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An Analytical Study of the Components and Genres of Indian Classical and Semi-Classical Music

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ABSTRACT

People think of music as a performance art that lets people express their feelings of pleasure. To put it simply, music has a direct connection to the soul. Music is a combination of three great arts: singing (vocal), playing instruments (instrumental), and dancing. People think that music is one of the most important forms of creative art. Because of continuing exploration, everything is always changing in our modern age of science. Music and its fields have also gone through these changes. Because musical instruments are now the main source of energy for important music, it was important to talk about how Indian music has changed throughout time and how musical instruments were made. There is also more and more attention in how religion affects mental health. Researchers have linked several parts of religious life, such as being involved in an organization, praying, believing in an afterlife, using religion to cope, getting help from a congregation, and having a strong relationship with God, to mental health.

Keywords*:* Raga, Tala, Indian Classical Music, Semi-Classical Music, Religious Music

Introduction

People think of music as a performance art that lets people express their feelings and pleasures. In terms of ideas, music combines three main types of art: singing, playing instruments, and dancing. It serves as both a skill and a cultural practice, and its organised organisation across time is what makes it unique (Sharma, 1996).

Pitch (melody and harmony), rhythm (tempo, meter, articulation), dynamics (loudness variations), and timbre (tone colour) are all basic parts of music that are included in full definitions. These parts are given varied amounts of importance in different genres (Kasliwal, 2001).

People often call Indian music "Sangeet," which is one of the oldest musical traditions still going on today. It is based on three main parts: Swara (notes), Tala (rhythmic cycles), and Laya (pace). Gayan (vocal music), Vadan (instrumental music), and Nritya (dancing) are all ways that these things are shown (Prjananada, 1984).

Indian Music and Its Styles

The Vedas are where Indian music got its start. They say that sound, which they call Nadabrahma, is divine (Singh, 1994). Musicians are told to give up their own will in order to become one with Lord Brahma, the mythological author of the four Vedas, especially the Sama Veda, which is sung in melodic patterns (Saxena, 2009). The first Vedic hymns used simple tunes

with three notes. Indian music features metric cycles such duple, triple, and quadruple time signatures, with the first beat often emphasised. In mythology, Brahma is tied to Samgana (musical chanting), and Goddess Saraswati, who is linked to wisdom and art, is linked to the Veena (SuneeraKasliwal, 2001).

People think that vocal music is the basis for all instrumental music, and the human voice is the first instrument. India has preserved almost all of the stages of musical evolution, from Vedic writings to classical treatises like Sangeet Ratnakara (Sarangadeva, around 1230 A.D.), which is the basis for later works like Sangitopanishatsaroddhara, Sangitaraja, and Sangita Damodara (Saraf, 2011).

The basic ideas behind classical music, such Shruti, Grama, Murchana, Jatis, Svara, Raga, Tala, and Prabhanda, haven't altered much. However, new styles that came from Gramme ragas and Desi sangeet revolutionised classical music. By the 13th century, new ideas had added to tala systems, which had started with five talas (Bharata Muni) and grown to more than 120 (Durga, 2004).

A description of the parts of music

1. **Melody and Pitch**

   Pitch is how high or low a sound seems to be. A melody is a series of pitches that make up a tune, and it is generally made up of modes or scales. For instance, a folk song in C major might exclusively use notes from the C major scale (Sharma, 1996).

2. **Harmony**

Harmony is when vertical sounds (notes) are played or sung at the same time to make chords. It can also be conveyed melodically by outlining chord notes in a certain order (Kasliwal, 2001).

3. **Beat**

Rhythm puts sounds and silences in order over time. There are meter groups that group beats into bars or measures like 2/4, 3/4, and 4/4. The first beat is usually the most important one (Prjananada, 1984).

Indian Classical Music (Shastriya Sangeet)

There are two main styles of Indian classical music, which is the classical music of the Indian subcontinent. These are Hindustani (North Indian) and Carnatic (South Indian). During Islamic governance in the 16th century, they started to go their separate ways. Hindustani music focusses on improvising on ragas, while Carnatic concerts are largely based on written music. Even if they are different, they have more in common than differences (Saraf, 2011).

Art Music, Kalatmak Sangeet, or Raagdari Sangeet are some of the names for the rules and principles that govern Indian classical music. Ragas express feelings, and the words and structure are important in their own right. In folk music, the words are typically more important than the notes (Sharma, 1996).

Tala (rhythm) and raga (melodic framework) are the most important parts. The raga is the melody, and the tala is the rhythm that you can use to improvise. Indian classical music doesn't

include harmony or chord structures like Western music does. Instead, it focusses more on the space between notes (Singh, 1994).

Indian semi-classical music

Semi-classical music, also called Light Music, is not as stringent and doesn't require you to know classical ragas and rhythms perfectly. It mixes poetry, pace, and melody, putting more emphasis on the content of the composition than on the purity of the raga (Saxena, 2009). Semi-classical music uses classical elements but doesn't necessarily follow traditional laws exactly. Instead, it changes based on the singer's skills and the situation. This also includes folk songs sung in a classical way (Kasliwal, 2001).

Lok Sangeet or Folk Music

Folk music doesn't have a set grammar like classical music does, and it changes from place to place. It comes from village life and tradition and is full of feeling and expression. India has a lot of different cultures, which leads to a lot of different folk music styles, like Bhangra, Sufi folk rock, Dandiya, and Lavani (Saraf, 2011).

Religious Music:

In Indian culture and tradition, religious music is one of the best means for devotion and worship of the Divine. Among the nine types of devotion for spiritual bhakti, religious music is considered the most excellent form of devotion. It is used during festivals, rituals, customs, and worship ceremonies.

In Sikh music, the hymns of Sri Guru Granth Sahib are organized according to ragas (musical modes), and the Sikh Gurus established a definite method and system for singing this sacred text. The tradition of Kirtanthe combined presentation of sacred words (shabad) and musicwas initiated by the Sikh Gurus and continues uninterrupted to this day.

In Indian culture, devotional songs and religious music hold significant importance and are part of the religious customs of almost every faith. Within devotional music, traditions such as Gurmat (Sikh) devotional songs, Sufi music, and Hindu devotional songs dedicated to goddesses and deities are the most widespread and distinctiv

Religious music includes Upasana Sangeet, Bhakti Sangeet (devotional), and Goodhatma (mystical). Today, Bhakti Sangeet is the most well-known and important (Sharma, 1996).

Popular Music

The music that most people like is basic and easy to understand, which shows how different groups of people interact with each other. Social movements, urbanisation, the media, and ideas about free time all affect how it grows. Media shapes the structure and content of popular music through time limits and transmission facilities (Prjananada, 1984).

Conclusion

Music is an important part of our creative and cultural history. Changes in music and its fields happen because people keep trying new things. This study looks at how experimentation affects instrumental music and how Indian music has changed over time and how musical

instruments were made. Listening to religious music is also becoming more linked to mental health. Studies have shown that it is linked to mental health (Aldridge, 1995; Bailey, 1984).

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Bow: Ancient Indian Science and Tradition

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Abstract

The bow and arrow have been significant weapons in ancient Indian culture, used not only for warfare but also in religious rituals, meditation, and traditional arts. This research studies various types of bows, their structure, uses, and the materials required for their construction, based on treatises such as Dhanurveda, Vishnudharmottara Purana, Agni Purana, and Kautilya's Arthashastra.

The study highlights different types of bows, their measurements, and the importance of materials such as wood, iron, horn, and silk used in their construction. It also elaborates on guidelines related to prohibited bows and bowstrings. This research brings out the historical, cultural, and scientific aspects of the bow in the Indian tradition.

Keywords: Bow, Types of Bows, Dhanurveda, Bowstring, War Skills, Bow-making, Ancient Weapons.

Introduction

The bow and arrow in Indian culture are not merely weapons of war; they represent a unique tradition, art, and science. From ancient battlefields to religious rituals, bows have played a prominent role. Their significance goes beyond physical protection and extends to spiritual and cultural dimensions. Ancient texts such as Dhanurveda, Vishnudharmottara Mahapurana, Agni Purana, and Kautilya's Arthashastra discuss in detail the types of bows, their structure, uses, and technical features.

Dhanurveda describes ten types of bows—such as Yogic Bow, Kriya Bow, Shalaka Bow, Jyaghat Bow, and Sangramik Bow—each designated for a specific purpose. For example, the Yogic Bow is used for meditation, while the Sangramik Bow is for warfare. Other treatises like Nitiprakasika and Vaijayanti Kosha provide additional classifications, reflecting high technical expertise of the period.

The materials used for bow construction are equally important. According to Dhanurveda, iron, horn, wood, gold, silver, copper, and steel were used for crafting bows. Bamboo, sandalwood, teak, and willow were considered ideal. Bamboo and cane from the banks of the Ganga and Vitasta rivers were highly valued. Bowstrings were made from silk, animal sinews, or tree bark.

Ancient texts also specify ideal measurements: a bow measuring four-and-a-half cubits is considered superior, four cubits is moderate, and anything smaller inferior. The grip portion must be smooth and rounded.

This research paper examines textual references to bows, their types, structure, measurements, and features. It reflects the perfect balance between ancient Indian warfare techniques, religious practices, and technical skills, revealing both the historical background and scientific perspective behind the bow.

The bow and arrow symbolized valor, discipline, and cultural expression. Through this study, we gain a deeper understanding of the cultural and scientific significance of this ancient weapon.

