*. 2015)
Nyctanthes arbortristis (NAF)	Flowers	Parijat	Anti-diabetic, treats hypertension (Haque *et al*. 2015)

The aim of this study is the phytochemical screening of plants and the cytotoxic activity of phytoconstituents in living cells. Plants used for the study along with their local name, parts taken, and local use are shown in Table 1. The study is important because plants showing cytotoxic effects in living cells could be further investigated and specifically studied for developing drugs against cancer and also against microbes and bacteria. Curcumin present in turmeric has been reported anticancer properties (Carroll et al. 2011). Fruits and vegetables containing flavonoids showed cancer chemo-preventive activity (Mishra et al. 2013). The presence of classes of phytochemicals as such; flavonoid, alkaloid, and tannin showed cytotoxic effects (Chaudhary et al. 2017).

Materials and Methods

Ten different plant samples were identified and collected. Collection of plants for the study purpose which is located in Bhopal areas and is situated at an altitude of 1412 m height with latitude 85°27' 32"east and longitude 27°38' 42" north. The climate of the village is moderate with deciduous vegetation. The plants were collected in October.

Collected plant parts were washed with distilled water, cut into small pieces, and dried in shade for 4 weeks. Dried plant parts were ground into fine powder using an electric grinder. 100 g of each powdered sample was soaked in 100-150 mL methanol in a conical flask, shaken occasionally to mix, and macerated for 72 hours at room temperature. Maceration intends to soften and break the plant's cell wall to release the soluble phytoconstituents (Handa et al. 2008). All the laboratory activities were performed in the laboratory of the Department of Chemistry, SAM Global University. An electronic analytical balance was used for weighing the powdered sample and chemicals in the experiments. Then the solution was percolated through cotton. Filtrate and marc were obtained.

Phytochemical Screening: The prepared extract of all ten plants was used to test various phytoconstituents present in them. Different chemical reagents were prepared and specific tests, for specific phytochemicals were done. These various tests were qualitative and hence termed phytochemical screening. All chemicals and solvents were procured from Fisher Scientific, India, and were used without further purification. The tests were done by following standard procedures based on journal articles. (Alamzed et al. 2013), (Thusa and Mulmi 2017), and (Talukdar & Chaudhary, 2010).

Test for Tannin/Polyphenol (Talukdar & Chaudhary, 2010): To the diluted extract, 3-4 drops of 10% $FeCl_3$ were added, a blue color was seen for gallic tannins and the presence of catechol tannin turned the solution green.

Test for Reducing Sugar (Thusa and Mulmi 2017): To 0.5 mL of plant extract, add 1mL of water, and 5-8 drops of Fehling's solution were added and heated. The presence of reducing sugar was indicated by the appearance of brick-red precipitation.

Test for Quinine (Thusa and Mulmi 2017): To the extract, freshly prepared $FeSO_4$ solution (1mL) and ammonium thiocyanate were added then conc. H_2SO_4 was added drop by drop. The deep red color indicated the presence of quinine.

Test for Glycosides (Alamzed et al. 2013): Molisch's Reagent Test: To the extract, 5 mL of Molisch's reagent and concentrated H_2SO_4 were added. The Violet color indicated glycosides.

Test for Flavonoids (Talukdar and Chaudhary 2010): Shinoda test: 4 mL of extract solution, 1.5 mL of 50% methanol solution a small magnesium chunk were warmed. 5-6 drops of concentrated HCl were added, red color was observed for flavonoids.

Dil. NH_3 Test: 5 mL of dilute NH_3 solution in the extract was taken with the addition of conc. H_2SO_4. The appearance of yellow-colored precipitation indicated flavonoids.

Test for Terpenoids (Alamzed et al. 2013): 0.2 g of each sample was mixed with 2 mL chloroform, 3 mL conc. H_2SO_4. Reddish-brown coloration indicated the presence of terpenoids.

Test for alkaloids: Meyer's Test (Talukdar and Chaudhary 2010): To 2 mL of extract, 1 mL of Meyer's reagent was added. The presence of a pale yellow precipitate indicated the presence of alkaloids.

Dragendroff's Reagent Test (Alamzed et al. 2013): 2 mL of extract was warmed with 2% H_2SO_4. A few drops of Dragendroff's reagent were added. Orange-red precipitate indicated the presence of alkaloids.

Test for Saponins (Alamzed et al. 2013): 2 g of powdered sample was boiled in 20 mL of distilled water. 10 mL of filtrate and 5 mL of

distilled water were quivered vigorously. The appearance of frothing indicated the presence of saponins.

Test for Volatile Oils (Talukdar and Chaudhary 2010): 2 mL extract was shaken with 0.1 mL of NaOH and a small quantity of dilute HCl. White precipitate indicated the presence of volatile oil.

Test for Cardiac Glycosides (Talukdar and Chaudhary 2010): 5 mL of plant extract was treated with 2 mL of glacial acetic acid with one drop of $FeCl_3$ solution. A violet ring may appear or a greenish ring may form just which shows the presence of cardiac glycosides.

Test for Steroids (Talukdar and Chaudhary 2010): 1 g of plant extract was dissolved in a few drops of acetic acid and a drop of conc. H_2SO_4 was added. The appearance of green color indicated the presence of steroids.

Study of Effect in Seed Germination

Germinating *Pisum* seeds were taken as the representative of living cells which was the basis to study the cytotoxic activity of phytoconstituents in living cells. The study of the effect of phytoconstituents in the germination of *Pisum* seed was done in aqueous extract, methanol extract, and methanol by soaking in the solutions for five days. The method implied was based on procedures given by Radwan et al. (2019), Hassan and Samy (2007) and Chekuboyina and Rao (2015).

Results and Discussion

The results of the various phytochemical screening tests obtained during the experiment are shown in Table 2. Tannin, quinine, terpenoid, flavonoid, steroid, alkaloid, cardiac glycoside, glycoside, volatile oils, etc were the phytoconstituents found in plants. According to the literature and the tally done with the obtained result, Curcumin present in turmeric has reported improved insulin resistance, and glucose uptake, affected blood pressure, and reduced inflammation (Azhdari et al. 2019). Flavonoids cause risk reduction mainly from cardiovascular diseases and cancer (Ballard and Marostica 2019).

Table 2. Photochemical screening of different medicinal plants.

	Phytochemical Screening													
			Flavonoid					Alkaloid						
Plant extract	Tannin	Reducing	Quinine	Glycoside	Shinoda	Dil. NH_3	Terpenoid	Meyer's	Dragendroff	Saponin	Volatile oil	Cardiac Glycoside	Steroids
ACB	–	–	+	+	+	+	+	–	–	+	+	+	+
			+	+	+	+	+				+		
			+	+	+	+	+				+		
CLR	+	–	+	+	+	+	+	+	+	+	+	+++	+
	+		+	+	+	+	+	+	+	+	+		+
	+		+	+	+	+	+	+	+		+		
OSL	+	–	+	+	+	+	+	+	+	+	+	+++	+
	+		+	+	+	+	+	+	+	+	+		+
	+		+	+			+	+	+		+		+
MAL	+	–	+	+	+	+	+	+	+	+	+	+++	+
	+		+	+	+	+	+	+	+	+	+		+
	+		+	+	+	+	+	+	+		+		+
ASB	–	–	+	+	+	+	+	–	–	+	+	+	+
			+	+			+				+		
			+	+			+				+		
ZOR	+	–	+	+	+	+	+	+	+	+	+	+++	-
	+		+	+	+	+	+	+	+	+	+		
	+		+	+	+	+	+	+	+	+	+		
ACR	–	–	+	+	+	+	+	+	+	+	+	+++	+
			+	+		+	+	+	+	+	+		
			+	+			+	+	+	+	+		
ZAS	+	+	+	+	+	+	+	+	+	–	+	++	+
	+		+	+	+	+	+	+	+		+		+
	+		+		+	+	+	+	+		+		
NAL	+	–	+	+	+	+	+	+	+	+	+	+++	+
	+		+	+	+	+	+	+	+	+	+		+
	+		+	+			+	+	+	+			
NAF	+	–	+	+	+	+	+	+	+	+	+	+++	–
	+		+	+	+	+	+	+	+	+			
	+		+	+	+	+	+	+	+	+			

Source – Experimental results, - indicated absent, + indicated present, ++ indicated moderate present, +++ indicated high presence.

The presence of classes of phytochemicals as such; flavonoid, alkaloid, and tannin showed cytotoxic effects (Chowdhury et al. 2017). The color and aroma imparting flavonoids were stated to show anti-cancer properties. Additionally, cholesterol-lowering, as well as cytotoxic qualities, anti-bacterial, and anti-viral properties, are credited to the presence of saponin (Bailly and Vergote 2020). Tannin shows an anticancer property that is perceptible from its inhibitory activity toward growth (Mazni, ho Yin, Azizul, & Nurdin, 2016). Plants containing a high amount of flavonoids could be useful as anti-bacterial (Ballard and Marostica 2019). So plants like *Zingiber, Curcuma,* and *Acorus* could be used as antibacterial, and antiseptic agents.

Plants containing phenolic compounds could be useful as antioxidants. Quinine showed antipyretic properties so plants containing quinine like *Ocimum, Nyctanthes*, *Mentha,* etc could be used to reduce fever. *Mentha* is also used as a soothing agent, for relieving toothache, and also as an anti-bacterial anti-helminthic agent (Patil and Godghate 2016). *Nyctanthes and zingiber* also play a role in maintaining blood sugar. *Zingiber, Acorus, and Curcuma* consist more amount of cardiac

glycoside which is beneficial for the heart. The phenolic compound, tannin, terpenoid, and flavonoids possess an anti-helmintic property so the plant *Zanthoxylum*, *Acorus* could be used to treat stomach problems (Nath and Yadav 2016). The polyphenolic compounds, flavonoids, terpenoids found in *Allium cepa,* and *Allium sativum* are useful as antioxidant, anti-inflammatory, and antibacterial agents. Likewise, they play an important role in reducing blood pressure, in preventing heart disease.

Study of the Effect of Plant Extracts in the Germination of *Pisum sativum*

Seeds:

According to the observation germination of seed in water was with a short length of 0.9 cm. Water and methanol were used as positive control and negative control respectively. The observed results in the aqueous extract and methanol extract are shown in Table 3. The inhibition in growth in the aqueous extract may be due to the presence of phytoconstituents. In the methanol extract of the plant sample, the seeds did not germinate. The table below indicates the length of shoot of the seeds in aqueous and methanol extract which was the obtained result for determining the cytotoxic effect of the extracts.

Table 3. Shoot growth in the extracts.

Plant Extract	ACB	CLR	OSL	MAL	ASB	ZOR	ACR	ZAS	NAL	NAF
Shoot growth in Aq. Ext. (cm)	0.2	0.2	0.3	0.2	0.2	0.2	0.3	0.3	0.3	0.3

Source – Experimental Result, Shoot growth in methanol extract: - ve Shoot growth in water: 0.9 cm.

This result revealed that the phytoconstituents in plant extracts showed a cytotoxic effect in the germinating *Pisum sativum* seeds. Hence these plants can be further studied and experimented with to develop drugs against cancer cells and also against microbes and bacteria.

Conclusions

Hence, the phytochemical screening of the selected plant sample was done. From the study, it could be concluded that plants are a great source of phytochemicals that could be utilized in curing various ailments. Tannin, quinine, terpenoid, flavonoid, steroid, alkaloid, cardiac glycoside, glycoside, volatile oils, etc were the phytoconstituents present abundantly in plants.

Phytochemical screening played an important role in identifying various phytoconstituents present in plant extracts. Phytochemicals in the aqueous extract slightly inhibited the growth. This study helped to know the cytotoxic effect of the phytoconstituents present in plant extracts on the living cells.

The study provided an important basis for further investigation into the isolation and characterization of phytoconstituents from the selected plants for the development of drugs. The study was only based on qualitative analysis and screening. It would be better if a quantitative detection, their bioactivity, and IR spectra of the various phytochemicals could be performed. The study would be more beneficial if the detection, analysis, and separation of the phytoconstituents could be done.