Types of Bows

In ancient India, bows and arrows were regarded as highly important weapons. Various texts mention their classifications. According to Dhanurveda, there are ten types of bows, referred to by the term Chāpa:

1. Yogic Bow – used for practice
2. Kriya Bow – used for aiming practice
3. Shalaka Bow – for shooting iron arrows
4. Jyaghat Bow – to cut the opponent's bowstring
5. Shramik Bow – for daily practice
6. Sangramik Bow – for actual warfare
7. Long-range Bow – for distant targets
8. Difficult-target Bow – for precise aiming
9. Vikarsha Bow – with a highly stretchable string
10. Phala Bow – for accomplishing specific tasks

Nitiprakasika classifies bows into two major types:
Shangra Bow – curved at three points
Vainava Bow – made by bending a four-cubit bamboo cane like a rainbow
Measurements of the Bow
According to Vasishtha Dhanurveda:
A bow of 5½ cubits is considered superior (used by Lord Shiva)
A bow of 4 cubits is suitable for humans
Width should be 3, 5, 7, or 9 fingers; widths of 4, 6, and 8 fingers are rejected
Vishnu used a 3½-cubit Shangra bow designed by Vishwakarma
According to Vishnudharmottara:
Wood bow of 4½ cubits – excellent
Bow of 4 cubits – moderate
Bow of 3½ cubits or less – inferior
Grip must be smooth and round
Vaijayanti Kosha mentions various bows derived by increasing the two-finger length of the four-cubit bow, such as Vidyadhara, Sharayudha, Gandiva, etc.
Materials for Bow Construction
Dhanurveda recommends:
Iron, wood, horn, gold, silver, copper, steel
Woods such as sandalwood, cane, teak, salmalia, bamboo
Vishnudharmottara suggests:
Bows of iron, horn, and wood
Bamboo bows should have bamboo bowstrings
Shangra bows should be decorated with gold patterns
Gold bows studded with diamonds and pearls
Horn bows plated with gold
Bamboo from the Ganga, and cane from the Vitasta river, are superior
Wood from autumn season is ideal
Agni Purana recommends:
Iron, horn, and wood
Four-cubit bow – superior
3½-cubit bow – moderate

3-cubit bow – inferior
Arthashastra mentions:
Tal-tree bows – Karmuka
Bamboo bows – Kodanda
Wooden bows – Drina
Prohibited Bows
The following are to be avoided:
Very old or raw bamboo bows
Worn-out, burnt, insect-infested bows
Bows made from low-quality wood
Bows with weak or excessively thick bowstrings
Bows with cracked or perforated structure
Such bows may break during use, fail in accuracy, or cause defeat in battle.
The Bowstring (Pratyanchā)
The string tied to both ends of the bow is called Pratyanchā, also known as Guṇa, Maurvī, Jīva, and Drina. It must:
Reach the ear when pulled
Produce a strong twang
Be made of durable material so it does not break during battle
According to various texts:
Dhanurveda: Three-ply string, representing Brahma, Vishnu, Mahesh
Silk is superior; sinews of deer (best), buffalo (moderate), cow (inferior)
Vishnudharmottara: Make strings from hide, mature bamboo, or tree bark
Arthashastra: Use murva fibre, arka, hemp, wheat-grass, bamboo, or animal sinews

Conclusion:

The bow and arrow symbolize ancient Indian culture, with importance extending beyond warfare into religious, spiritual, and cultural domains. This research highlights various bow types, construction materials, measurements, and scientific techniques from ancient texts such as Dhanurveda, Vishnudharmottara, Agni Purana, and Arthashastra.

The study reveals the advanced technical knowledge and scientific understanding embedded in ancient weapon-making traditions. The bow reflects the harmony of philosophy, craftsmanship, and martial preparedness in Indian civilization.

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Language, Culture, and Identity: A Postcolonial Reading of Tagore's *Gitanjali*

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Abstract

Rabindranath Tagore's *Gitanjali* (Song Offerings) occupies a unique place in world literature, representing a blend of Indian spiritual sensibility and modernist aesthetics within a colonial context. This paper explores *Gitanjali* through a postcolonial lens, focusing on the dynamics of language, cultural negotiation, and identity formation under colonial rule. Tagore's translation of his original Bengali poems into English serves not only as a medium for cross-cultural communication but also as a site of cultural resistance and self-articulation. The paper discusses how *Gitanjali* navigates the tension between indigenous expression and colonial expectations, highlighting Tagore's role as both a cultural bridge and a nationalist voice. Through this reading, the paper demonstrates how language in *Gitanjali* becomes a tool of spiritual universality while also resisting imperial homogenization.

Keywords: Rabindranath Tagore, *Gitanjali*, postcolonialism, language, identity, cultural hybridity, colonialism, translation.

Introduction:

Rabindranath Tagore, a towering figure of Indian literature and the first Asian Nobel Laureate, made a lasting contribution to modern world literature with Gitanjali (1912). Born in British India and educated both in the East and the West, Tagore's life and works represent a synthesis of diverse cultural influences. Gitanjali is perhaps his most celebrated work, showcasing deeply personal and spiritual poems originally written in Bengali and later translated into English by Tagore himself.

While Gitanjali is often celebrated for its lyrical beauty and spiritual depth, this paper argues that its significance extends far beyond the realm of religious poetry. A postcolonial reading of the work reveals it as a rich site of cultural negotiation, resistance, and identity formation. Composed and published during the height of British colonial rule in India, Gitanjali speaks not only to the soul but also to the political and cultural condition of the colonized Indian subject. In translating his own poems into English, Tagore performs a subtle act of resistance—one that reclaims and redefines the colonizer's language as a medium of Indian expression.

This paper examines Gitanjali as a postcolonial text through three interlinked themes: language, culture, and identity. Drawing from theorists like Homi Bhabha, Edward Said, and Ngũgĩ wa Thiong'o, it explores how Tagore employs English to communicate Indian cultural and spiritual values, how his hybrid identity shapes the voice of the poems, and how Gitanjali acts as a subtle but powerful counter-narrative to colonial discourses.

Language as Resistance and Reclamation

Language has long been recognized as a key instrument of colonial domination. Through education systems and administrative structures, colonial powers imposed their languages on subject populations, marginalizing indigenous languages and worldviews. In India, English became the language of governance and prestige, separating the colonized elite from the masses. However, for writers like Tagore, English was

also a potential weapon—a means to speak back to power, to transcend borders, and to participate in the global literary sphere.

Tagore's translation of Gitanjali into English must be viewed in this light. While some critics have seen his English version as a concession to Western tastes, a closer reading reveals a different picture. Tagore does not imitate British idiom; instead, he transforms English to carry the cadence and mysticism of Bengali thought. His style is lyrical, often archaic, evoking both the sacred tone of the Upanishads and the intimate devotion of Bhakti poetry. By doing so, he asserts the legitimacy of Indian spiritual and poetic traditions in the very language that symbolized colonial authority.

This act of translation is more than linguistic. It is a cultural and political act. As Ngũgĩ wa Thiong'o writes in Decolonising the Mind, "language carries culture, and culture carries... the entire body of values by which we perceive ourselves and our place in the world." Tagore's English Gitanjali carries the spirit of India into the Western literary canon, challenging the idea that only Western languages can express "universal" truths.

Furthermore, Tagore's self-translation can be read as a form of agency and autonomy. Rather than relying on Western translators, he retained control over the representation of his work. This ensured that his poems retained their philosophical essence, even as their form changed. In this way, Tagore disrupts the colonial hierarchy of knowledge and asserts his voice as an equal participant in global literary dialogue.

Translation and the Postcolonial Dilemma

Translation, especially under colonial conditions, is a fraught enterprise. On one hand, it enables cross-cultural exchange; on the other, it risks distortion and appropriation. As Gayatri Spivak warns, translation can become an act of "rewriting," where the original text is adapted to meet the ideological needs of the dominant culture. This is especially true when the translator is external to the source culture. Tagore, however, complicates this binary by acting as both author and translator.

In the case of Gitanjali, Tagore was aware of his Western readership. He selectively translated and even slightly modified some poems to appeal to the sensibilities of a global audience. Yet this does not necessarily imply a loss of authenticity. Instead, it reflects a sophisticated understanding of how to mediate cultural meaning across linguistic and ideological divides.

Indeed, by translating his poems himself, Tagore preserved the philosophical integrity of his work. He ensured that key themes—such as surrender to the divine, the sanctity of nature, and the universality of human longing—remained central. In doing so, he subverted the expectation that Indian literature must be exotic, ornamental, or simplistic. He presented India not as a mystical "Other" but as a civilization with profound insights into human existence.

This strategic use of translation allowed Tagore to challenge colonial narratives from within. As Homi Bhabha suggests, the colonized subject can "mimic" the colonizer's language and discourse in a way that subtly destabilizes its authority. Tagore's English poems resemble the structure and decorum of Western lyrical poetry, but they infuse it with Indian spiritual philosophy, thus transforming the genre itself.

Cultural Identity and Hybrid Subjectivity

Tagore's identity, like his work, was hybrid. Born into a progressive Bengali family deeply involved in both the Indian renaissance and nationalist movement, Tagore was educated in both Sanskrit traditions and British literature. He studied briefly in England, interacted with European intellectuals, and was well-versed in

Romantic and Victorian poetry. Yet he remained deeply rooted in Indian cultural traditions—particularly the Bhakti movement, the Upanishads, and Vaishnava devotionalism.

This hybridity is not a weakness but a strength. In Gitanjali, Tagore speaks from a liminal space—not entirely Indian in the traditional sense, nor Western in outlook, but a synthesis of both. His voice is personal and universal, mystical and rational, intimate and philosophical. He brings Indian spiritual insight to the Western literary world, while also redefining Indian identity in terms that resonate globally.

The speaker in Gitanjali frequently invokes God not as a distant omnipotent being but as a close companion present in the labor of the farmer, the rhythm of the river, the silence of the soul. This democratization of the divine is rooted in Indian traditions but articulated in a language that invites global understanding. Such expressions of identity challenge the colonial notion that Indians were spiritually rich but intellectually inferior. Tagore proves that Indian thought could be both profound and articulate, emotionally rich and intellectually rigorous.

Bhabha's theory of hybridity helps us understand this dynamic. In colonial societies, identity is often negotiated in the "third space" between tradition and modernity, indigenous and colonial. Gitanjali occupies this space. It is neither a mimicry of Western poetry nor a nostalgic return to pre-colonial forms. It is something new—a hybrid that resists binaries and creates a fresh mode of expression.

Spirituality as Cultural and Political Resistance

While Gitanjali is not overtly political, its spiritual message can be read as a form of cultural resistance. During colonial rule, Indian culture was often dismissed as irrational, regressive, or stagnant. British colonialists justified their presence in India partly on the grounds of a "civilizing mission"—the idea that they were bringing reason and progress to a primitive society.

Tagore subverts this narrative by presenting Indian spirituality not as superstition but as a profound philosophy of life. His poems express a vision of divinity that is embedded in the natural world, in human relationships, and in the inner quest for meaning. This spirituality is inclusive, egalitarian, and deeply humanistic. It stands in contrast to the exploitative and hierarchical ethos of colonial power.

Moreover, the values expressed in Gitanjali—simplicity, humility, compassion, inner freedom—challenge the values of colonial modernity: domination, materialism, and control. Tagore's poetry suggests that true progress lies not in conquering others but in realizing the divine within oneself. This is a radical message in a world structured by colonial violence and economic exploitation.

By spiritualizing the everyday and affirming the dignity of the marginalized, Tagore's work becomes a quiet yet powerful form of resistance. It reminds readers that cultural sovereignty begins with reclaiming the inner world—the world of language, thought, and feeling.

Language as Resistance and Bridge

Language in the colonial context is both a tool of subjugation and a medium of empowerment. Tagore's decision to translate *Gitanjali* into English can be seen not as capitulation to colonial authority but as an assertion of agency. By rearticulating Indian spirituality in the colonizer's language, Tagore challenges the Eurocentric monopoly on literary and spiritual expression. His English is distinct—not mimicking British idiom but imbued with the rhythm and cadence of Bengali thought, forming a unique literary hybridity.

This act of translation is thus both an accommodation and a subtle resistance. While it enabled Tagore to reach a global audience, it also allowed him to smuggle Indian philosophical ideas into Western consciousness,

undermining colonial stereotypes of the "Oriental" as mystic yet irrational. Tagore's language becomes a space where colonizer and colonized encounter each other, not in conflict, but in a dialogic relationship.

The Spiritual and the Political

Although *Gitanjali* is often read as a spiritual text, its postcolonial significance lies in how it reclaims the colonized subject's inner world. The poems' spiritual core serves as a counter-narrative to colonial materialism and rationalism. In the assertion of an Indian mode of thought, feeling, and being, Tagore affirms cultural sovereignty.

This spiritual resistance is subtle but profound. The poems invite the reader to witness the divine in nature, the self, and human relationships—concepts that contrast sharply with the colonial ideology of control, hierarchy, and exploitation. Thus, *Gitanjali* becomes a quiet act of political defiance, offering a vision of freedom that is inner and outer, personal and collective.

Conclusion

Tagore's *Gitanjali*, when read through a postcolonial lens, reveals a complex interplay between language, culture, and identity. The collection exemplifies how a colonized writer can utilize the language of the colonizer to assert indigenous worldviews and challenge hegemonic narratives. Far from being a passive cultural artifact, *Gitanjali* is a dynamic space of negotiation, resistance, and affirmation. It is in this confluence of tradition and modernity, spirituality and politics, that Tagore's enduring relevance lies.

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Studies on the Effect of Extract of *Parthenium hysterophorous* on the Common Household Pest *Periplaneta americana*

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Abstract

The effect of the extract of *Parthenium hysterophorous* on the household pest *Periplaneta americana* were observed. These weed were selected because they grow wild, and are found everywhere, causing nuisance to the farmers. The use of Parthenium for biocontrol, hence the effect of this plant was also observed. The movements of the cockroach after the application of the extracts were observed.

Introduction

Parthenium hysterophorus is a tropical American weed, has invaded most parts of India largely affecting the crop productivity. It appears both in cropland and in wastelands and cannot be is not easily eliminated. Cockroaches are not only a major pest but are vectors of various diseases causing public health hazards. Many organic chemicals are being used as a pesticide which has various side effects and are harmful to environment. The botanical or herbal product obtained from *parthenium* can serve the purpose. To search for a herbal product which will act as an alternative to manage the population of cockroaches, without harming the environment and to find out the sustainable way for controlling spread of *parthenium.*

METERIALS AND METHODS

Plant material and extraction:

The plant was collected from agriculture farms of Baramati, Pune District, India and identified in the laboratory. The plant material was stored in departmental laboratory. The 20 gm of air dried leaves of *Parthenium hysterophorus* were extracted with 200 ml. of alcohol in Soxhelet's apparatus. In order to assess the lethality of *parthenium* extract obtained from Soxhelet's apparatus.

Exposure to cockroach:

Adult cockroaches were acclimatized for a period of 10 days at room temperature. The 20 cockroaches were used for different concentration exposure in two groups. The exposure was given in an area of 171.95 cm2 and observed for four days. Different doses of 1 ml and 1.5 ml were administered for exposure. Number of surviving animals in each group was recorded over a four days period (Fig. 1, 2).

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Fig. 1 control group

Fig. 2 during experimental condition

Result and Discussion

The 20 cockroaches were selected for the toxicity test and both cockroaches divided into two groups. The first group of cockroach was exposed with 1 ml and second group with the 1.5 ml *parthenium* extract. The table 1 and fig. 1, 2 shows the toxicity effect of *parthenium* on the cockroaches.

Groups	Dose	Exposure Time in hrs			
		24 hrs.	48 hrs.	72 hrs.	96hrs.
		Cockroaches died			
Group I	1 ml.	1/10	4/10	4/10	6/10
Group II	1.5 ml.	1/10	5/10	6/10	7/10

Table 1 - The toxicity of different doses concentration given

The alcoholic extract of Parthenium hysterophorus is affecting on the cockroaches and its causes death of cockroach. In four days period, total six cockroaches in first group and seven out of ten cockroaches were dead in second group of exposure (Table 1).

Antifeedant activity was also observed in two different groups of cockroaches separately. In both the cases the cockroaches that did not receive any treatment served as control (Fig. 3).

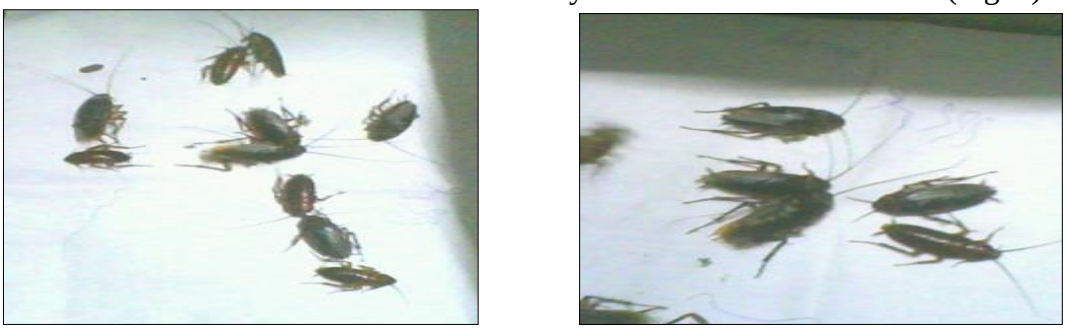

Fig. 3 During Observation period

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Present hydro-meteorological and agricultural trends in Karha Basin, western India

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Abstract:

The Intergovernmental Panel on Climate Change (IPCC) has highlighted that agriculture in the semi-arid regions of South Asia is particularly vulnerable to the adverse effects of climate change. In this context, a scientific understanding of hydro-meteorological and agricultural changes in water-scarce areas is essential for developing effective strategies for water resource management and crop planning under changing climate conditions. This study focuses on the Karha Basin, located in the rain shadow region of the Western Ghats, and aims to identify trends in monsoon rainfall, surface runoff, dam storage, post-monsoon groundwater (PMGW) levels, and agricultural practices. It also includes an analysis of projected trends in monsoon rainfall and average annual temperature. The findings reveal no significant increase in monsoon rainfall over the basin during the historical period (1981–2013). However, a notable decline in monsoon runoff has been observed, primarily due to the effective implementation of surface water harvesting measures. These interventions have led to a significant improvement in post-monsoon groundwater levels. The study also identifies a shift in cropping patterns, with traditional rainfed crops increasingly being replaced by high water-demanding and cash crops. This transition may escalate future agricultural water demand, placing further pressure on the region's already limited water resources. Given that the Karha Basin is already experiencing water scarcity, the combination of human-driven increases in agricultural water use and adverse climatic changes is expected to intensify drought conditions and further complicate water management efforts in the region.

Key words: Groundwater, Temperature, Agricultural crops, Climate change, Trend analysis.