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Research

Forensic Screening of Medicinal Plants for Qualitative Phytochemical Analysis Using Various Solvent Extracts

Neelanjana Namdev
Department of Forensic Sciences, School of Science, SAM Global University, Raisen- 464 551, Madhya Pradesh, India
Corresponding Email: namdeoneelanjana99@gmail.com
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Abstract: Medicinal plants in forensic studies play a very significant role and are rich in bioactive components that are utilized to treat and harm various human ailments. They are crucial to healing as well as to creating artificial injuries. Phytochemical screening is an important step in identifying bioactive compounds present in particular medicinal plants. Hence, in this present work, phytochemical screening of leaf extract of some traditional medicinal plants, such as *Cannabis sativa*, *Ricinus communis*, and *Bryophyllum pinnatum* was carried out. The solvent extracts of the leaves of respective plants were prepared using the Soxhlet apparatus with acetone, chloroform, petroleum ether, and aqueous solvents. Qualitative phytochemical analysis of plants included tests for reducing sugars, flavonoids, steroids, glycosides, polyphenols, tannins, terpenoids, and coumarins. All eight tested phytoconstituents were found present in all three plants in any solvent extracts. Aqueous extract confirmed the presence of a maximum number of phytoconstituents in *C. sativa* in comparison to other solvents. Acetone confirmed the maximum and chloroform confirmed the minimum number of phytoconstituents in *R. communis*, while chloroform confirmed the maximum and aqueous extract confirmed the minimum number of phytoconstituents in *B. pinnatum*. These phytochemicals may be a source of innovative plant-based medications because their existence is connected with the therapeutic potential of these plants. Investigation with a preliminary screening of phytochemicals is used in Forensic Science.

Keywords: *Bryophyllum pinnatum, Cannabis sativa, Ricinus communis,* Forensic science, Phytoconstituents

Introduction

Medicinal plants are an excellent source as they provide a wide variety of possible therapeutic compounds that are both diversified and reasonably safe, compared to manufactured pharmaceuticals. According to the World Health Organization (WHO), traditional plant-based medicines constitute the major source of healthcare for more than 80% of the world's population in developing and underprivileged nations. The WHO has made an effort to identify all internationally used medicinal plants and recognized over 20,000 species. The demand for plant-originated raw materials is increasing at a rate of 15% to 25% annually and is expected to increase by over US$5 trillion by the year 2050. The estimation of total trade by medicinal plants is approximately US$ 1 billion annually. India is incredibly rich in plant species that have therapeutic significance. Most people in society utilize these plants as herbal remedies or as pharmaceutical ingredients in contemporary medicine (Savithramma et al. 2011). Researchers have been concentrating more on herbal remedies recently, and various plants are being investigated for potential therapeutic benefits (Kumari et al. 2017). Collaborative work on forensic botany evidences ethnobotanicals, ethnomedical, ethnopharmacological, and phytochemicals is crucial to attaining research progress in the field of medicinal plants (Yadav and Agarwala 2011). Most of the studies have focused on the phytochemical screening of medicinal plants with an extraction efficiency of one or two

solvents included in this study. The focus point of some of the studies was on the single solvents on multiple plants. So the present study was designed to include the preliminary phytochemical analysis of *C. sativa*, *R. communis*, and *B. pinnatum* and also shows the comparative metabolite extraction efficiency of acetone, chloroform, petroleum ether, and aqueous solvent extracts with the particular plant.

Medicinal Uses of Plant Parts

Cannabis sativa is an important herbaceous plant that originated from Central Asia and has been used in traditional medicine since the dawn of time. The plant has been used medicinally for centuries in a variety of civilizations in the treatment of various ailments. For example, for treating asthma, loss of appetite, depression, and sleeplessness. In modern medicine, it has medical usage in the treatment of anorexia related to HIV/AIDS, nausea and vomiting in cancer chemotherapy, spasticity in multiple sclerosis, gastrointestinal disorders, postpartum hemorrhage, difficulties during child labor, and in the management of sexually transmitted diseases (Selvakumar 2022). There is significant evidence that cannabinoids are also effective in the treatment of several other disorders like neuropathic and chronic pain, movement disorders, and spasms (Ogidigo et al. 2022, Rana et al. 2019).

B. pinnatum is a succulent perennial plant native to Madagascar that has been used in medicines for a long time. *B. pinnatum* and other herb extracts in herbal compositions are said to operate as tonics, boosting health and respiration. The plant shows neurosedative activities, muscle relaxant activities, anticonvulsant activities, nephroprotective, urolithic, antibacterial, antiallergic, antileishmanial, anticonvulsant, anti-inflammatory, anti-ulcer, and analgesic activities. Leaves of *B. pinnatum* also have Neuro-restorative potential.

R. communis is a small woody tree found in India, South Africa, Russia, and Brazil. The root, leaf, and seed oils of this plant have been used in Indian medicine to treat hypoglycemia, liver diseases, and inflammation. The plant parts have anticancer, antidiabetic, antitumor, antiasthmatic, antifertility, bone regeneration, cytotoxicity, antioxidant, insecticidal, antimicrobial, antiprotozoal, and anti-ulcer properties. The seed oil also has a laxative effect and induces labor in pregnant females.

Materials and Methods

Collection of Plant Materials

Fresh leaves of plants free from diseases were collected during January 2023. Taxonomic identification of plants was carried out by the Department of Forensic Science, SAM Global University, Raisen, Madhya Pradesh.

Preparation of Extracts

Collected plant leaves were washed thoroughly with running tap water. Leaf materials were cut down into small pieces and air-dried under shade for 26 days. An electric blender was used to grind the dried plant material into a fine powder and kept in small plastic bags with paper labeling. The crude plant extracts were prepared with different solvents like acetone, petroleum ether, chloroform, and aqueous solvent using the Soxhlet extraction method for approximately 24 hours. The crude extracts were collected and kept in the refrigerator at 5°C in sealed bottles for further use.

Qualitative Phytochemical Analysis

The qualitative analysis of phytochemicals was done for different plant extracts with four different solvents, acetone, petroleum ether, chloroform, and aqueous solvent by using the following standard protocols. The experimental method is illustrated in Fig. 1.

Test for Steroid

Two ml of chloroform was added to the crude extract and concentrated H_2SO_4 was also added side by side. The evolution of red color in the lower chloroform layer directs the presence of steroids. Another test was also conducted, where 2 ml of chloroform was mixed with crude extract. After that 2 ml of acetic acid and 2 ml of concentrated H_2SO_4 were added to the mixture. The appearance of a greenish color depicts the occurrence of steroids in the sample.

Test for Terpenoids

The crude extract was mixed in 2 ml of chloroform and the solution was evaporated to dryness. 2 ml of concentrated H_2SO_4 was then added and the solution heated for another 2 minutes. The appearance of a grayish color indicates the Test for cardiac glycosides (Keller-Kiliani's test)

A few drops of 2% $FeCl_3$ solution were added to glacial acetic acid and 2 ml of this solution was mixed with the crude extract. The mixture wasthen transferred to another vessel having 2 mlof concentrated H_2SO_4. The formation of a brown availability of terpenoids in the sample (Zia et al. 2022, Grotenhermen and Müller-Vahl 2016).

Test for Coumarins

Two ml of 10% sodium hydroxide (NaOH) was mixed with 2 ml of crude extract, the appearance ofayellow color depicts the presence of coumarins (Ogidi et al. 2019, Harborne 1973).

Test for Reducing Sugar (Fehling Test)

One ml of each of Fehling A and Fehling B reagents was mixed and the mixture was then added to the crude extract and the solution boiled. The formation of brick red color precipitates in the bottom of the vessel shows the availability ofreducing sugars in the sample (Zia et al. 2022).

Test for Polyphenols and Tannins

One ml of 2% $FeCl_3$ solution was added to the crude extract. The appearance of a bluish-green or bluish-black color shows the occurrence of polyphenols and tannins in the sample.

Test for Flavonoids

The crude extract was mixed with a few small pieces of magnesium ribbon and then concentrated Hydrochloric acid was added to it drop by drop. After a few minutes, the appearance of pink or magenta color indicates the availability of flavonoids in the sample.

Test for Glycosides (Salkowski's Test)

Two ml of chloroform was added to the crude extract. Then 2 ml of concentrated H_2SO_4 was addedand gently shaken. A reddish brown color shows theoccurrence of the steroidal ring, i.e., the glycone portion ofthe glycoside. The color ring at the interface indicates the availability of cardiac glycosides in the sample.

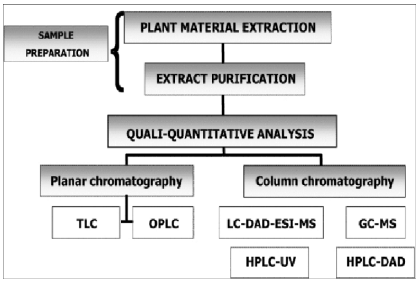

Fig. 1. A schematic diagram showing the experimental method.

Results and Discussion

The phytochemical characteristics of the leaf extract of *C. sativa* tested with different solvent extracts are summarized in Table 1, which shows the presence of medically active compounds in the plant. Reducing sugars, glycosides, cardiac glycosides, polyphenols, tannins, flavonoids, steroids, terpenoids, and coumarins, all were found present in different solvent extracts. Aqueous extract yielded more metabolites in comparison to acetone, chloroform, and petroleum ether extracts of *C. sativa*. Comparative studies for the same plant are shown in Table 2, which demonstrate the presence of most of the phytoconstituents confirmed by our study, but the solvents were not similar. Studies confirmed the maximum yield with aqueous extract.

Table 1. Phytochemical analysis of leaf extracts of *C. sativa.*

Phyto-constituents	Acetone	Chloroform	Petroleum ether	Aqueous
Reducing sugars	-	-	+	-
Glycosides	-	-	+	+
Cardiac glycosides	-	-	-	+
Polyphenols and Tannins	+	+	+	+
Flavonoids	+	-	-	-
Steroids	+	-	+	+
Terpenoids	-	+	-	-
Coumarins	+	+	-	+

Present (+), Absent (-)

Table 2. Comparative studies (*C. sativa*). Source: Nandagoapalan et al. 2016, Kulkarni and Mane 2019, Mekuria et al. 2017.

Plant part	Solvent	Phyto-constituents
Leaf, Stem, Root	Chloroform, Alcohol Aqueous, n-hexane	steroids, resins, fixed oil, alkaloids, flavonoids, terpenoids, tannin, amino acids, proteins, glycosides, phenol, saponins
Leaf	-	Alkaloids, flavonoids, cardiac glycosides, resins, terpenes, steroids
Leaf	-	phenol, saponins, Alkaloids, flavonoids, glycosides, steroids
Leaf	-	Anthocyanines, Steroids, Terpenoids

Table 3. Phytochemical analysis of leaf extracts of *R. communis*

Phytochemical test	Acetone	Chloroform	Petroleum ether	Aqueous
Reducing sugars	+	+	+	-
Glycosides	-	+		
Cardiac glycosides	+	-	+	+
Polyphenols and Tannins	+	+	+	+
Flavonoid	+	-	+	+
Steroids	+	+	+	+
Terpenoids	+	-	+	+
Coumarins	+	+	+	-

The phytochemical characteristics of *R. communis* tested with different solvent extracts are summarized in Table 3. Medically active compounds, reducing sugars, glycosides, cardiac glycosides, Polyphenols, tannins, flavonoids, steroids, terpenoids, and Coumarins, all were found present in different solvent extracts. For *R. communis*, all the phyto-constituents were found present in acetone extract, glycosides(1 compound) were found absent in petroleum ether extract, reducing sugars and Coumarins (2 compounds) were found absent in aqueous extract, while cardiac glycosides, flavonoids and terpenoids (3 compounds) were found absent in chloroform extract. Results revealed that acetone extract yielded maximum and chloroform extract yielded minimum numbers of constituents. Various studies on the phytochemical analysis of *R. communis* are summarized in Table 4, which shows the presence of similar compounds in different parts of the plant with the same or different solvent extracts. Most of the studies don't reveal the extraction efficiency of solvents with particular metabolites, which can be treated as a drawback of that study.

Table 4. Comparative studies (*R. communis*).

Plant Part	Solvent	Phyto-constituents
Leaf	Water, Methanol, Ethanol, Acetone	Proteins Carbohydrates Phenol/Tannins, Alkaloids, Flavonoid, Steriods,
Leaf	-	Flavonoid Saponins Glycosides Steroids, Phenol, Tannins, Saponins, Starch
Seed, Root, Leaf	-	Phenol, Flavonoid, Glycosides, Steroid
Seed Oil	-	Alkaloids, Terpenoids, Cardiac Glycosides, Tannins, Steroids, Saponins

The results of phytochemical analysis of different solvent extracts of *B. pinnatum* are shown in Table 5. Results revealed the presence of all tested compounds in the plant, chloroform extract shows the presence of all Phytoconstituents, while reducing sugars were absent in acetone extract and flavonoids were found absent in petroleum ether extract. Four compounds were absent in the aqueous extract. It implies chloroform extract yielded maximum and aqueous extract yielded minimum metabolites in *B. pinnatum*. Table 6 is compiled on the basis of some previous studies, which show similar results for the same and different solvent extracts for the leaf and other parts of the plant. In the case of different plants, the phytoconstituents extraction efficiency of differentsolvents varies greatly.