Introduction:

Rainfed agriculture is the primary livelihood in the semi-arid region of Maharashtra, where rainfall is both low (typically under 700 mm during the monsoon) and highly variable (IMD, 2005; Todmal and Kale, 2016). This variability places immense stress on the agrarian economy. Despite localized increases in rainfall near the Western Ghats (Guhathakurta and Saji, 2013); recent decades have shown declining trends in rainfall and stream flow across Madhya Maharashtra (Kale et al., 2014). During this time, a major shift from food grains to high water-demanding cash crops like sugarcane and maize has occurred (Deosthali, 2002; World Bank, 2008), supported by new water storage structures that reduced runoff in the Upper Bhima Basin by 0.78 km³ (Biggs et al., 2007). Due to insufficient surface water, over half the cultivable land depends on groundwater, but unregulated extraction has caused a significant drop in both pre- and post-monsoon groundwater levels (GSDA, 2014).

Climate projections indicate worsening conditions, with rising temperatures (1–1.5°C by 2050) and potential declines in rainfall and water yield in regions like the Krishna Basin (Gosain et al., 2006; TERI, 2014). This could reduce crop productivity and intensify water scarcity, particularly in semi-arid areas (World Bank, 2003). Groundwater models for the Upper Bhima Basin suggest a 6-

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meter decline in water tables over the next 30 years if current extraction continues (Surinaidu et al., 2013). Combined with a shift toward water-intensive crops (Kalamkar, 2011), this trend poses serious challenges for future food and water security. To assess these impacts, the present study analyzes trends in rainfall, runoff, dam storage, groundwater, and cropping patterns in the Karha River Basin, along with future rainfall and temperature projections and their implications for rainfed agriculture.

The Karha Basin:

The Karha River Basin, covering an area of about 1140 km² with a river length of 103 km, is a severely drought-prone region in Maharashtra and forms part of the Krishna Basin as a left-bank tributary of the Nira River. It encompasses parts of Purandar, Baramati, Haveli, and Daund Talukas of Pune District, with over 75% of its area lying in Purandar (Upper Karha) and Baramati (Lower Karha) Talukas. The basin receives 85–95% of its annual rainfall, less than 500 mm, during the monsoon period (June to October), which exhibits high spatial variability (350–750 mm) due to its proximity to the Western Ghats. Since the 1970s, rainfall variability has notably increased, with a bimodal distribution peaking in September (130 mm) and June (110 mm). The Karha River remains mostly dry in the non-monsoon season due to minimal rainfall, resulting in a soil moisture deficit of 800–1100 mm and a high drought frequency (once every three years). To mitigate water scarcity, numerous minor irrigation structures and KT weirs were built in the 1990s, especially in Baramati (4 minor projects and 27 weirs) and Purandar (8 minor projects and 6 weirs). With low surface and sub-surface water availability, drought-resistant crops like sorghum, pearl millet, gram, and pulses dominate (covering 55% of cropped area), while water-intensive crops such as sugarcane, maize, and wheat account for about 12%. A medium-sized dam, Nazare Dam, located near Jejuri Town, has a total capacity of 22.31 MCM and supports irrigation of approximately 3200 hectares. The dam's upstream catchment spans 400 km² (35% of the basin), and its regulation of surface runoff often leaves the downstream Karha River dry, even during monsoon.

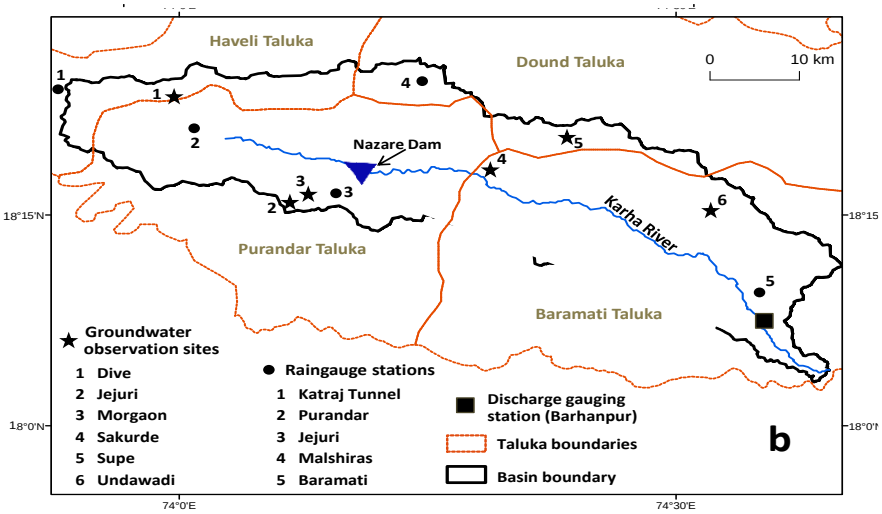

Figure 1 Location map of Karha Basin with rainfall, groundwater and discharge gauging stations

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2. Data and Methodology:

In this study, six types of data were analyzed, including rainfall, stream flow, dam storage, groundwater levels, agricultural crop productivity, and area under principal crops. The daily rainfall and discharge data were obtained from the India Meteorological Department (IMD) and the Hydrological Data Users Group (HDUG), respectively. Among the five selected rain gauge stations, Katraj Tunnel is located outside the basin. Missing rainfall values were estimated using linear regression based on significant relationships with nearby stations. Daily storage and spillway discharge data for Nazare Dam, spanning about three decades, were provided by the Maharashtra State Irrigation Department (IDMS). Annual water availability at the dam was calculated by summing the maximum storage and annual spillway discharge. Groundwater level data, recorded pre- and post-monsoon (May and October) and obtained from the Groundwater Survey and Development Agency (GSDA), also had missing values filled using linear regression, leveraging their strong correlation with monsoon rainfall. To assess agricultural and water resource changes in the semi-arid Karha Basin, the study included both drought-resistant crops (sorghum, pearl millet, gram, pulses, edible oil seeds, pigeon pea) and high water-requiring crops (sugarcane, maize, wheat, onion). Crop area and productivity data for Purandar, Baramati, Haveli, and Daund Talukas (1980–2010) were collected from the Agriculture Department of Maharashtra State (ADMS), with missing data filled by averaging adjacent years.

In the Upper Bhima Basin, including the Karha Basin, about 16% of agricultural area relies on surface irrigation and 21% on monsoon rainfall (Udmale et al., 2014). Due to limited rainfall and surface water, groundwater plays a crucial role in determining agricultural productivity. Rainfed crops like sorghum, gram, pearl millet, and pulses show significant dependence on monsoon rainfall ($r^2 \sim 0.20$) and groundwater (r^2 between 0.28 and 0.37), with sorghum and gram requiring groundwater for post-monsoon cultivation. High rainfall variability increases reliance on groundwater. High water-requiring crops such as wheat and sugarcane are mostly irrigated from perennial surface water, but in summer depend on groundwater, as reflected by their significant, though weaker, correlation with groundwater levels ($r^2 < 0.20$).

Table 1 Details of data used in the present study.

Variables	Selected stations/ crops/ pixels	Length of records	Station/crop name
Monsoon rainfall	5	1970-2013 (43 years)	Katraj Tunnel, Saswad, Jejuri, Malshiras and Baramati
Monsoon discharge	1	1981-2006 (26 years)	Barhanpur
Dam storage	1	1983-2014 (32 years)	Nazare Dam site
Post-monsoon groundwater level	6 (post-monsoon)	1981-2014 (34years)	Dive, Jejuri, Morgaon, Sakurde, Supe, and Undawadi Kadepathar

Agriculture data for four basin covering talukas	8 crops (cropped area)	1980-2010 (30 years)	sorghum, pearl millet, gram, pulses, wheat, sugarcane, maize and onion
	8 crops (productivity)	1980-2014 (35 years)	

Table 2 Coefficient of linear regression (r^2) between hydrological variables and agricultural productivity in the Karha Basin.

Particulars	Irrigated crops		Rainfed crops		
	Wheat	Sugarcane	Sorghum	Gram	Pearl millet
Monsoon rainfall	0.05	0.04	**0.20**	**0.19**	**0.21**
Post-monsoon groundwater level	**0.19**	**0.15**	**0.37**	**0.28**	**0.33**

Numbers in bold indicate statistically significant relationship at 0.05 level

3. Results

3.1 Trends in monsoon runoff, dam storage and groundwater levels

In the semi-arid Karha Basin, where hydrology is largely rain-dependent, a statistically significant declining trend in monsoon runoff is observed at a rate of 6.1 MCM/year (Table 3), consistent with Kale et al. (2014). This decline is not attributed to climatic change, as the Upper Karha Basin (Nazare Dam catchment) shows a non-significant increasing runoff trend, linked to a significant positive shift in monsoon rainfall after 2003, likely driving increased runoff post-2004 (Table 3). Conversely, most dug well sites show a decreasing groundwater trend (i.e., rising water table), with significant post-monsoon groundwater rise at Dive, Jejuri, Morgaon, and Undawadi Kadepathar (Table 3). The average post-monsoon groundwater level across the basin rises significantly at 0.1 meters per year. The majority of stations reflect a step increase in monsoon rainfall and corresponding rise in groundwater levels after 2003, indicating strong rainfall-PMGW linkage. Additionally, the expansion of surface water storage over the past two decades likely contributes to the groundwater rise.

3.2 Trends in agricultural cropped area and productivity

About 75% of the Karha Basin lies in Purandar and Baramati Talukas, and therefore, the trends in agricultural cropped area are presented specifically for these two regions (Table 3). In Purandar Taluka (Upper Karha Basin), rainfed crops show a general declining trend, except for gram. Notably, the area under sorghum and pulses has significantly decreased at annual rates of 892 and 315 hectares, respectively, especially after 1991 and 1997. Pearl millet also shows a decline after 1996, though not statistically significant. In contrast, irrigated crops such as sugarcane, wheat, maize, and onion show increasing trends, with onion and maize rising significantly by 20 to 35 hectares per year. The expansion of irrigated crops, particularly post-1994, reflects a clear shift in cropping practices in the Upper Karha Basin (Table 3).