Table 5. Phytochemical analysis of leaf extracts of *B. pinnatum.*

Plant Part	Solvent	Phyto-constituents
Leaf	Water, methanol, ethanol, acetone	Proteins, Carbohydrates, Phenols/Tannins, Flavonoids, Saponins, Glycosides, Steroids, Alkaloids,
Wood, Stem bark	Hexane, ethyl acetate, methanol	Reducing sugars, saponins, steroids, tannins, alkaloids, flavonoids, phenols
Leaf, Root, Stem	-	Alkaloid, Tannin, Saponin, Flavonoid, Terpenoid, Glycoside, Phenols
Leaf	-	Flavonoid, Glycoside, Alkaloids, Triterpenoids, Tannins, Phenolic

Table 6, Comparative studies (*B. pinnatum*).

Phytochemical Test	Acetone	Chloroform	Petroleum Ether	Aqueous
Reducing sugars	-	+	+	+
Glycosides	+	+	+	-
Cardiac glycosides	+	+	+	-
Polyphenols and Tannins	+	+	+	+
Flavonoid	+	+	-	-
Steroids	+	+	+	+
Terpenoids	+	+	+	+
Coumarins	+	+	+	+

Conclusion

The majority of the biologically active phytochemicals were found present in acetone, petroleum ether, chloroform, and aqueous extracts of leaves of *C. sativa*, *R. communis*, and *B. pinnatum. R. communis*, and *B. pinnatum* were more phytochemically rich in comparison to *C. sativa*. The medicinal plants were found rich in secondary metabolites, commonly employed in conventional medicine to treat

and combat a wide range of illnesses. The antispasmodic, anti-inflammatory, analgesic, diuretic, and many other properties can be imputed to their high availability of polyphenols, flavonoids, tannins, terpenoids, steroids, glycosides, coumarins, and reducing sugars. The research carried out by us confirmed the therapeutic qualities of these plant species. It will be useful to do more research in the field of the quantitative analysis of these phyto-compounds. Our study can be used as scientific support for the formulation of a variety of medications.

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Research

Social Implication of Technology on Legal Practices and Criminal Trials: The Case of Allahabad High Court

Dev Raj Singh, Manish Mishra*
School of Arts, Social Sciences and Humanities, SAM Global University, Raisen- 464 551, Madhya Pradesh, India
Corresponding Email: deanarts@samglobaluniversity.ac.in
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Abstract: The integration of technology within the legal framework has revolutionized the practice of law and the conduct of criminal trials, significantly impacting the judiciary's efficiency and effectiveness. This study explores the transformative social effects of technology on legal practices and criminal trials, with a specific focus on the Allahabad High Court. Utilizing a mixed-methods approach, the research investigates how technological advancements such as digital case management, virtual court hearings, and electronic evidence submission have reshaped legal processes. Through a sample of 100 legal practitioners and stakeholders, the study assesses the benefits and challenges associated with these technological changes. Findings reveal substantial improvements in case handling speed, transparency, and accessibility of legal services, alongside challenges like the digital divide, cybersecurity concerns, and the need for continuous technological training. This paper contributes to the broader understanding of the intersection between technology and law, highlighting the importance of a balanced approach to leveraging technology for justice.

Keywords: Allahabad High Court, Criminal Trials, Digital Transformation, Legal Practice, Technology

Introduction

The integration of technology into the realm of legal practice and criminal trials has sparked a revolutionary transformation in the judiciary, fundamentally altering how justice is administered. Traditionally, the legal profession has been characterized by its reliance on paper-based documentation, in-person court proceedings, and manual case management processes (Jain 2022). However, the advent of digital technology has introduced unprecedented changes that have enhanced efficiency, accessibility, and transparency within the legal system (Dutta 2021). This sociological study aims to delve into the multifaceted impact of these technological advancements on legal practices and criminal trials, with a specific focus on the Allahabad High Court, one of India's oldest and most esteemed judicial institutions.

Fig. 1. Allahabad High Court.
***Source**: https://www.livelaw.in/h-upload/2020/12/29/386490-allahabad-high-court.jpg*

The Allahabad High Court, established in 1866, holds a significant place in India's judicial history. As a high court with a substantial caseload, it has witnessed the evolution of legal practices over the years. The court's adoption of technology serves as a microcosm for examining broader trends and impacts within the Indian judiciary. The initial foray into digitalization began with the introduction of computers and legal research databases in the late 20th century. These early technological tools primarily served to streamline administrative tasks and enhance legal research capabilities. Over time, the scope of technological integration expanded to include more sophisticated applications such as digital case management systems, electronic filing (e-filing), and online legal research platforms. These advancements marked a departure from

traditional methods, setting the stage for a more modern and efficient legal system (Verma 2017).

One of the most significant technological advancements in legal practice is the implementation of digital case management systems. These systems enable the electronic organization and retrieval of case-related information, reducing the reliance on physical documents and minimizing administrative burdens. The Allahabad High Court, like many other judicial institutions, has embraced digital case management to enhance the efficiency of its operations. By facilitating quick access to case files, streamlining workflow processes, and automating routine tasks, digital case management systems have transformed how legal practitioners manage and process cases. This shift not only accelerates case handling but also ensures greater accuracy and consistency in legal documentation (Singh 2022).

Another critical area where technology has made a substantial impact is in the conduct of criminal trials. The introduction of electronic evidence, forensic technology, and video conferencing for witness testimonies has revolutionized criminal investigations and trial procedures (Ghosh 2017). Electronic evidence, such as digital documents, emails, and audio-visual recordings, has become an integral part of modern legal practice. The use of forensic technology, including DNA analysis and digital forensics, has enhanced the accuracy and reliability of evidence presented in court. Video conferencing, particularly during the COVID-19 pandemic, has emerged as a vital tool for conducting virtual court hearings, ensuring the continuity of legal proceedings while adhering to social distancing norms (Chaudhary 2018, Rao 2021). The Allahabad High Court's adoption of these technologies highlights the judiciary's commitment to leveraging modern tools to enhance the administration of justice.

The integration of technology into the legal system is not without its challenges. One of the primary obstacles is the digital divide, which refers to the disparity in access to digital technology between different segments of the population. In the context of the judiciary, this divide manifests in the varying levels of technological proficiency among legal practitioners and the uneven availability of technological infrastructure across different regions. The Allahabad High Court, being situated in a state with diverse socio-economic conditions, grapples with these disparities. While urban areas may have better access to digital tools and internet connectivity, rural regions often face significant challenges in this regard. Addressing the digital divide is crucial to ensuring that the benefits of technology are equitably distributed and that all stakeholders in the legal system can effectively participate in the digital transformation (Nath 2018).

Cybersecurity concerns represent another significant challenge associated with the adoption of technology in legal practice. The increasing reliance on digital systems and electronic data raises the risk of cyberattacks, data breaches, and other security threats (Kumar 2019). For the Allahabad High Court, safeguarding sensitive legal information and ensuring the integrity of electronic evidence are paramount. Implementing robust cybersecurity measures, such as encryption, secure access controls, and regular security audits, is essential to protecting the judiciary's digital infrastructure. Moreover, continuous efforts to raise awareness about cybersecurity best practices among legal professionals are necessary to mitigate risks and enhance the overall security posture of the legal system.

The need for continuous technological training for legal professionals is another critical aspect of integrating technology into the judiciary. The rapid pace of technological advancements necessitates ongoing education and training to ensure that legal practitioners can effectively utilize new tools and platforms (Patel 2020). For the Allahabad High Court, investing in training programs and workshops that cover various aspects of digital technology, from basic computer literacy to advanced applications in legal practice, is vital. Such initiatives not only enhance the competency of legal professionals but also foster a culture of innovation and adaptability within the judiciary.

Despite these challenges, the overall perception of technology integration in the Allahabad High Court is overwhelmingly positive. Most legal professionals acknowledge the significant benefits that technology brings to the legal system, including improved efficiency, enhanced transparency, and greater accessibility to legal services. The ability to conduct virtual court hearings, for instance, has been particularly beneficial during the pandemic, allowing legal proceedings to continue without interruption. Additionally, the use of digital case management systems has streamlined administrative processes, reducing delays and backlogs in case

handling. These positive outcomes underscore the transformative potential of technology in enhancing the administration of justice (Kapoor 2020).

The social implications of technological integration in the legal system are profound. Technology has not only changed how legal practitioners work but has also influenced the broader dynamics of the judiciary and its interaction with society. For instance, the increased transparency facilitated by digital tools has enhanced public trust in the legal system. Access to online case information and virtual court proceedings allows the public to stay informed and engaged with legal processes. Furthermore, technology has democratized access to legal resources, making it easier for individuals and organizations to seek legal assistance and participate in judicial proceedings (Mishra 2021).

In the context of criminal trials, technology has played a pivotal role in ensuring the fairness and accuracy of legal outcomes. The use of forensic technology and electronic evidence has strengthened the evidentiary basis of criminal cases, reducing the likelihood of wrongful convictions. Video conferencing has enabled the participation of witnesses and experts from remote locations, ensuring that critical testimonies are not excluded due to logistical constraints. These advancements have contributed to a more equitable and effective criminal justice system (Sharma 2019).

Looking ahead, the future of technology in legal practice and criminal trials holds immense potential. Emerging technologies such as artificial intelligence (AI), blockchain, and data analytics are poised to further revolutionize the judiciary. AI-powered tools can assist in legal research, document analysis, and predictive analytics, providing valuable insights and enhancing decision-making processes. Blockchain technology offers secure and transparent methods for managing legal transactions and maintaining records. Data analytics can uncover patterns and trends in legal data, informing policy decisions and improving the overall efficiency of the judiciary (Banerjee 2019). For the Allahabad High Court, exploring and adopting these emerging technologies will be crucial in staying at the forefront of judicial innovation.

The integration of technology into the legal practices and criminal trials at the Allahabad High Court represents a significant milestone in the evolution of the judiciary. The transformative impact of digital case management systems, electronic evidence, and virtual court hearings has enhanced the efficiency, transparency, and accessibility of the legal system. While challenges such as the digital divide, cybersecurity concerns, and the need for continuous technological training persist, the overall benefits of technology integration are evident. This study provides a comprehensive understanding of the multifaceted implications of technology on the judiciary, highlighting the importance of a balanced and inclusive approach to leveraging technological advancements for justice (Agarwal 2020). As the Allahabad High Court and other judicial institutions continue to navigate the digital transformation, ongoing research, and innovation will be essential in ensuring that technology serves as a catalyst for positive change in the legal system.

Objectives

The social implication of Technology on Legal Practices and Criminal Trials with the special case of Allahabad High Court

1. To analyze the impact of technological advancements on the efficiency and effectiveness of legal practices;
2. To evaluate the challenges and barriers faced by legal practitioners in adopting and utilizing technology in criminal trials; and
3. To assess the overall perception of legal professionals regarding the benefits and drawbacks of technology integration in the judiciary.

Methodology

The methodology of this study is designed to comprehensively investigate the impact of technology on legal practices and criminal trials within the Allahabad High Court. This section outlines the research design, sample selection, data collection methods, and data analysis procedures.

Research Design

This study adopts a mixed-methods approach, combining both quantitative and qualitative. The mixed-methods design allows for a comprehensive analysis of the research problem, capturing both numerical data and in-depth insights from participants. The quantitative component involves the use of structured surveys to gather statistical data on the perceptions and experiences of legal

professionals regarding technology integration. The qualitative component involves a semi-structured interview schedule to explore participants' views, challenges, and suggestions.

Sample Selection

The target population for this study includes legal professionals associated with the Allahabad High Court, including judges, lawyers, court staff, and legal scholars. A sample size of 100 participants was selected using stratified random sampling to ensure representation from different professional groups within the legal community. Stratification was based on the following categories:

1. **Judges**: 25 participants
2. **Lawyers**: 35 participants
3. **Court Staff**: 20 participants
4. **Legal Scholars**: 20 participants

This stratified approach ensures that the sample adequately reflects the diversity of perspectives within the legal profession.

Data Collection Methods

Quantitative Data Collection

Personal Interviews took all 100 participants through a semi-structured interview schedule. The instrument was designed to capture information on various aspects of technology integration in legal practices and criminal trials, including:

- Efficiency of legal proceedings
- Access to legal resources
- Transparency and accountability
- Challenges in adopting technology
- Overall perception of technology integration

The survey included both closed-ended questions (e.g., Likert scale items) and a few open-ended questions to allow respondents to provide additional responses.