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Similar patterns are observed in the Lower Karha Basin (Baramati Taluka), where sorghum and pulses exhibit significant declines at rates of 1372 and 235 hectares per year, especially after 1996 (Table 3). Areas under pearl millet and gram also decreased but without statistical significance. In contrast, high-water requiring crops, except onion, have expanded significantly since 1991–1993. The most striking change is in sugarcane cultivation, which increased by 115 hectares annually, likely due to improved water harvesting infrastructure in Baramati. Wheat and maize expanded at rates of 158 and 71 hectares per year, respectively. Similar trends are seen in Haveli and Daund Talukas, covering the remaining 25% of the basin. Overall, there has been a clear shift from drought-resistant to high-water requiring crops over the last two decades, with sorghum showing the most significant reduction, indicating a major change in cropping pattern. These agricultural trends align with the district-level findings of Kalamkar (2011), and productivity trends for both rainfed and irrigated crops show a significant increase, particularly after 1990 (Table 3).

Table 3 Trends in hydrological variables and agricultural crops in the Karha Basin

	Particulars	Trend (b value)	Step-jump year
Monsoon rainfall (in mm)	Baramati	↑	+1994
	Jejuri	↑	+2004*
	Malshiras	↑* (+8.9)	+2003*
	Purandar	↑	+1986*
	Katraj	↑	+2003*
	Karha Basin	↑	+2003
	Dam catchment	↑	+2003*
	Karha Basin runoff	↓*(-6.1)	-1996
	Dam catchment runoff	↑	+2004*
Post-monsoon groundwater levels (in meters)	Dive	↓* (-0.3)	-2004*
	Sakurde	↑	+2000
	Jejuri	↓* (-0.3)	-2003*
	Morgaon	↓* (-0.1)	-2003*
	Supe	↓	-2004*
	Undawadi Kadepathar	↓* (-0.1)	-2003*
	Karha Basin	↓* (-0.1)	-2003*

	Crops	Trend (b value)	Step-jump year
Area under crops in Purandar Taluka	Sorghum	↓* (-892)	-1991*
	Pearl millet	↓	-1996*
	Gram	↑	+1995
	Pulses	↓* (-315)	-1997*
	Wheat	↑	+1987*
	Onion	↑* (34)	+1994*
	Maize	↑* (20)	+1995*
	Sugarcane	↑	+1994*
Area under crops in Baramati Taluka	Sorghum	↓* (-1372)	-1997*
	Pearl millet	↓	-1991*
	Gram	↓	-2001
	Pulses	↓* (-235)	-1996*
	Wheat	↑* (158)	+1990*
	Onion	↑	+1993*
	Maize	↑* (71)	+1991*
	Sugarcane	↑* (115)	+1993*

Increasing trend in groundwater implies fall in water table and vice-versa, b values for cropped area are in hectares. Runoff volume in MCM (million cubic meters).

Conclusion:

The present study provides valuable insights into changes in monsoon rainfall, runoff, groundwater levels, agricultural productivity, and cropping patterns in the water-scarce Karha Basin, located in the drought-prone region of Maharashtra State. While the increasing commercial interest in agriculture has driven the expansion of cash crop cultivation (Kalamkar, 2011), crop productivity in the Karha Basin remains heavily dependent on groundwater and monsoon rainfall. The significant rise in watershed management structures, especially in the lower basin, explains the observed decline in monsoon runoff, leading to a notable increase in the pre-monsoon groundwater table due to effective surface water harvesting. However, in the upper basin, there is considerable scope for further surface water impoundment, which may exacerbate future water shortages for cash crop cultivation in the lower Karha Basin.

Despite no significant increase in monsoon rainfall, cash crop cultivation has expanded considerably, driving up agricultural water demand. Anthropogenic activities, particularly the shift in cropping patterns, are already stressing the limited water resources of the Karha Basin, and future climate changes are likely to compound this challenge. Therefore, effective water resource management under changing climate conditions is critical. Policy measures should mandate and subsidize water-saving agricultural practices, while agronomists can contribute by promoting low-water requiring varieties of cash crops to tackle this agro-climatic challenge.

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Spirituality and Science in Harmony: A Study of Dualism in Dr. A. P. J. Abdul Kalam's *Wings of Fire*

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INTRODUCTION:

Dualism in Indian philosophy is the view that reality is fundamentally composed of two distinct and separate principles.A common understanding of duality is the coexistence of two contrasting ideas, feelings, or things. *Wings of Fire*, the autobiography of Dr. A.P.J. Abdul Kalam, is not merely a chronicle of personal achievements, but a profound narrative that intertwines the realms of science and spirituality. As one of India's most revered scientists and a former President, Dr. Kalam's life stands as a testament to the belief that scientific temper and spiritual depth are not mutually exclusive but can co-exist in a meaningful and productive harmony. This research paper aims to explore the dualism present in *Wings of Fire*, a dualism that bridges practical inquiry with philosophical introspection, modern technology with ancient wisdom, and material progress with inner peace.

Throughout the text, Dr. Kalam reflects on his early influences, particularly the spiritual grounding provided by his father, a devout Muslim and an *imam.* Simultaneously, the narrative follows his evolution into one of India's foremost aerospace scientists, highlighting his involvement in the nation's missile and space programs. These two tracks, spirituality and science appear not as conflicting forces, but as complementary dimensions of his identity. His life suggests that ethical grounding and spiritual insight can enrich scientific innovation, leading to more holistic human development.

The harmony between science and spirituality in *Wings of Fire* also mirrors a broader Indian philosophical tradition, where sages and scientists have historically shared intellectual space. Dr. Kalam draws inspiration from figures like Swami Vivekananda and echoes ideas of universal harmony and divine purpose, even while engaged in highly technical scientific pursuits. This juxtaposition challenges the conventional binary between faith and reason and offers a unique lens through which to view the potential of integrated thinking.

By examining key episodes, quotes, and reflections within *Wings of Fire*, this paper seeks to analyze how Dr. Kalam reconciles the scientific worldview with spiritual values. It argues that his life and work model a balanced approach that is particularly relevant in the modern age, where rapid technological advancement often raises ethical and existential questions. The study ultimately aims to contribute to the discourse on the merging of science and spirituality, using Dr. Kalam's life as a compelling case study.

The connection of science and spirituality has been a subject of increasing scholarly interest, especially in studies exploring the lives of polymaths and thought leaders who operate across domains of rational inquiry and metaphysical belief. In the Indian context, this duality is often viewed not as contradictory but as complementary, a sentiment deeply embedded in the cultural and

philosophical traditions of the subcontinent. Dr. A.P.J. Abdul Kalam's *Wings of Fire* has attracted attention from researchers across disciplines, literary studies, philosophy, education, and leadership, precisely because it exemplifies this combination.

Scholars such as Dr. S. Radhakrishnan and Swami Vivekananda have historically written about the compatibility of scientific thinking and spiritual wisdom in the Indian tradition. The book explores Kalam's writings to argue that spiritual values such as humility, discipline, and devotion directly informed his scientific and administrative work. He says;

> "I wonder why some people tend to see science as something which takes man away from God.As I look at it, the path of science can always wind through the heart. For me, science has always been the path to spiritual enrichment and self-realization."(p.15)

Literary critics have also analyzed *Wings of Fire* from a narrative and thematic perspective. The autobiography functions not only as an inspirational text but also as a philosophical treatise that integrates Kalam's inner spiritual journey with his outer professional accomplishments. Furthermore, educational scholars have pointed out the influence of Kalam's spiritual beliefs, shaped by Islamic Sufism, Vedantic thought, and personal meditation practices on his approach to teaching and mentoring.

While traveling through Rishikesh, Kalam visits Swami Sivananda, a renowned spiritual teacher and founder of the Divine Life Society. In the book, Kalam describes Sivananda as an ascetic radiating peace and wisdom, clothed in a simple white dhoti, and surrounded by an aura of calm. During their conversation, Kalam shares his struggles with scientific work, his anxieties about technological success, and his concerns about the nation's future. Swami Sivananda listens intently and responds with a profound spiritual message: to remain detached from the outcome and to perform one's duties with sincerity and devotion.When Kalam told him about his unsuccessful attempt to join the Indian Air Force, and his long cherished desire to fly, the Swami said:

> "Desire, when it steps from the heart and spirit, when it is pure and intense, possesses awesome electromagnetic energy.This energy is released into ether each night, as the mind falls into the sleep state. Each morning it returns to the conscious state reinforced with the cosmic currents."(p. 25)

This encounter leaves a deep impact on Kalam. It reinforces his belief in the *Bhagavad Gita*'s principle of *Nishkama Karma*, action without attachment to results which he later applies to his scientific projects. Rather than being distracted by potential failure or public scrutiny, Kalam channels his energy into the process, trusting that sincere effort, aligned with moral values, will yield the right outcomes.

What makes this moment significant is that Kalam does not see spiritual wisdom as a substitute for scientific thinking but as a complement to it. The clarity, calmness, and ethical grounding offered by spiritual insight become tools that sharpen his focus, sustain his motivation, and temper his ego. This balance allows him to approach his scientific work with both intellectual precision and inner peace.

Thus, his experience at Swami Sivananda's ashram exemplifies how Kalam integrated inner spiritual discipline with outer scientific excellence, forming the foundation of his leadership style and philosophical outlook.