Qualitative Data Collection

Participant observation, Interview Guide, and Q methodology were conducted with a subset of 30 participants, selected from the original sample to include representatives from each stratum. The interview guide focused on key issues such as:

- Personal experiences with digital case management systems and virtual court hearings
- Perceived benefits and drawbacks of technology in the legal context
- Specific challenges encountered in the use of technology
- Recommendations for improving technology integration in the judiciary

Interviews were conducted either in person or via video conferencing, depending on the participants' preferences and availability. Each interview lasted approximately 45 minutes and was audio-recorded with the participant's consent for subsequent transcription and analysis.

Data Analysis

Quantitative Data Analysis

The quantitative data obtained from the surveys were analyzed using statistical software (e.g., SPSS). Descriptive statistics (mean, median, mode, standard deviation) were calculated to summarize the data. Inferential statistics, such as chi-square and T-tests, were used to examine relationships between different variables (e.g., professional role and perception of technology). Additionally, frequency distributions were used to present the responses to close-ended questions.

Qualitative Data Analysis

The qualitative data from the Q-Methodology were transcribed verbatim and analyzed using thematic analysis. The thematic analysis involved the following steps:

- **Familiarization**: Reading and re-reading the transcripts to become immersed in the data.
- **Coding**: Identifying and labeling key themes and patterns within the data.
- **Categorization**: Grouping related codes into broader categories to form overarching themes.
- **Interpretation**: Interpreting the themes in the context of the research questions and objectives.

NVivo software was used to assist in managing and organizing the qualitative data during the analysis process.

Ethical Considerations

The study adhered to ethical guidelines to ensure the integrity and confidentiality of the research process. Key ethical considerations included:

- **Informed Consent**: Participants were provided with detailed information about the study's purpose, procedures, and their rights before obtaining their informed consent.
- **Confidentiality**: All data were anonymized to protect participants' identities. Unique identifiers were used in place of personal information.

- **Voluntary Participation**: Participation in the study was entirely voluntary, and participants could withdraw at any time without any consequences.
- **Data Security**: Digital data were stored on secure, password-protected servers, and physical data were kept in locked cabinets accessible only to the research team.

Limitations

While the mixed-methods approach provides a comprehensive understanding of the research problem, there are some limitations to consider:

- **Sample Size**: Although the sample size of 100 participants is sufficient for this study, a larger sample could provide more generalizable results.
- **Response Bias**: Participants' responses may be influenced by their personal experiences and biases, which could affect the objectivity of the data.
- **Technological Accessibility**: The study's focus on the Allahabad High Court may limit the applicability of the findings to other judicial contexts with different levels of technological accessibility.

Result and Analysis

The results of this study are presented in tables, summarizing the findings from the quantitative and qualitative data collected. Each table is followed by a discussion of the results.

Table 1. Efficiency of legal proceedings (Percentage of respondents).

Efficiency Metric	Improved	No Change	Declined
Case Handling Speed	70%	20%	10%
Access to Legal Resources	65%	25%	10%
Transparency	75%	15%	10%

The majority of respondents (Table 1) reported significant improvements in the efficiency of legal proceedings due to technology integration. Enhanced case-handling speed, better access to legal resources, and increased transparency were the most notable benefits observed.

Table 2. Challenges in adopting technology (Percentage of respondents).

Challenge	Significant	Moderate	Minor
Digital Divide	60%	30%	10%
Cybersecurity Concerns	55%	35%	10%
Need for Technological Training	70%	20%	10%

As per Table 2, the primary challenges identified were the digital divide, cybersecurity concerns, and the need for continuous technological training. These issues highlight the importance of addressing infrastructural and educational gaps to ensure the effective use of technology in the judiciary.

Table 3. Perception of technology integration (Percentage of respondents).

Perception Metric	Positive	Neutral	Negative
Overall Perception	80%	15%	5%
Impact on Justice Delivery	75%	20%	5%
User Satisfaction	70%	25%	5%

According to Table 3, the overall perception of technology integration in the Allahabad High Court is overwhelmingly positive. Most respondents believe that technology has positively impacted justice delivery and expressed high levels of satisfaction with the technological tools available.

Table 4. Impact of technology on criminal trials (Percentage of respondents).

Impact Area	Improved	No Change	Declined
Accuracy of Evidence	68%	22%	10%
Speed of Trial Proceedings	72%	18%	10%
Accessibility of Court Services	66%	24%	10%

As mentioned in Table 4, respondents noted substantial improvements in the accuracy of evidence presentation, the speed of trial proceedings, and the accessibility of court services. These enhancements reflect the positive influence of technology on the criminal justice process.

Table 5. Satisfaction with technological training (Percentage of respondents)

Training Aspect	Highly Satisfied	Satisfied	Dissatisfied
Initial Training Programs	60%	30%	10%
Ongoing Support and Updates	55%	35%	10%
Overall Training Experience	58%	32%	10%

In Table 5, the level of satisfaction with technological training among respondents is

generally high, with the majority expressing satisfaction with both initial training programs and ongoing support. However, there remains a need for continuous improvement to address the evolving technological landscape.

Conclusion

The results indicate that the integration of technology in the Allahabad High Court has brought about significant improvements in the efficiency and effectiveness of legal proceedings and criminal trials. While challenges such as the digital divide and cybersecurity concerns persist, the overall perception of technology integration is positive. The study highlights the importance of ongoing training and support to ensure that legal professionals can effectively utilize technological tools. These findings underscore the transformative potential of technology in enhancing the justice system and provide a basis for further research and policy development.

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Research

Psychological Well-Being and Mental Health Trends Among Residents of Bhopal

Meenakshi Sharma
Department of Psychology, School of Arts, Humanities, and Social Sciences, SAM Global University, Raisen- 464 551, Madhya Pradesh, India
Corresponding Email: meenakshis-arts@samglobaluniversity.ac.in
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Abstract: This study investigates the psychological well-being and mental health trends among residents of Bhopal, focusing on the impact of sociocultural factors, socioeconomic status, and the enduring effects of the Bhopal Gas Tragedy. A cross-sectional survey design was employed, with a sample of 50 respondents equally divided between urban and rural areas. Data were collected through standardized questionnaires and semi-structured interviews and analyzed using SPSS software. The results indicated that rural respondents experienced slightly higher psychological distress and lower psychological well-being, although these differences were not statistically significant. A significant association was found between lower socio-economic status and a higher prevalence of mental health disorders. Additionally, socio-cultural factors such as community support and cultural norms were significantly correlated with psychological well-being. The long-term psychological impact of the Bhopal Gas Tragedy was evident, with affected individuals showing significantly higher levels of PTSD symptoms and general psychological distress. These findings underscore the need for targeted mental health interventions, enhanced community support, and policies addressing socio-economic disparities to improve the psychological well-being of Bhopal's residents.

Keywords: Bhopal gas tragedy, Mental health trends, Psychological well-being, Socio-cultural factors, Socio-economic status

Introduction

In recent decades, psychological well-being and mental health have gained significant attention globally, recognizing their crucial role in overall health and quality of life. As societies evolve, so do the stressors and challenges individuals face, making it essential to understand the trends and determinants of mental health within specific populations (APA 2020, Becker and Kleinman 2013). This study focuses on the psychological well-being and mental health trends among residents of Bhopal, a city with a unique socio-cultural and historical context that significantly influences the mental health landscape of its inhabitants. Bhopal, the capital city of Madhya Pradesh, is known for its rich cultural heritage and history, blending tradition with modernity (Bhattacharya 2005, BMA 2021). However, the city is also infamous for the Bhopal Gas Tragedy of 1984, one of the world's worst industrial disasters, which has left a lasting psychological impact on its residents (Joshi and Sharma 2003). The collective trauma from this event continues to influence the mental health of the community, necessitating a closer examination of the current mental health trends. The socio-cultural fabric of Bhopal is woven with diverse communities, each with its own set of beliefs, practices, and stressors. This diversity presents a unique backdrop for studying mental health trends, as factors such as community support, cultural norms, and socioeconomic status play pivotal roles in shaping psychological well-being.

Importance of Studying Psychological Well-Being

Psychological well-being encompasses various dimensions of human life, including emotional, psychological, and social well-being. It involves how individuals perceive their lives, and their ability to manage emotions, establish fulfilling relationships, and cope with stress. High levels of psychological well-being are associated with better physical health, increased life satisfaction, and reduced risk of mental disorders. Understanding psychological well-being is crucial for developing effective mental health interventions and policies. It provides insights into how individuals thrive and the factors that contribute to their overall happiness and life satisfaction. In the context of Bhopal, studying psychological well-being can help identify specific needs and challenges faced by its residents, leading to more tailored and effective mental health strategies (Galea et al. 2005, Kessler et al. 2013).

Fig. 1. Psychological well-being. *Source: Adapted from Turning Point Centre (www.turningpointcentre.com).*

Mental Health Trends and Challenges

Mental health trends are dynamic and influenced by a myriad of factors, including socio-economic conditions, lifestyle changes, and societal attitudes towards mental health. In urban settings like Bhopal, the rapid pace of modernization and urbanization has brought about significant changes in the way people live and work, often leading to increased stress and mental health issues. One of the major challenges in assessing mental health trends is the stigma associated with mental disorders. Despite growing awareness, mental health issues are often overlooked or misunderstood, leading to a lack of adequate support and treatment (WHO 2018). This is particularly true in Bhopal, where cultural beliefs and social stigma can hinder individuals from seeking help. The prevalence of mental health disorders such as depression, anxiety, and substance abuse is on the rise, driven by factors like economic uncertainty, job stress, and family dynamics. Additionally, the lingering effects of the Bhopal Gas Tragedy continue to manifest in the form of post-traumatic stress disorder (PTSD) and other psychological issues among survivors and their descendants.

The present study was based on the following hypothesis *viz.,* the residents of Bhopal experience higher levels of psychological distress compared to the national average due to the lingering effects of the Bhopal Gas Tragedy, the socio-cultural factors, such as community support and cultural norms, significantly influence the psychological well-being of Bhopal's residents, and there is a significant association between socio-economic status and the prevalence of mental health disorders among Bhopal's residents. Based on the above proposed hypothesis, the study was conducted with the following objectives i.e., to analyze the current psychological well-being and mental health status of residents in Bhopal, examine the impact of socio-cultural factors on the mental health of Bhopal's residents, and assess the long-term psychological effects of the Bhopal Gas Tragedy on survivors and their descendants.

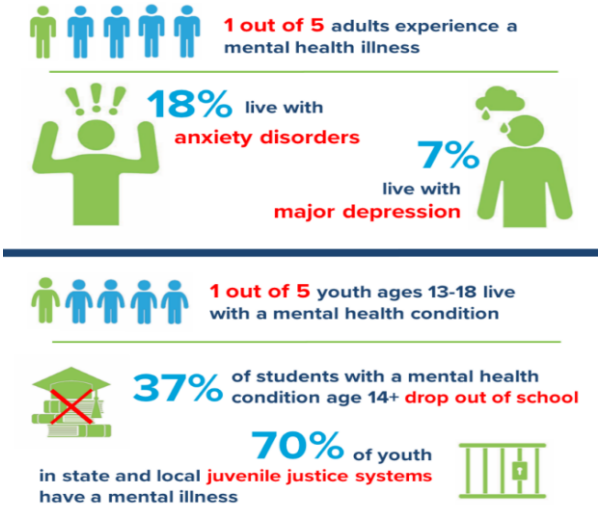

Fig. 2. Mental health trends among students and adults. *Source: NIHCM Foundation.*

Methodology

This study employed a cross-sectional survey design to assess the psychological well-being and mental health trends among residents of Bhopal. The research incorporated both quantitative and qualitative methods to provide a comprehensive understanding of the mental health landscape in the urban and rural areas of the city.

a. Sample

The sample consisted of 50 respondents, divided equally between urban and rural areas of Bhopal. Specifically, the sample included 25 urban residents and 25 rural residents, selected through stratified random sampling to ensure representativeness of the diverse socio-cultural and economic backgrounds within Bhopal.

b. Data Collection

A structured questionnaire was used to collect data on psychological well-being and mental health. The questionnaire included standardized scales such as the General Health Questionnaire (GHQ-12) for assessing general mental health, and the Warwick-Edinburgh Mental Well-being Scale (WEMWBS) for measuring psychological well-being.