However, fewer studies have examined this dualism as a deliberate philosophical stance, rather than as a coincidental feature of his upbringing or personality. This paper attempts to fill that

gap by arguing that *Wings of Fire* presents a conscious, reasoned reconciliation of two worldviews that are often seen as mismatched in modern discourse. By analyzing the narrative structure, symbolic motifs, and philosophical reflections in the text, this study adds to the evolving academic conversation on the coexistence of science and spirituality, particularly through the lens of lived experience and autobiographical storytelling.

Dr. A.P.J. Abdul Kalam's early life in the coastal town of Rameswaram played a pivotal role in shaping his integrated worldview of science and spirituality. Born into a devout Muslim family in 1931, Kalam was raised in an environment where faith, simplicity, and discipline were central values. His father, Jainulabdeen, was not formally educated but was deeply spiritual, known in the community for his wisdom, generosity, and regular engagement in religious practices. His quiet strength and unwavering faith in God had a profound impact on Kalam, instilling in him a sense of humility, inner calm, and reverence for the divine. Kalam mentions:

> "The famous Shiva temple, which made Rameswaram so sacred to pilgrims, was about a ten minute walk from our house…There was a very old mosque in our locality where my father would take me for evening prayers. I had not the faintest idea of the meaning of the Arabic prayers chanted, but I was totally convinced that they reached God."(p. 4)

Thus, Kalam's early exposure to pluralistic traditions, growing up in close proximity to Hindu temples and Christian churches, fostered in him a deep respect for all religions and a belief in the unity of spiritual thought. His parents were widely regarded as an ideal couple. His mother, Ashiamma, was equally influential, nurturing his curiosity and providing a stable, emotionally supportive environment. This familial backdrop of faith, tolerance, and moral strength became the foundation upon which Kalam later built his scientific career. Rather than being in conflict, his religious upbringing encouraged reflection, discipline, and ethical responsibility, qualities that seamlessly complemented his later life as a scientist and leader. Once his father told him:

> "…Every human being is a specific element within the whole of the manifest divine Being. So why be afraid of difficulties, sufferings and problems? When troubles come, try to understand the relevance of your sufferings. Adversity always presents opportunities for introspections."(p. 5)

Throughout *Wings of Fire*, Dr. A.P.J. Abdul Kalam reflects on experiences that highlight the synthesis of spiritual conviction and scientific rigor in his life. One of the earliest examples appears in his recollection of his father's morning prayers and quiet reflection by the seashore. Kalam writes about the profound calm he felt in those moments, observing his father's faith not as blind belief but as disciplined spiritual practice. This sense of inner stillness, he notes, became a vital tool during stressful phases of his scientific career, particularly in high-pressure projects like the SLV-3 launch.One of the most significant episodes in *Wings of Fire* that reveals Dr. Kalam's inner stillness and spiritual grounding is his leadership role in the SLV-3 (Satellite Launch Vehicle-3) project. This mission marked a major milestone in India's space program and was a defining moment in Kalam's career as a scientist. The challenges he faced, technical failures, administrative pressures, and national expectations, created an environment of immense stress. Yet, Kalam's ability to remain composed focused, and strong under pressure reveals the spiritual discipline that supported his scientific rigor. He says:

> "I wanted to throw all my being into the creation of the SLV. I felt as if I have discovered the path I was meant to follow, God's mission for me and my purpose on His earth."(p.89)

Kalam openly discusses the initial failure of the SLV-3 in 1979, an event that brought not only public embarrassment but also personal disappointment. However, instead of succumbing to frustration or blame, he chose to reflect inward, drawing strength from his spiritual practices and philosophical readings. He refers to concepts from the ***Bhagavad Gita***, especially the idea of **"***Karmanyevadhikaraste***"**-perform your duty without attachment to results, as guiding principles that helped him maintain steadiness in moments of crisis.

In *Wings of Fire*, Kalam credits this mindset for helping him and his team recover emotionally and intellectually to ensure the successful launch of SLV-3 in 1980. His calm leadership not only inspired confidence in his colleagues but also reinforced a culture of accountability and learning. Rather than viewing setbacks as failures, he interpreted them as steps toward growth, an approach deeply influenced by his inner spiritual training.

This blend of technical perseverance and spiritual composure became a hallmark of Kalam's professional ethos. The SLV-3 episode exemplifies how inner stillness cultivated through prayer, meditation, and philosophical reflection served as a stabilizing force in his scientific journey, enabling him to lead with clarity, humility, and resilience.

Another key passage occurs during his time at the Indian Space Research Organization (ISRO), when a major project faced delays and public criticism. In *Wings of Fire*, Dr. A.P.J. Abdul Kalam offers a detailed and deeply personal account of his journey through India's premier defense and space institutions, ISRO (Indian Space Research Organization) and DRDO (Defence Research and Development Organization). His impressions of these institutions are shaped not merely by professional milestones but by a broader vision of national service, technological self-reliance, and ethical leadership.

At **ISRO**, where Kalam played a pivotal role in the launch of India's first Satellite Launch Vehicle (SLV-3), he describes an environment of intellectual rigor, collective teamwork, and patriotic purpose. He holds deep admiration for visionary leaders like Dr. Vikram Sarabhai, who emphasized both innovation and human values. Kalam reflects on how ISRO functioned as a crucible of both science and national idealism, where young engineers were encouraged to take risks and dream big for India. His experience at ISRO profoundly shaped his belief that scientific research must be directed toward societal benefit.

At DRDO, Kalam's role became more complex, involving leadership over defense technology projects like missile development under the Integrated Guided Missile Development Programme (IGMDP). He encountered bureaucratic challenges and systemic inactivity, but he also found opportunities to demonstrate resilience, innovation, and team-building. He shares both frustrations and triumphs, particularly the successful development of missiles like *Agni* and *Prithvi*as steps toward India's strategic autonomy.

What stands out in Kalam's narrative is his consistent commitment to combining scientific excellence with ethical responsibility. Whether navigating the technical intricacies at ISRO or the defense imperatives at DRDO**,** Kalam remained grounded in values of humility, national pride, and spiritual clarity. His impressions of both organizations are not limited to infrastructure or technology, but include a deep appreciation for the people and principles that guided them. He says:

> "What if we did not have the technological might of the Western countries, we knew we had to attain that might, and this determination was our driving force."(p.113)

This quote reflects Kalam's belief in self-reliance and national determination. Lacking the technological advantages of the West, India's scientists were driven by purpose and resolve, turning limitation into motivation to achieve indigenous innovation and global respect through persistent effort.

Perhaps, most revealing is Kalam's description of his interactions with spiritual leaders like Pramukh Swami Maharaj and his admiration for Swami Vivekananda. These relationships were not ornamental; they deeply influenced his thoughts on ethics, purpose, and national development. Such moments in *Wings of Fire* reveal that, for Kalam, spirituality was not a retreat from scientific reasoning but a source of resilience, vision, and moral clarity. They offer compelling evidence of how deeply intertwined these two dimensions were in his life and legacy.

CONCLUSION:

Dr. A.P.J. Abdul Kalam's *Wings of Fire* stands as a powerful testament to the harmonious coexistence of science and spirituality in a world often divided between the two. Through his life experiences, from his humble beginnings in Rameswaram to his leadership in India's space and defense programs, Kalam demonstrates that scientific achievement need not come at the cost of spiritual depth. On the contrary, his inner stillness, rooted in religious tolerance, meditation, and ethical grounding, became the very force that sustained his scientific vision through trials and setbacks.

This dualism, where the logical and the metaphysical, the empirical and the intuitive, exist in balance, offers a model of integrated thinking that is increasingly relevant in today's complex and fragmented world. Kalam's reflections, particularly his reverence for the *Bhagavad Gita, Quran,* and his encounters with spiritual leaders like Swami Sivananda, reveal that spiritual conviction can deepen one's sense of purpose in scientific pursuits.

In *Wings of Fire*, science is not stripped of soul, and spirituality is not devoid of reason. Instead, the two operate in a dynamic interplay that enriches both the individual and the society he serves. Kalam championed an **integrated approach**, which acts as a solution to this dualism by bridging the gap between the spiritual and scientific, and advocating for a holistic worldview that unifies these seemingly disparate fields.

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Phytochemical Characterization of Pharmacologically Important Bioactive Compounds of *Artemisia pallens* Wall from Shikhar Shingnapur of Satara District

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Abstract:

The present study investigates the phytochemical composition of *Artemisia pallens* Wall collected from Shikhar Shingnapur, Satara District, Maharashtra, using advanced analytical techniques. A total of 55 bioactivecompounds were identified, belonging to five major groups: sesquiterpenes, monoterpenes, phenolics, flavonoids and terpenoids. Sesquiterpenes were the dominant constituents, with davanone, cis-davanone, trans-davanone, davana ether and hydroxy davanone showing the highest peak intensities. GC–MS analysis confirmed davanone as the major compound, supporting its known antimicrobial, antioxidant and fragrance-related properties. Monoterpenes such as linalool, α-pinene, β-pinene, limonene and borneol further enhanced the aromatic and therapeutic profile of the plant. In addition, the detection of phenolic acids (caffeic, ferulic, vanillic acid), flavonoids (quercetin, kaempferol, luteolin, rutin) and terpenoids/sterols (phytol, squalene, stigmasterol, β-sitosterol) indicated strong antioxidant, anti-inflammatory, cardioprotective and antimicrobial activities. These findings demonstrate that *A. pallens* is a rich source of pharmacologically valuable phytochemicals and highlight its potential applications in medicine, aromatherapy, natural antioxidants and the perfumery industry.

Keywords: *A. pallens*, phytochemical analysis, GC–MS, sesquiterpenes, davanone, monoterpenes, phenolic compounds, flavonoids, terpenoids, essential oils and bioactive compounds.

Introduction:

Artemisia pallens Wall commonly known as Davana, is an aromatic medicinal herb belonging to the family Asteraceae. It has long been used in traditional Indian medicinal systems for ailments such as diabetes, respiratory infections, hypertension, wounds and general debility (Rasal *et al.,* 2016). The essential oil of *A. pallens*, known as davana oil, is widely used in perfumery and flavoring industries due to its distinctive fragrance and therapeutic properties (Rasal *et al.,* 2016).

Phytochemical studies have shown that *A. pallens* contains a diverse range of secondary metabolites, including phenolics, flavonoids, tannins and terpenoids, which contribute to its pharmacological activities (Sunkara *et al.,* 2018). Essential oil components such as davanone, linalool and various sesquiterpenes vary significantly based on plant part, maturity stage and extraction method (Rao *et al.,* 1999).

Recent research highlights the strong antioxidant, antimicrobial, antidiabetic, anthelmintic, and anti-inflammatory potential of *A. pallens* extracts (Srinivasan *et al.*, 2025). A 2025 phytochemical investigation found high phenolic and flavonoid levels correlating with strong antioxidant potential (Karthik*et al.,* 2025). Similarly, Srinivasan *et al.* (2025) demonstrated significant anthelmintic activity of ethanolic extracts, supporting traditional medicinal use.

The identification of novel pharmacologically important metabolites both volatile and non-volatile requires advanced analytical techniques such as GC–MS, HPLC, FTIR and UV–Vis spectroscopy (Bhadauria, 2021). Comprehensive chemical characterization with biological evaluation is essential to validate its therapeutic potential and support future drug-development initiatives. Thus, the present study aims to conduct a systematic phytochemical investigation of *Artemisia pallens* using modern analytical tools and to identify pharmacologically important metabolites responsible for its medicinal value. This study will contribute to establishing a scientific basis for the therapeutic applications of *A. pallens*.

Material and Methods:

Plant material of *Artemisia pallens* Wall was collected from Shikhar Shingnapur, Satara District, Maharashtra, during the flowering season to ensure maximum phytochemical content. The site's geographical features such as altitude, temperature and soil type were recorded.

The collected plant material was initially washed thoroughly under running tap water followed by rinsing with distilled water to remove dust and contaminants. The material was shade-dried at room temperature (25–28^{0}C) for 10-12 days to prevent degradation of thermolabile compounds by Harborne (1998). The dried material was powdered using grinder and stored in airtight amber bottles to avoid photodegradation.

Extraction of phytochemicals was carried out using the Soxhlet extraction method, which is widely employed for the efficient recovery of plant secondary metabolites (Sasidharan*et al.*, 2011). Approximately 50g of powdered plant material was sequentially extracted using solvents of increasing polarityhexane, chloroform, ethyl acetate, methanol and water. Each extraction was performed for 6-8 hours until the siphon became colorless. The extracts were concentrated using a rotary evaporator

under reduced pressure at temperatures below 45^0C and stored at 4^0C for further analyses.

Preliminary phytochemical screening of various extracts was performed using qualitative chemical tests described by Harborne (1998) and Trease & Evans (2002). These tests were used to detect major classes of phytoconstituents, including alkaloids, flavonoids, phenolics, tannins, terpenoids, glycosides, steroids and saponins. The presence or absence of these compounds was recorded based on the visual characteristics of color formation, precipitation or foam stability.

Identification of bioactive compounds, Gas Chromatography-Mass Spectrometry (GC-MS) analysis was performed following the method outlined by Adams (2007). A GC–MS system equipped with an HP-5MS capillary column was used, with helium as the carrier gas. The injection port was maintained at 250^0C, and the oven temperature was programmed from 60^0C to 280°C at a rate of 10^0C/min. The compounds were identified based on retention times and comparison of their mass spectra with NIST and Wiley libraries.

Results and Discussion:

The phytochemical analysis of *Artemisia pallens* showed that the plant contains 55 bioactive compounds belonging to five major groups: sesquiterpenes**,** monoterpenes, phenolics, flavonoids, and terpenoids**.** Among these, sesquiterpenes were found in the highest amount. Important compounds like davanone, cis-davanone, trans-davanone, davana ether and hydroxy davanone showed strong peaks. Davanone was the major compound and is well knownforits antimicrobial, antioxidant and perfume-related uses**.** Other sesquiterpenessuch asgermacrene D, caryophyllene oxide, β-caryophyllene and eudesmol are linked with anti-inflammatory, antifungal and antibacterial activities (Table-1)**.**

The study also detected many monoterpenes, which appeared between 1.18 and 10.50 minutes during analysis. Compounds like linalool, α-pinene, β-pinene, limonene**,** sabinene and myrcene were found and are commonly used for their fragrance**,** antimicrobial action, and calming effects**.** Oxygenated monoterpenes such as borneol**,** camphor, 1,8-cineole and bornyl acetate added to the medicinal value of the plant, especially in treating respiratory problems, pain and infections**.**

In addition to terpenes, several phenolic compounds, flavonoids and plant sterols were identified. Phenolics like coumarin, caffeic acid, vanillic acid and chlorogenic acid are powerful antioxidants**.** Flavonoids such as quercetin, kaempferol, rutin and luteolin showed strong anticancer, heart-protective and anti-inflammatory properties. Terpenoids and sterols including phytol, squalene, stigmasterol and β-sitosterol further contribute to the plant's health-boosting and antimicrobial potential. Overall, these findings show that *Artemisia pallens* is a rich source of natural

compounds useful in medicine, cosmetics, aromatherapy, and natural antimicrobial products.

Table-1: List of Sesquiterpenes, Monoterpenes, Phenolic, Flavonoids and Terpenoids extracted from *Artemisia pallens*

Sr. No.	Compound	RT	m/z	Applications
1.	Davanone	10.136	319.1889	Perfume industry, antimicrobial, antioxidant
2.	cis-Davanone	4.627	507.52543	Aromatherapy, anti-inflammatory
3.	trans-Davanone	9.095	154.52911	Antioxidant, fragrance
4.	Davana ether	8.199	338.18441	Antifungal, aromatic compound
5.	Hydroxy davanone	3.547	554.569	Antimicrobial, therapeutic applications
6.	Bicyclogermacrene	3.853	710.2424	Anti-inflammatory, insecticidal
7.	Germacrene D	4.459	695.08915	Anticancer, antibacterial
8.	Germacrene A	7.417	149.0164	Anti-inflammatory
9.	β-Caryophyllene	4.858	136.0759	Anti-inflammatory, analgesic, wound healing
10.	Caryophyllene oxide	6.898	373.84246	Antifungal, antioxidant
11.	β-Eudesmol	7.101	819.81092	Sedative, antibacterial
12.	α-Eudesmol	7.111	160.94673	Anti-inflammatory
13.	γ-Eudesmol	10.100	715.2895	Antimicrobial
14.	Spathulenol	1.367	204.1229	Antioxidant
15.	Viridiflorol	7.27	315.2317	Antimicrobial, cytotoxic
16.	α-Copaene	3.573	218.1382	Antioxidant, fragrance
17.	α-Bisabolol	8.215	221.1532	Anti-inflammatory, skin-healing
18.	β-Bisabolene	5.486	260.1858	Antitumor, antimicrobial
19.	α-Humulene	3.456	986.6307	Anti-inflammatory
20.	δ-Cadinene	9.365	122.3273	Antifungal, antioxidant
Monoterpenes				
21.	Linalool	1.507	118.0862	Antimicrobial, sedative
22.	α-Pinene	1.186	130.0865	Bronchodilator, antimicrobial
23.	β-Pinene	1.185	147.1129	Anti-inflammatory
24.	Myrcene	10.509	284.2949	Antioxidant, analgesic
25.	Sabinene	1.43	170.0925	Antimicrobial
26.	Limonene	5.167	229.1542	Anticancer, fragrance
27.	Camphene	6.614	354.8457	Antioxidant
28.	α-Terpinene	6.911	114.5575	Antioxidant
29.	γ-Terpinene	7.27	119.75610	Antifungal
30.	Terpinolene	7.334	219.77115	Antioxidant
31.	1,8-Cineole	7.732	567.2036	Expectorant, antimicrobial
32.	Camphor	7.976	842.18177	Analgesic, anti-inflammatory

33.	Borneol	8.148	275.77680	Antimicrobial
34.	Bornyl acetate	8.208	260.3203	Analgesic, aromatic
35.	Geraniol	8.215	148.6650	Antimicrobial
36.	Citronellol	9.042	577.6056	Mosquito repellent
37.	Nerol	9.212	320.2521	Antifungal
38.	Geranyl acetate	9.465	600.4047	Antimicrobial
Phenolics				
39.	Coumarin	9.465	600.4047	Anticoagulant, antimicrobial
40.	Caffeic acid	9.484	788.0433	Antioxidant
41.	Ferulic acid	9.792	238.4490	UV-protective, anti-inflammatory
42.	Vanillic acid	4.071	159.57379	Antioxidant
43.	Syringic acid	4.076	748.3363	Anti-inflammatory
44.	Chlorogenic acid	6.785	830.1766	Antidiabetic, antioxidant
Flavonoids				
45.	Quercetin	5.241	360.1717	Antioxidant, anticancer
46.	Kaempferol	5.356	195.0878	Anti-inflammatory
47.	Luteolin	6.487	317.2111	Antioxidant
48.	Apigenin	4.754	177.1021	Anti-inflammatory
49.	Rutin	5.216	205.0968	Cardioprotective
50.	Hesperidin	7.122	1224580	Anti-inflammatory
Terpenoids				
51.	Phytol	10.343	293.1509	Antioxidant, antimicrobial
52.	Neophytadiene	1.413	189.15929	Anti-inflammatory
53.	Squalene	8.208	291.2312	Antioxidant, anticancer
54.	Stigmasterol	5.293	114.09161	Anticholesterol
55.	β-Sitosterol	3.573	218.13818	Antidiabetic, immune booster

The present study confirmed that *Artemisia pallens* contains a wide range of bioactive secondary metabolites, mainly sesquiterpenes, monoterpenes, phenolic compounds, flavonoids and terpenoids. The dominance of sesquiterpenes particularly davanone and its derivatives is consistent with earlier reports describing *A. pallens* essential oil as rich in davanone-type molecules, which contribute to its characteristic aroma and biological activity (Choudhary *et al.*, 2014).