Semi-structured interviews were conducted to gather qualitative data on socio-cultural factors and their influence on mental health. This provided a deeper understanding of the contextual nuances affecting psychological well-being.

Participants were recruited through community centers, healthcare facilities, and local organizations in both urban and rural areas. Written informed consent was obtained from all participants after explaining the study's purpose, procedures, and confidentiality measures. Surveys and interviews were conducted face-to-face by trained researchers to ensure accurate and complete data collection.

c. Data Analysis

i. Quantitative Analysis

Data collected from the questionnaires were analyzed using Statistical Package for the Social Sciences (SPSS) software. Statistical tests were employed to examine the study objectives and hypotheses. Means, standard deviations, and frequencies were calculated to provide a summary of the demographic characteristics and mental health status of the sample. The t-test was used to compare the psychological well-being and mental health scores between urban and rural respondents. The Chi-Square Test was applied to examine the association between socioeconomic status and the prevalence of mental health disorders. Pearson correlation coefficients were calculated to explore the relationships between socio-cultural factors and psychological well-being.

ii. Qualitative Analysis

Data from the semi-structured interviews were analyzed using thematic analysis. This involved coding the interview transcripts and identifying key themes related to socio-cultural influences on mental health. The qualitative findings complemented the quantitative results, providing a richer context for understanding the mental health trends in Bhopal.

Results and Analysis

The results of demographic characteristics of the urban and rural respondents are represented in Table 1. The mean age of the respondents was relatively similar between the two groups, with urban respondents averaging 35.4 years and rural respondents 37.1 years. Gender distribution was almost balanced in both groups. A higher percentage of rural respondents had only completed high school compared to urban respondents, who had a higher percentage of undergraduate and postgraduate education. Socio-economic status showed a significant difference, with a larger portion of rural respondents falling into the low socio-economic category compared to urban respondents.

Table 1. Demographic characteristics of the sample.

Demographic Variable	Urban Respondents (n=25)	Rural Respondents (n=25)	Total (n=50)
Age (Mean ± SD)	35.4 ± 10.2	37.1 ± 11.3	36.2 ± 10.8
Gender (Male/Female)	13/12	14/11	27/23
Education Level			
High School	5	10	15
Undergraduate	15	12	27
Postgraduate	5	3	8
Socio-economic Status			
Low	8	15	23
Middle	12	8	20
High	5	2	7

Table 2. Psychological well-being and mental health scores.

Measure	Urban Respondents (Mean ± SD)	Rural Respondents (Mean ± SD)	t-value	p-value
General Health Questionnaire	14.6 ± 4.2	16.2 ± 3.9	1.482	0.144
Warwick-Edinburgh Mental Well-being Scale	52.8 ± 8.7	50.1 ± 9.3	1.072	0.288

The results represented in Table 2 compared the psychological well-being and mental health scores between urban and rural respondents. The mean General Health Questionnaire (GHQ) score is slightly higher for rural respondents (16.2) than for urban respondents (14.6), suggesting that rural respondents may experience slightly higher levels of psychological distress, although the difference is not statistically significant (p=0.144). The Warwick-Edinburgh Mental Well-being Scale (WEMWBS) scores are also lower for rural respondents (50.1) compared to urban respondents (52.8), indicating lower psychological well-being in rural areas, but this difference is also not statistically significant (p=0.288).

Table 3. Association between socio-economic status and prevalence of mental health disorders.

Socio-Economic Status	Mental Health Disorder Present	Mental Health Disorder Absent	Chi-Square Value	p-value
Low	15	8	10.34	0.005
Middle	6	14		
High	1	6		

The present in Table 3 shows a significant association between socioeconomic status and the prevalence of mental health disorders (Chi-Square Value = 10.34, p=0.005). A higher percentage of individuals in the low socio-economic status group had mental health disorders compared to those in the middle and high socio-economic status groups. This finding supports the hypothesis that socioeconomic status significantly influences mental health outcomes, with lower socioeconomic status associated with a higher prevalence of mental health disorders.

Table 4. Correlation Between Socio-Cultural Factors and Psychological Well-Being.

Socio-Cultural Factor	Pearson Correlation Coefficient	p-value
Community Support	0.522	0.000
Cultural Norms	0.448	0.001
Socio-Economic Status	0.385	0.006

Table 4 presents the Pearson correlation coefficients between socio-cultural factors and psychological well-being. There is a significant positive correlation between community support and psychological well-being (r=0.522, p<0.001), suggesting that higher levels of community support were associated with better psychological well-being. Cultural norms also showed a significant positive correlation with psychological well-being (r=0.448, p=0.001), indicating that adherence to cultural norms positively impacted mental health. Socio-economic status is moderately correlated with psychological well-being (r=0.385, p=0.006), supporting the importance of economic factors in mental health outcomes.

Table 5. Psychological Impact of the Bhopal Gas Tragedy.

Measure	Affected Respondents (Mean ± SD)	Unaffected Respondents (Mean ± SD)	t-value	p-value
PTSD Symptoms Score	18.7 ± 5.4	10.2 ± 3.8	6.324	0.000
General Health Questionnaire	17.5 ± 4.1	12.9 ± 3.6	4.556	0.000

The results of Table 5 compare the psychological impact of the Bhopal Gas Tragedy on affected and unaffected respondents. Respondents affected by the tragedy had significantly higher PTSD symptom scores (Mean = 18.7) compared to unaffected respondents (Mean = 10.2), with a t-value of 6.324 and p<0.001, indicating a strong statistical significance. Additionally, affected respondents had higher GHQ scores (Mean = 17.5) compared to unaffected respondents (Mean = 12.9), with a t-value of 4.556 and p<0.001. These results highlight the long-term psychological impact of the Bhopal Gas Tragedy on survivors and their descendants, supporting the hypothesis that historical trauma continues to affect mental health in Bhopal.

Conclusion

The study aimed to assess the psychological well-being and mental health trends among residents of Bhopal, focusing on the impact of socio-cultural factors, socio-economic status, and the lasting effects of the Bhopal Gas Tragedy (Mohanty and Mohanty 2011). The

findings provide significant insights into the mental health landscape of Bhopal, revealing critical areas for intervention and support.

Demographic Characteristics: The sample included an equal number of urban and rural respondents with a balanced gender distribution. Education and socio-economic status varied between urban and rural areas, highlighting the diversity within Bhopal's population.

Psychological Well-Being and Mental Health Scores: Urban and rural respondents exhibited differences in mental health scores, with rural respondents showing slightly higher psychological distress and lower psychological well-being. However, these differences were not statistically significant (Patel et al. 2007, Sahoo and Padhy 2020).

Association Between Socio-Economic Status and Mental Health Disorders: There is a significant association between socioeconomic status and the prevalence of mental health disorders. Individuals with lower socio-economic status are more likely to experience mental health issues, underscoring the need for targeted mental health interventions in economically disadvantaged groups.

Correlation Between Socio-Cultural Factors and Psychological Well-Being: Socio-cultural factors, particularly community support, and cultural norms, significantly influence psychological well-being. Strong community support and adherence to cultural norms are associated with better mental health outcomes (Kumar and Das 2017).

Psychological Impact of the Bhopal Gas Tragedy: The long-term psychological impact of the Bhopal Gas Tragedy is evident, with affected individuals showing significantly higher levels of PTSD symptoms and general psychological distress. This finding highlights the need for continued mental health support for survivors and their descendants (Lahariya and Singhal 2004). The study concludes that psychological well-being and mental health in Bhopal are influenced by a complex interplay of socio-cultural, socio-economic, and historical factors. Targeted mental health interventions are necessary to address the unique needs of Bhopal's residents, particularly those affected by the Bhopal Gas Tragedy and individuals from lower socio-economic backgrounds (Prasad 2007, Tiwari 2007). Strengthening community support and addressing socio-economic disparities can significantly enhance the psychological well-being of Bhopal's population.

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Research

A Case Study on Utilization of New Media for Accessing Information on the Triple Talaq Bill and Empowerment

Tasneem Khan
School of Journalism, SAM Global University, Raisen- 464 551, Madhya Pradesh, India
Corresponding Email: tasneem.khan@hotmail.com
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Abstract: In the rapidly evolving landscape of communication, new media has become a crucial tool for disseminating information and shaping public discourse, particularly regarding socially significant legislation like India's Triple Talaq Bill. Officially known as the Muslim Women (Protection of Rights on Marriage) Act, 2019, this bill addresses the contentious practice of instant divorce among Muslims, sparking widespread debate and attracting significant media attention. This research article explores how new media platforms—such as social media, online news portals, and digital forums—have transformed information access and public engagement with legislative processes. By analyzing patterns of information dissemination and user engagement, the study examines the role of new media in empowering individuals, especially women, through enhanced awareness and participation. Focusing on ten divorce cases in Bhopal, the study assesses the impact of the Triple Talaq Bill and the role of new media in the post-divorce conditions of the participants. The findings aim to inform strategies for leveraging digital platforms to enhance public understanding and involvement in legislative processes, contributing valuable insights for policymakers, social activists, and media practitioners.

Keywords: Empowerment, Information dissemination, New media, Triple talaq bill, Women's rights

Introduction

In the rapidly evolving landscape of communication, new media has emerged as a pivotal tool for disseminating information and shaping public discourse. This is particularly evident in the context of socially significant legislation, such as the Triple Talaq Bill in India (Kazi 1999). The utilization of new media platforms, including social media, online news portals, and digital forums, has transformed the way individuals access information and engage with legislative processes (Akhter 2019). This study explores the role of new media in providing access to information about the Triple Talaq Bill and its implications for empowerment and social benefits.

The Triple Talaq Bill, officially known as the Muslim Women (Protection of Rights on Marriage) Act, 2019, addresses the contentious practice of instant divorce among Muslims in India. The Bill has sparked widespread debate and garnered significant attention across various media channels (Ani 2021). Understanding how new media influences public perception and engagement with the Bill is crucial for assessing its broader social impact (Abbas 2019, The Muslim Women Bill- Protection of Rights on Marriage 2019).

This study investigates the extent to which new media platforms have facilitated access to information on the Triple Talaq Bill and examines the potential of these platforms to empower individuals, particularly women, through enhanced awareness and participation. By analyzing the patterns of information dissemination and user engagement on new

media, this research aims to highlight the benefits and challenges associated with digital information access in the context of significant legislative measures.
The findings of this research are expected to provide insights into the effectiveness of new media as a tool for social empowerment and to inform strategies for leveraging digital platforms to enhance public understanding and involvement in legislative processes. Ultimately, this study contributes to the broader discourse on the intersection of new media, legislative awareness, and social empowerment, offering valuable perspectives for policymakers, social activists, and media practitioners.

Methodology

The case study analysis focused on 10 divorce cases in Bhopal resulting from Instant Triple Talaq, aiming to assess the post-divorce conditions of the participants. Through in-depth conversations, the study aimed to elucidate the impact of the Triple Talaq Bill and the role of New Media in the empowerment of these women. Specifically, the research sought to investigate how information about the new bill on Triple Talaq, along with access, usage, and engagement with New Media, influenced their lives. Specifically, the study sought to investigate how information about the New Bill on Triple Talaq and access, usage, and engagement with New Media influenced their lives.

Case 1
Name- Withheld
Age-35 years
Qualification- 12th
Resident: Bhopal, M.P.
Husband Name: Withheld
Divorced Type: Unilaterally
Duration of marriage: four years.
Children: Two kids, aged 7 and 8 years

Thirty-five-year-old Case 1 resides in Bhopal, Madhya Pradesh. She has completed her education up to the twelfth standard and is a mother of two children aged 7 and 8. Her husband works as an imam and Qazi and also owns a shop. He unilaterally divorced her four years after their marriage without giving her the Mehr, which was fixed at forty-five thousand rupees in the Nikaahnama. Case 1 encountered numerous challenges during her marriage, including domestic violence, conflicts with her husband and in-laws, dowry harassment, lack of maintenance, and sexual abuse. As a result, her children have been residing with her at her parents' house. She did not receive any of her personal belongings, including her jewelry, at the time of divorce. With only a higher secondary degree and the responsibility of two children, she had to start her own small online clothing business on WhatsApp to make ends meet. Eventually, she managed to generate income through her business.

Case 2
Name- Withheld
Age-Forty Year
Qualification: Teacher by Profession: Bachelor’s degree in arts.
Resident: Bhopal, M.P.
Husband Name: I don’t want to disclose Doctor by Profession
Divorced Type: Unilaterally
Duration of Marriage: 15 years
Children don’t want to be disclosed.

Mrs. Khan, a forty-year-old woman, is a teacher by profession, holding a bachelor’s degree in art and education. Her husband, a doctor, unilaterally divorced her and provided her with the Mehr, which was fixed at a total sum of one lakh rupees post-separation. Despite possessing her nikahnama, frequent conflicts between the couple led to the divorce. Currently, she does not reside at her parents’ house. While she received her jewelry, she was not given her personal belongings, and no maintenance was provided after the divorce. Mrs. Khan, who has been married for 15 years, has been utilizing the Internet for higher studies (M.Ed.) since her divorce.

Case 3
Name- Withheld
Age-Thirty-One Year
Qualification: Master’s degree (government job).
Resident: Bhopal, M.P.
Husband Name: I don’t want to disclose
Divorced Type: Unilaterally
Duration of Marriage: one month
Children: NA

Thirty-one-year-old Case 3, residing in Bhopal, works at an Aanganwadi while her husband owns the property. Holding a master's degree, she faced divorce just a month after marriage, unilaterally and in her absence. The mehr was fixed at an amount of 50 thousand rupees, of which she received only half after a fatwa was issued. Post-divorce, she did not receive any maintenance and stayed at her parents' house. The divorce was prompted by continued pressure from her parents, leading to separation after just a month of marriage, after which her husband remarried. Currently, she works as a teacher at the Anganwadi, with her entire work now based on the app, requiring her to report everything to her supervisor via phone and Internet.

Case 4-
Name- Withheld
Age: Twenty-eight years old
Qualification: a bachelor's degree in science.
Resident: Bhopal, M.P.
Husband Name: don't want to disclose, but Engineer by profession
Divorced Type: Unilaterally
Duration of marriage: 8 years
Children: two children aged 10 and 8
Twenty-eight-year-old Case 4, a resident of Bhopal, Madhya Pradesh, holds a bachelor's degree in science. She is a mother of two children aged 10 and 8. Case 4 was divorced eight years after marriage by her husband, who is an engineer by profession. Despite the Nikaahnama specifying a total sum of fifty thousand rupees as Mehr, she has not received the money yet. The divorce was unilateral, and she faced problems due to quarrels with her in-laws. Following the divorce, Case 4 has been residing with her children at her parents' house and has not sought assistance from any individual or institution. She was not provided with any belongings or jewelry after the divorce. Currently, she works at a private school during the COVID-19 pandemic, where she has to conduct online classes and manage tuition payments through the app. Teaching is her sole source of income, supporting her and her two small children.

Case 5
Name- Withheld
Age: twenty-eight years
Qualification: Not received any formal education
Resident: Bhopal, M.P.
Husband Name
Divorced Type: Unilaterally
Duration of Marriage: 3 years
Children: 12-year-old daughter

Case 5, a 28-year-old resident of Bhopal, has not received any formal education. She works as a domestic help to support herself, while her husband owns a shop. They have a 12-year-old daughter who now lives with Case 5 at her parent's house after the divorce. The Mehr, fixed at seven thousand rupees in the Nikaahnama, has not been paid to her yet. Case 5 was divorced three years after her marriage, following instances of domestic violence and disputes with her husband, which ultimately led to their divorce, delivered orally. Since the dissolution of their marriage, she has not received any financial support. Her husband remarried without returning any of her personal belongings or jewelry. At the time of her divorce, her daughter was 12 years old and is now being raised in her grandparents' house. Despite not having a formal degree, Case 5 has started utilizing the internet to educate herself and teach her daughter, particularly through platforms like YouTube.

Case 6
Name- Withheld
Age: Thirty-six years
Qualification: Basic education
Resident: Bhopal, M.P.
Husband Name: NA
Divorced Type: Unilaterally
Duration of marriage: 5 years
Children- 0

Case 6, a 36-year-old resident of Talaiya, Bhopal, underwent instant triple talaq in December 2020 after a five-year marriage with Mr. Khan from Aishbagh, Bhopal, which began in 2015. The primary reason for discord was dowry-related issues. The woman's family had provided cash and gold to Nadir as dowry. In December 2012, she and her sister won Rs 50 lakh by participating in Kaun Banega Crorepati in Mumbai. The groom had always been interested in the prize money she won and eventually squandered it all. The woman's family members allege that Mr. Khan's elder brother, a lawyer, threatened them with consequences. Meanwhile, Mr. Khan informed

the police that he had attempted to reconcile with his wife, but she refused. After her divorce, she found herself without any means of income. She joined her sister's boutique, despite initially lacking knowledge of design. However, she has since learned to design with the help of the internet.

Case 7
Name- Withheld
Age: twenty-one years
Qualification: Basic education
Resident: Bhopal, M.P.
Husband Name: NA
Divorced Type: Unilaterally
Duration of marriage: 5 years
Children- 0

The 22-year-old woman from Bhanpur, Bhopal, married Mr. Khan in April 2021. Shortly after the wedding, she experienced mental trauma due to dowry demands from the groom, which escalated over time. Mr. Khan's family subjected her to extreme torture, alleging that she had not brought sufficient dowry. Within a month of their marriage, the girl was forced to return to her parental home as her husband angrily uttered Instant Triple Talaq three times during an argument. She reported to the police that her husband frequently instigated fights with her. Despite her family's efforts to salvage her marriage, they were unsuccessful. Consequently, Case 7 and her family filed a police complaint against Mr. Khan. While browsing the internet, she came across the BMMA organization, which helped her file an FIR against her husband for issuing Triple Talaq.

Case 8
Name- Withheld
Age: Twenty-eight years
Qualification: Basic education
Resident: Bhopal, M.P.
Husband Name: I don’t want to disclose it.
Divorced Type: Unilaterally
Duration of marriage: 2 years
Children- 0

The twenty-eight-year-old Case 8 entered into a marital union with the accused in September 2017. Dowry demands surfaced after the initial months of marriage, leading to continuous harassment. In 2018, the woman left her husband's home due to the harassment, but the dispute was temporarily settled. However, the harassment resurfaced over the issue of dowry. In September 2019, the accused, Mr. Khan, issued her an instant Triple Talaq. Despite Case 8's efforts to reconcile, their differences could not be resolved. Eventually, she filed a police complaint under the provisions of the Muslim Women’s (Protection of Rights on Marriage) Act, 2019. She utilized the internet and new media to find information about similar cases of Triple Talaq like hers.

Case 9-
Name- Withheld
Age: twenty-three years old
Qualification: Basic education
Resident: Bhopal, M.P.
Husband Name: I don’t want to disclose it.
Divorced Type: Unilaterally
Duration of marriage: 2 years
Children- 0

Case 9 married Mr. Khan in September 2019. According to the police report, the husband harassed the victim, demanding money from her mother as she was a government employee. When she refused, the harassment escalated. The accused was summoned to his in-laws' home to resolve the conflict. However, in a fit of rage, he pronounced Instant Triple Talaq on Case 9, ending their marriage. Subsequently, Case 9 and her family filed a case against him under the Indian Penal Code (IPC) and the Muslim Women (Protection of Rights on Marriage) Act of 2019. The accused was arrested and brought before the court. After the sudden divorce, Case 9 immersed herself in using the internet to alleviate her depression.

Case 10-
Name- Withheld
Age: twenty-eight years old
Qualification: Basic education
Resident: Bhopal, M.P.
Husband Name: I don’t want to disclose it.
Divorced Type: Unilaterally
Duration of Marriage: 1 year
Children- 0

Case 10 entered into a marital alliance with her husband in 2018. Subsequently,

harassment by the in-laws began. Initially, the woman filed a police complaint against the in-laws in 2018, but the dispute was resolved, and she returned home. However, the issue resurfaced as she was regularly subjected to physical abuse by her husband, prompting him to instantly pronounce Instant Triple Talaq. He cited marital discord as the reason. Eventually, Case 10 approached the police and filed a case against the man for Instant Triple Talaq and his family for ongoing harassment. She continued to endure regular beatings by her husband. Currently residing with her parents, she sought solace by watching motivational videos and speeches by famous women and influencers on the internet.

Results and Discussion

Positive societal change is evident as these women are not only embracing economic independence but also gaining empowerment and confidence.

- The importance of New Media is showcased in Bhopal, where Muslim women have taken on the task of self-reliance by venturing into online business.
- The contribution of WhatsApp and social media has been enormous for them to gain a better understanding of dealing with the aftermath of Triple Talaq, Divorced or separated women are exploring new courses to become vocational experts online.
- Muslim homemakers are learning and gaining knowledge through YouTube about various skills.
- Awareness of the legalities concerning the Triple Talaq Bill, which became the Muslim Women (Protection of Rights on Marriage) Act 2019, is visible.
- New Media plays a prominent role in this awareness through access, usage, and engagement.

Conclusion and Future Scope

The evolution of New Media in humankind began as a technological advancement in the world of the information superhighway. These digital technologies, which emerged as modernized sources of communication to make tasks easier, have significantly contributed to societies and cultures through their usage and acceptance. New Media penetrated households and lives where communication of important aspects of life was previously far-fetched. It provided a holistic approach for certain people to experience and adapt to the changes the 21st-century world has been witnessing, allowing them to sail in the same boat altogether (Dwary 2020, Ebrahimi and Salaverria 2015, Kushwaha 2018).

In the case of the Triple Talaq Bill, it was predominantly New Media that made the Muslim women in Bhopal become properly aware of the case and its constitutional changes through the judicial process. Despite the political mudslinging surrounding the Triple Talaq Bill case by Muslim clerics opposing it, the Muslim women of Bhopal kept politics aside and warmly welcomed the bill as a step towards the emancipation of Muslim women from the horrendous practice of Triple Talaq. The Muslim society is hopeful that the bill will serve its purpose and make the lives of such deprived Muslim women better (Bhalla 2015, Bharatiya Muslim Mahila Andolan 2016).

The New Media as a transformational tool is important but this study on the issue of Triple Talaq lends credence to the subject matter of how Muslim Women are adapting to changes and bigger transformations in their lifestyle and living. The New Media acts as a mouthpiece for their daily struggles and problems. There is a significant transformation and changes in the social life of Muslim women who have faced instant divorce in Bhopal and are engaged with new media (Lister et al. 2018, Manjula 2015, Trivedi 2018).

Empowerment in Dealing with Triple Talaq: New media, particularly WhatsApp and social media, have played a crucial role in empowering divorced or separated Muslim women by providing them with information and support networks to navigate the aftermath of Triple Talaq. These platforms offer spaces for discussion, sharing experiences, and accessing legal rights and emotional support resources.

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Research

An Analysis of Financial Statements: Measurement of Profitability with Reference to BHEL, Bhopal

Ishika Tiwari
Department of Commerce and Management, SAM Co-Ed College, Bhopal- 462 021, Madhya Pradesh, India
Corresponding Email: ishikatiwari0905@gmail.com
Received: 15/Jun/ 2024; **Accepted**: 17/Jun/2024; **Published**: 25/Jun/2024.

Abstract: The objective of the study is to measure the profitability and validity of the financial statements of the business enterprise. This paper is prepared to analyze the financial statement and measure the performance of the organization in terms of profitability it is focusing on the performance of BHEL Bhopal. It is based on secondary data which have been collected from the annual reports of the company. In this paper calculation of the profitability ratios has been done to study the financial strength and position of BHEL Bhopal. The profitability ratios like gross profit ratio operating ratio operating profit ratio net profit ratio and return on investment ratio have been calculated in this paper to analyze the profitability and earning capacity of the business enterprise.

Keywords: BHEL, Financial statements, Performance, Profitability

Introduction

Financial statements are summarized statements of accounting data prepared by the enterprise at the end of an accounting process that is after preparing a trial balance it shows a summarized form of the financial performance of an enterprise for an accounting period. The analysis of financial statements is an attempt to determine the importance of the financial statements and their usage for planning and forecasting about future earnings, liquidity, solvency, and profitability. The financial statement is prepared at the end of the year and for understanding the financial statement analysis is done with the help of tools of analysis. Financial statements help us to determine the financial position of a business and to ascertain the profit or loss earned by the business with the help of tools of analysis (Rashid 2018, Grewal 2024). The present study was undertaken with the following objectives, to analyze the earning capacity or the profitability of the company in the past five years, identify the financial position of the enterprise, and measure the performance in terms of profitability ratios.

Research Methodology

Company Profile

BHEL is a Maharatna company of the Indian government. It is an integrated power plant and one of the leading engineering and manufacturing companies in India. BHEL has about 16 manufacturing divisions 4 regional offices 8 service centres to repair units and 15 regional centres. It is engaged in designing, engineering, constructing, testing, and servicing various types of products and services. BHEL Bhopal unit manufactures a wide range of electrical equipment. It has its own laboratories for testing materials which are accredited with ISO 17025 by NABL. The strength of BHEL Bhopal is its employees it consists of around 1162 engineers 950 supervisors and more than 2500 artisans as well as supporting staff. The area is spread over about 20 square kilometers and has provided all types of facilities to its residents whether it is a Bank, Post Office, shopping center, or Kasturba Hospital which contains 350 beds for its employees. The financial statement is a very crucial data of a company which contains the

most important information. By analyzing and interpreting the financial statements we can find out the profitability solvency liquidity and efficiency of the business. Through the present study, we can conclude the earning capacity of BHEL and also we can know the financial position of the enterprise. The objective of the study is to analyze the financial strengths and the weaknesses of BHEL with the help of ratio analysis we are going to calculate the profitability of the firm over the past 5 years. It would help us to forecast the profit of coming years and also to know the earning capacity over the past 5 years of the business enterprise (Bharat Heavy Electricals Limited 2024).

The research is done to measure the profitability or the earning capacity and performance of BHEL Bhopal. The research has been done on the basis of profit and loss accounts over the past 5 years taken from the annual reports of the company. It is based on secondary data collected from the annual reports of the company. Profitability ratios are the tools used for analyzing the financial statements of the company. The limitation of the study was that it is based on secondary data, the financial statements are prepared on the basis of a going concern, and only the profitability ratio is calculated for knowing the earning capacity of the company

Analysis- Profitability Ratios

The formula used to calculation was:

a. Gross Profit Ratio= Gross Profit/Net Sales * 100

b. Operating Ratio= Cost of Revenue from Operations + Operating Expenses / Net Sales * 100

c. Net Profit Ratio= Net Profit/ Revenue from Operations * 100

d. Return of Investment= Profit Before Interest, Tax and Dividend / Capital Employed * 100 {Capital Employed = Share Capital + Reserve and Surplus + Long Term Borrowing |+ Long Term Provisions}

Results

Gross Profit Ratio

The gross profit of the company in the last five years has been in a decreasing stage from 2020 to 2022 and will remain constant from 2022 to 2024. It indicates that the company's performance has declined over the past years. It is trying to increase its profit but it has been constant in the last three years. The company needs to increase its efficiency to increase its gross profit (Table 1, Fig. 1).

Table 1. Data showing the gross profit ratio of the company.

Year	2024	2023	2022	2021	2020
Gross Profit	70,856.70	69,212.60	62,894.40	45,222.50	53,144.20
Net Sales	238,927.80	233,649.40	212,110.90	133,839.10	173,086.90
Ratio	29.66%	29.62%	29.65%	33.78%	30.7%

This study focuses on profitability ratios which help us to know the forms profit. There are a number of ratios that come under profitability ratio, here we are using gross profit ratio, operating ratio, operating profit ratio, net profit ratio, and return on investment ratio for analysis and interpretation of data to make it meaningful and understandable.

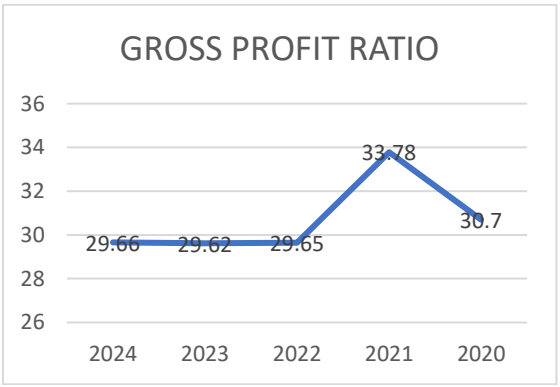

Fig. 1. Graph showing the gross profit ratio of the company.

Operating Ratio

The operating ratio of the firm is more than 100% which indicates the company is unable to generate profits from its investing activities. However, there has been a decline in the operating ratio from 2021 to 2024. The company is inefficient in gaining profit through underwriting and investing activities (Table 2, Fig. 2).

Table 2. Data showing the operating ratio of the company.

Year	2024	2023	2022	2021	2020
Cost of Revenue from Operations	168,071.10	164,436.80	149,216.50	119,942.70	-
Net Sales	238,927.80	233,649.40	212,110.90	133,839.10	173,086.90
Operating Expenses	235,290.80	233,595.90	208,594	209,776.80	-
Ratio	169.20%	170.35%	168.86%	246.3%	-

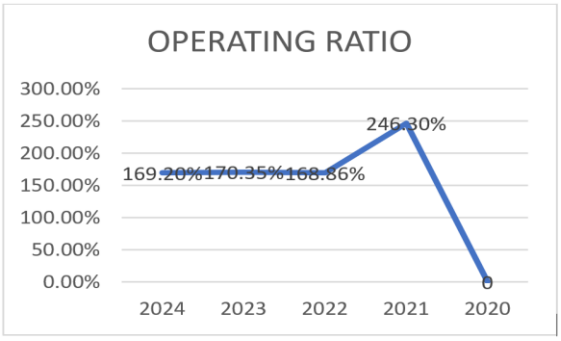

Fig. 2. Graph showing the operating ratio of the company.

Net Profit Ratio

This ratio indicates overall efficiency of the business. Higher the net profit ratio, better the business. BHEL, Bhopal seems to have a very poor performance in 2021. But tried to improve the net profit from 2022, declining in the upcoming years. The performance or can say the earning capacity of the company is extremely poor (Table 3, Fig. 3).

Table 3. Data showing the net profit ratio of the company.

Year	2024	2023	2022	2021	2020
Net Profit After Tax	2,822.20	4,773.90	4,447.10	-26,997	-
Net Sales	**238,927.80**	**233,649.40**	**212,110.90**	**133,839.10**	**173,086.90**
Ratio	1.18%	2.04%	2.09%	-20%	-

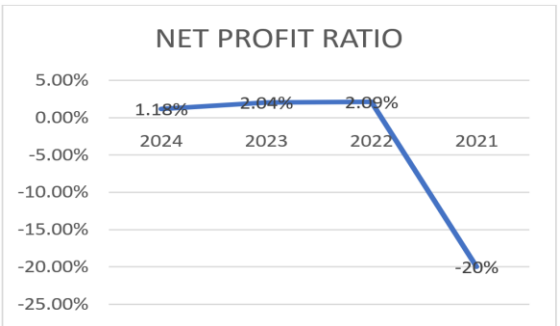

Fig. 3. Graph showing the net profit ratio of the company.

Return on Investment or Return on Capital Employed

This ratio assesses the overall performance of the enterprise. It measures how efficiently the resources entrusted to the business are used. It can be seen that the overall performance of the enterprise has been drastically declined in 2021 but increased in 2022 and again declined in 2024. This shows that the overall performance of the company is poor. The resources are not efficiently utilized (Table 4, Fig. 4).

Table 4. Data showing the return on investment of the company.

Year	2024	2023	2022	2021	2020
Profit Before Interest, Tax and Dividend	**220.33**	**449.60**	**436.95**	**-3,611.60**	**-662.11**
Capital Employed	34,084.63	36,452.47	35,337.17	35,379.58	37,656.61
Ratio	0.64%	1.23%	1.23%	-10.21%	-1.75%

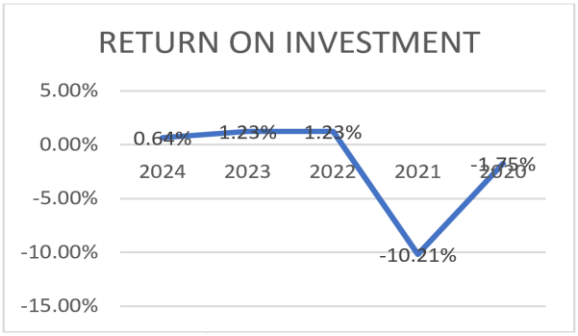

Fig. 4. Graph showing the return on investment of the company.

Conclusion

After the research, it can be concluded that the performance and the profitability of BHEL Bhopal is not very good, it's very poor. The gross profit ratio is average but the operating ratio and net profit ratio as well as the return on investment ratio are extremely poor from which we can say that the position of BHEL is extremely poor and in a declining stage. It should improve its performance by increasing the efficiency of its resources and the operational efficiency of management and the business. It should also try to lower the cost of goods sold. On seeing the position, I conclude that it is not a good decision to invest as a stake of owners in the company as its long-term debt is continuously increasing. It means that the company is not in the stage of paying off its creditors and is at risk. However, in

the past years, it has been trying to increase its managerial and efficiency performance but should take more efficient steps to exist in the market (Money Control 2024a, b). BHEL Bhopal has achieved a total turnover of rupees 22920 crore during the financial 202324 which is 3.5% more than the previous year.

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Short Communication

Effectiveness of Pamphlet Regarding Knowledge on Ill Effects of Mobile Phones Among Mothers of School-Going Children in Selected Urban Area of Bhopal (M.P.)

Neelima Rani Chourasia
SAM College of Nursing Science and Hospital, Raisen- 464 551, Madhya Pradesh, India
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Abstract: A study to evaluate the effectiveness of a pamphlet regarding knowledge on the ill effects of mobile phones among the mothers of school-going children in the selected urban area of Bhopal". 60 Mothers of school-going children were selected by non-probability convenient sampling. Data was collected by using socio-demographic and self-structured questionnaires on the ill effects of mobile phones among mothers of school-going children. The finding revealed that the mean post-test score of 82 is higher than the mean pre-test score of 41.6 and the calculated 't' test value of t=31.49 was statistically significant at 0.05 level of significance. Thus it is established that the difference obtained in the mean knowledge score before and after giving the pamphlet was good and giving the pamphlet was effective and increasing the knowledge the knowledge level of mothers of school-going children regarding the ill effects of mobile phones.

Keywords: Mobile phones, Pamphlet, School children

The main difference concerning the use of mobile phones (MPs) between today's children and adults is the longer lifetime exposure of children when they grow older, due to starting to use MPs at an early age. Additionally, recent trends lead to a higher frequency of use among children, including higher popularity of MPs and features specifically designed to attract children. The prevalence of MP users is already very high and reaches >90% among adolescents in some countries. In a German study, 6% of 9–10-year-old children used an MP for making calls daily; 35% owned their own MP. For children, MPs are dominant sources of radio wave exposures and relevant sources of extremely low-frequency magnetic fields. For very young children, however, environmental exposure to radio waves may be of concern. In conclusion, children will have a much higher cumulative exposure to radio waves than today's adults when they are the same age. Radio wave exposure in children may be estimated more easily because the variety of exposure sources is smaller than for adults. As long as adverse health effects cannot be ruled out with some degree of certainty, it appears to be appropriate to instruct children and their parents about the prudent use of MPs. Agreeing with this survey of Medical Doctors the disease caused by mobile phone devices are Brain Tumor 74%, Male Infertility 37%, Heart Disease 45%, Effect on Fetus 21%, Ear Hearing Function 80%, Alzheimer's disease 11%, and Parkinson's disease 3% (Rai et al. 2016, Soni 2018).

Hence, the present study was conducted to evaluate the effectiveness of the pamphlet regarding knowledge on the ill effects of mobile phones among mothers of school-going children in selected urban areas of Bhopal with the following objectives, determination of the pre-test knowledge regarding the ill effect of mobile phones among the mothers of school going children, development of the pamphlet regarding

the ill effect of mobile phones among the mothers of school going children, determination of the post-test knowledge regarding the ill effects of mobile phones among the mothers of school-going children, to find out the effectiveness of a pamphlet on knowledge regarding the ill effects of mobile phones among the mothers of school-going children, to find out the association between the pre-test knowledge score of the mothers with their selected demographic variables.

In this present study, a pre-experimental (one group pre-test post-test) design was used to evaluate the effectiveness of a pamphlet regarding knowledge on the ill effects of mobile phones among the mothers of school-going children who were selected by non-probability sampling from a chosen population. Data was collected by using socio-demographic and self-structured questionnaires on the ill effects of mobile phones among mothers of school-going children.

In this present study, a total of 60 subjects were enrolled. The socio-demographic variables revealed that 36.6% (22) of mothers were belong to 26-30 years. It Reveals that the majority 56.6% (34) mothers were graduates. Reveals that the majority 51.66% (31) mothers are from joint families. Shows that 60% (36) of mothers were homemakers and the majority 26.7%. Shows that the highest 36.6% (22) of mothers have a family income of Rs. 20001-30000. Shows higher 55% (33) of mothers had previous knowledge regarding the ill effects of mobile phones, however, 45% (27) of mothers did not have much knowledge. Reveals that the majority of mothers' families 46.6% (28) were using more than 4 mobile it reveals higher 61.6% (37) were allowed to use mobile phones for less than 1 hour.

This study reveals that after the implementation of the pamphlets, 81.6%(49) of mothers of school-going children had a very good level of knowledge, followed by 18.4%(11) of mothers of school-going children had a good level of knowledge. The mean score of the level of knowledge score of mothers of school-going children before distributing the pamphlet was 41.6 and the post-test 82 with the pretest mean score and SD 41.6±6.2561 and the post-test mean score and SD being 82±6.024 mean difference of 40.4. Thus it is established that the difference obtained in the mean knowledge score before and after the pamphlet was good and giving the pamphlet was effective and increasing the knowledge level of mothers of school-going children regarding the ill effects of mobile phones. Hence research hypothesis H_1 was accepted.

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Book Review

Microbial Genetics

Rohit Sharma
School of Sciences, SAM Global University, Raisen- 464 551, Madhya Pradesh, India
Corresponding Email: rsfungus@gmail.com
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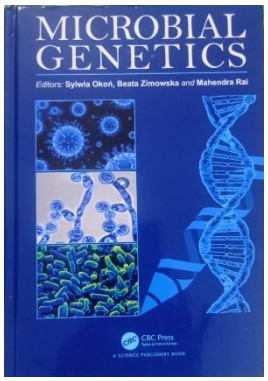

Title: Microbial Genetics

Editors: Sylwia Okoń, Beata Zimowska, Mahendra Rai

Publisher: CRC Press, Taylor & Francis Group

Year of Publication: 2024

ISBN: 9781032358413

"Microbial Genetics," edited by Sylwia Okoń, Beata Zimowska, and Mahendra Rai, is a comprehensive and expertly curated volume that explores the intricate and dynamic field of microbial genetics. This book brings together contributions from leading researchers and scholars, offering a wide-ranging overview of the latest advancements and foundational concepts in the study of microbial genetics. Divided into four distinct sections, this book covers a wide array of topics, offering in-depth insights into the genetic makeup of various microorganisms. It also covers the genetic mechanisms of various microorganisms, including bacteria, viruses, fungi, and protozoa, highlighting their roles in diverse environments and their implications for biotechnology and medicine. It is an invaluable resource for students, researchers, and professionals in microbiology, genetics, and related fields.

Section 1: Basics of Microbial Genetics

The first section of the book lays the foundation for understanding microbial genetics by covering fundamental concepts and principles. It begins with an introduction to microbial cells, focusing on their structural and functional aspects. The section progresses to discuss the genetic material of microbes, including the nature and organization of microbial genomes. Genomic Structure and Function: The organization of prokaryotic and eukaryotic genomes, plasmids, and extrachromosomal DNA. DNA Replication and Repair: Mechanisms of DNA replication in bacteria and archaea, and the various DNA repair pathways. Gene Expression and Regulation: An exploration of transcription, translation, and post-translational modifications in microbes. The section also delves into regulatory mechanisms, including operons and transcription factors. Genetic Variation and Evolution: The sources of genetic variation such as mutations, recombination, and horizontal gene transfer. The section discusses evolutionary processes and their impact on microbial diversity. The basics are thoroughly explained, providing a strong foundation for readers new to microbial genetics. The use of detailed diagrams and illustrations enhances understanding of complex processes. Concepts are presented clearly and concisely, making them accessible to a broad audience.

Section 2: Molecular Basis of Virus and *Phytoplasma*

The second section shifts focus to the genetic and molecular biology of viruses and phytoplasmas. This section explores the unique genetic mechanisms employed by these pathogens and their interactions with host organisms. Viral Genomes and Replication: The structure and diversity of viral genomes, including DNA and RNA viruses. Mechanisms

of viral replication and the role of host cellular machinery. Gene Expression in Viruses: How viruses hijack hosts cellular processes to express their genes and produce viral proteins. Phytoplasma Genetics: The genetic composition of phytoplasmas, their life cycle, and the impact on plant hosts. Pathogenic Mechanisms: The molecular basis of virulence, including strategies viruses and phytoplasmas use to evade host defenses and promote infection. Gene Therapy and Vaccines: Insights into how understanding viral genetics has led to advances in gene therapy and the development of vaccines. Real-world examples and case studies provide context and practical understanding of viral and phytoplasma genetics. Incorporates the latest research findings, making it a valuable resource for current knowledge in the field. Links between molecular biology, genetics, and biotechnology are well-established, showing the broader implications of viral and phytoplasma research.

Section 3: Bacterial Genetics

The third section delves into the genetics of bacteria, covering a wide range of topics from genetic mapping to the molecular mechanisms of gene transfer. Bacterial Chromosomes and Plasmids: Structure, replication, and inheritance of bacterial chromosomes and plasmids. Genetic Mapping and Mutagenesis: Techniques for genetic mapping in bacteria, including the use of transposons and mutagenesis approaches. Horizontal Gene Transfer: Mechanisms of transformation, transduction, and conjugation. The role of horizontal gene transfers in bacterial evolution and antibiotic resistance. Regulation of Gene Expression: Detailed examination of regulatory networks in bacteria, including two-component systems and quorum sensing. Biotechnological Applications: The use of bacterial genetics in biotechnology, including genetic engineering and synthetic biology. Provides a thorough understanding of bacterial genetics, from basic concepts to advanced topics. Offers practical insights into laboratory techniques and methodologies used in bacterial genetics research. Highlights the practical applications of bacterial genetics in medicine, agriculture, and industry.

Section 4: Fungal and Protozoan Genetics

The final section of the book focuses on the genetics of fungi and protozoa, covering their unique genetic properties and their roles in ecosystems and human health. Fungal Genomes: Structure and organization of fungal genomes, including the differences between yeasts and filamentous fungi. Gene Expression and Regulation in Fungi: Mechanisms of gene regulation in fungi, including signal transduction pathways and transcriptional control. Protozoan Genetics: Genetic diversity and the molecular biology of protozoa, with a focus on pathogenic protozoa such as *Plasmodium* and *Trypanosoma*. Genetic Manipulation: Techniques for genetic manipulation of fungi and protozoa, including CRISPR-Cas9 and RNA interference. Pathogenesis and Host Interaction: Genetic factors involved in the pathogenesis of fungal and protozoan infections, and the interaction with host immune systems. Thorough exploration of both fungal and protozoan genetics, providing a balanced view of these diverse organisms. Integrates current research findings, offering insights into the latest advancements in the field. Clinical Relevance: Discusses the implications of fungal and protozoan genetics for human health, including disease mechanisms and potential therapies.

Conclusion

The "Microbial Genetics" book edited by Sylwia Okoń, Beata Zimowska, and Mahendra Rai is a well-rounded and informative resource that covers a wide range of topics in microbial genetics. Each section is meticulously detailed, providing both foundational knowledge and insights into advanced research. The clear explanations, illustrative diagrams, and practical applications make it an indispensable guide for anyone interested in the genetic mechanisms of microorganisms. Whether you are a student, researcher, or professional, this book offers valuable information and perspectives that will enhance your understanding of microbial genetics.

References

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Book Review

A Compendium on Taxonomy of Ectomycorrhizal Mushrooms of Central India

Shaifali Sharma
Centre for Biodiversity Exploration and Conservation (CBEC), Mandla Road, Tilhari, Jabalpur- 482 021, Madhya Pradesh, India
Corresponding Email: sharmashaifali6@gmail.com
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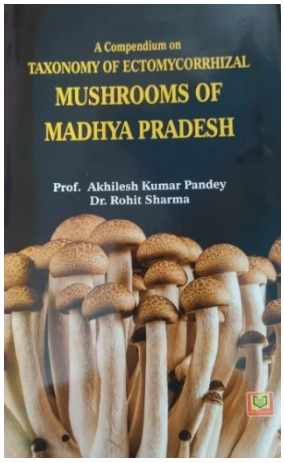

Title: A Compendium on Taxonomy of Ectomycorrhizal Mushrooms of Central India

Authors: Akhilesh Kumar Pandey and Rohit Sharma

Publisher: India Netbooks Pvt. Ltd.

Year of Publication: 2023

The "A Compendium on Taxonomy of Ectomycorrhizal Mushrooms of Central India" authored by Dr. Akhilesh Kumar Pandey, Vikram University, Ujjain, and Dr. Rohit Sharma, Centre for Biodiversity Exploration and Conservation (CBEC), is an exhaustive and meticulously detailed resource that offers invaluable insights into the diverse species of ectomycorrhizal fungi found in the central Indian region. This book is an essential read for mycologists, ecologists, and mushroom enthusiasts alike, as it covers a wide range of genera, including *Russula, Lactarius, Amanita, Boletus, Scleroderma,* and *Geaster*.

Overview

The book begins with an introduction to the ecological significance of ectomycorrhizal mushrooms, highlighting their crucial role in forest ecosystems. These fungi form symbiotic relationships with tree roots, aiding in nutrient absorption and improving tree health. The compendium emphasizes the importance of conserving these fungi due to their ecological contributions and potential medicinal properties. The key genera covered are:

Russula

Russula species are characterized by their brittle gills and vibrant colors. This genus is one of the most diverse among ectomycorrhizal fungi. The book provides detailed descriptions and illustrations of several *Russula* species found in Central India, including their morphological traits, habitat preferences, and ecological roles. Notable species include *Russula emetica*, known for its striking red cap and toxic properties, and *Russula cyanoxantha*, appreciated for its edibility and unique texture.

Lactarius

Lactarius mushrooms are easily identified by the milky latex they exude when cut or damaged. The compendium covers a variety of *Lactarius* species, focusing on their distinctive latex production and cap coloration. Species such as *Lactarius deliciosus*, with its orange latex and sought-after culinary value, and *Lactarius indigo*, known for its striking blue color, are detailed extensively.

Amanita

Amanita species are notable for their iconic appearance, often featuring a prominent cap with a volva at the base. This section delves into the *Amanita* genus, known for its range of edible to highly toxic species. The compendium discusses *Amanita muscaria*, recognizable by its red cap with white spots, and *Amanita phalloides*, infamous as the deadly "death cap". Detailed descriptions,

along with cautionary notes on identification, are provided to prevent accidental poisoning.

Boletus

Boletus mushrooms typically have a spongy layer of pores instead of gills under the cap. The book covers various Boletus species, focusing on their robust bodies and ecological importance. *Boletus edulis*, commonly known as the porcini mushroom, is highlighted for its culinary value, while *Boletus satanas* is noted for its toxic properties.

Scleroderma

Scleroderma fungi are earth balls with thick, tough skins and spore masses inside. This section provides insights into the less commonly known Scleroderma genus, detailing species such as *Scleroderma citrinum*, known for its ecological role in nutrient cycling and its potential toxicity.

Geaster

Geaster, or earthstar fungi, have a star-like appearance when their outer layer splits open to release spores. The compendium includes descriptions of *Geaster* species, emphasizing their unique morphology and spore dispersal mechanisms. Species like *Geaster hygrometricus*, known for its hygroscopic behavior, are discussed in detail.

Illustrations and Identification Guides

One of the standout features of this book is its comprehensive collection of illustrations and photographs. Each species is accompanied by high-quality images that highlight key identification characteristics, such as cap color, gill structure, and habitat. Additionally, the book includes detailed identification keys that make it easier for both novice and experienced mycologists to accurately identify the various species.

Ecological and Cultural Significance

Beyond taxonomy and identification, the compendium delves into the ecological roles and cultural significance of ectomycorrhizal mushrooms in Central India. It discusses how these fungi contribute to forest health by forming symbiotic relationships with trees, enhancing nutrient uptake, and providing resistance to pathogens. The book also touches on the traditional uses of some species in local cultures, whether for culinary, medicinal, or ritualistic purposes.

Research and Conservation

The final sections of the book focus on current research trends and conservation efforts. It highlights the need for continued study of ectomycorrhizal fungi, particularly in the face of deforestation and climate change, which threaten their habitats. The compendium calls for sustainable foraging practices and conservation strategies to preserve these vital fungal species for future generations.

Conclusion

The "A Compendium on Taxonomy of Ectomycorrhizal Mushrooms of Central India" is an authoritative and comprehensive resource that provides a deep understanding of the region's fungal biodiversity. It serves as an indispensable guide for identifying and appreciating the rich variety of ectomycorrhizal fungi in Central India. Through its detailed descriptions, high-quality illustrations, and emphasis on ecological importance, this book is a valuable addition to the library of anyone interested in mycology, ecology, or environmental conservation.

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General

Scope, Journal Policy, and Authors Instructions

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