In our analysis, davanone showed the highest peak intensity, indicating its abundance and supporting its recognized antimicrobial and antioxidant properties (Padalia and Verma, 2011). The presence of compounds such as β-caryophyllene, caryophyllene oxide and germacrene D also reinforces the therapeutic potential of the plant, as these molecules are known for anti-inflammatory, antifungal and cytotoxic activities in numerous medicinal plants (Hernandez *et al.*, 2014).

Monoterpenes identified in the study including linalool, α-pinene, β-pinene, sabinene and limonene further add to the medicinal and aromatic properties of *A. pallens*. These

compounds are commonly reported in many *Artemisia* species and are known for their broad spectrum of pharmacological activities such as antimicrobial, anxiolytic, respiratory relief and antioxidant effects (Khosravi*et al.*, 2019). Oxygenated monoterpenes such as borneol, camphor and 1,8-cineole have been associated with enhanced therapeutic value, particularly in traditional medicine for treating colds, cough and pain (Khan and Abourashed, 2010).

The presence of these compounds in significant quantities suggests that *A. pallens* may offer multifaceted medicinal benefits, supporting its traditional usage in aromatherapy and herbal medicine. In addition to terpenes, the detection of phenolics (e.g., caffeic acid, ferulic acid, vanillic acid) and flavonoids (e.g., quercetin, kaempferol, luteolin, rutin) indicates strong antioxidant potential, which is important in preventing oxidative stress-related diseases. Phenolic acids and flavonoids have been widely documented for their anticancer, cardioprotective, and anti-inflammatory activities (Panche*et al.*, 2016). The identification of terpenoids and sterols such asphytol, squalene, stigmasterol and β-sitosterol further highlights the plant's pharmacological richness, as these compounds possess immune-boosting, hypolipidemic and antimicrobial properties (Dias *et al.*, 2012).

Overall, the diversity and abundance of phytochemicals detected in *A. pallens* strongly support its potential application in pharmaceuticals, cosmetics, natural antimicrobials and perfumery industries. The results align with previous findings and provide a scientific basis for further biological evaluation and formulation development.

Conclusion:

The phytochemical investigation of *Artemisia pallens* revealed a remarkable diversity of bioactive secondary metabolites, with sesquiterpenes particularly davanone and its derivatives present in the highest concentration. The dominance of these compounds aligns with previous studies on *A. pallens* essential oils and confirms their importance in defining the plant's characteristic aroma and therapeutic profile. The identification of several pharmacologically significant monoterpenes, phenolic acids, flavonoids, terpenoids and sterols further highlights the plant's strong antioxidant, anti-inflammatory, antimicrobial and cytoprotective potential. These findings provide scientific evidence supporting the traditional use of *A. pallens* in medicinal, aromatic and cosmetic preparations. The broad spectrum of compounds detected in this study also suggests promising opportunities for developing natural drug formulations, herbal supplements and perfumery products. Overall, *Artemisia pallens* emerges as a valuable medicinal and aromatic plant requiring further exploration for its biological activities and commercial applications.

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Bacteria Based Self-Healing Concrete for Crack Repair

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Abstract:

Concrete is commonly used in construction to handle compression, but it has a low tensile strength which causes cracks to form. These cracks can let in water and chemicals, causing the reinforcement bars to corrode. Fixing these cracks is hard and costly. To prevent them, we can add special bacteria to the concrete that reacts with calcium to create calcium carbonate crystals. This process blocks the cracks in the concrete, and can even seal very small cracks up to 0.15mm. This study provides information on a technique to enhance the strength and durability of present-day concrete by introducing Bacillus pasteurii, a soil bacterium, which, as a byproduct of its metabolic activity, displays bio-calcification. When a carbonate ion is present, the calcium precipitate secreted by the bacterium during the bio-calcification process turns into CaCO3. The concrete's holes are filled with this material., resulting in a more compact texture. As a result, the growth of filler material within the concrete's pores enhances its strength. Concrete cubes and beams that underwent compressive and flexural strength tests with and without the bacterium were compared. The research discovered that after being exposed to loading, the specimens treated with the bacterium showed a notable improvement in strength and crack healing.

Keywords: Bacillus pasteurii, self-healing, bacteria for concrete, concrete.

Introduction:

Bacteria-based self-healing concrete is a type of concrete that has the ability to repair its own cracks. The process involves the use of a specific type of bacteria, called Bacillus bacteria, which is mixed into the concrete during the production process. When a crack occurs in the concrete, water enters and activates the bacteria, causing it to produce limestone that fills the crack and restores the structural integrity of the concrete. This technology has the potential to reduce maintenance costs and increase the lifespan of concrete structures, such as bridges and buildings. However, more research is needed to determine its effectiveness in real-world applications and its long-term durability. The use of bacterial concrete in India is a relatively recent development and its application is still limited. In 2016, researchers at the Indian Institute of Technology (IIT) Delhi developed a bacterial concrete that is capable of self-healing cracks. The researchers used a combination of bacteria and calcium lactate to create the self-healing concrete. Since then, there have been some pilot projects in India that have tested the effectiveness of this technology. For example, in 2019, the Indian Army used bacterial concrete to repair a damaged runway at its airbase in Jaisalmer. This successful project demonstrated the potential benefits of using bacterial concrete in infrastructure projects in India. However, the technology is still in its

early stages of adoption in the country and further research and development is needed to fully realize its potential. The process of bacterial healing is initiated when water penetrates a crack in concrete, which may initially be a tiny fissure that serves as a trigger for the bacteria to start working. Self-healing concrete can use a few different types of bacteria, such as Bacillus Pseudofirmus, Bacillus Cohnii, and Bacillus Sphaericus. These bacteria are inserted into the concrete matrix in spores or small round capsules that contain calcium lactate, which serves as a nutrient source for the bacteria when they become active. The bacteria are capable of surviving in the concrete matrix for more than 200 years and can be reactivated if the healed area experiences further cracking. If the concrete cracks, the capsules rupture, and water enter, this activates the bacteria.

Self-healing bacterial concrete is a novel technology that has been developed to enhance the durability and longevity of concrete structures. The application of self- healing bacterial concrete in India can be beneficial in several ways, including:

1. Infrastructure development: India is currently investing heavily in infrastructure development, with a focus on building highways, bridges, and airports. Self-healing concrete can be used to build these structures, making them more durable and reducing maintenance costs over time.
2. Water storage tanks: Self-healing concrete can be used to build water storage tanks that are resistant to cracking and leaks, ensuring the safety and reliability of the water supply.
3. Industrial flooring: Self-healing concrete can be used to build industrial flooring that is resistant to damage caused by heavy machinery and equipment.
4. Heritage conservation: India has a rich cultural heritage, and many historical monuments and buildings are in need of repair and restoration. Self-healing concrete can be used to repair and restore these structures, ensuring their preservation for future generations.

Problem Statement:

Conventional concrete structures are prone to cracking and damage over time, which can lead to costly repairs and reduced durability. These cracks can also compromise the structural integrity of the building, leading to safety concerns. Current repair methods often involve significant time and expense, resulting in lengthy downtimes and inconvenience. The use of self-healing bacterial concrete aims to address these problems by incorporating bacteria that can grow and repair the concrete on its own, reducing the need for costly and time-consuming repairs while increasing the durability and safety of the structure. However, there are still challenges that need to be addressed, such as optimizing the bacterial mixture for different applications, ensuring the long-term effectiveness of the healing process, and addressing any potential safety and environmental concerns related to the use of bacteria in construction materials.

Aim and Objectives:

1. The focus of this investigation was on the autogenously self-healing of cementitious materials. The effectiveness of this process has been a subject of concern due to the lack of a confirmed and fully comprehended governing mechanism. Consequently, the study had three primary goals:
2. To gain an understanding of the mechanisms responsible for the autogenous self-healing of concrete.
3. To develop a cementitious material or a set of materials with a specific chemical composition that can self-repair both internally and externally in specific environmental conditions.
4. To study the effect of bacterial concrete on the strength parameters.

1. **Methodology:**
   - Opening Section
   - Examination of Existing Research
   - Identifying Research Void
   - Work Objectives
   - Bacterial Cultivation for Concrete
   - Evaluation of Concrete Materials
   - Concrete Design Utilizing Various Bacterial Strains
   - Establishing the Optimal Dosage for Self-Healing Bacterial Concrete
   - Analysis and Discussion of Findings
   - Closing Remarks
2. **Materials used and mix proportions:** The different materials used in this investigation are
3. **Cement:**

The investigation employs 53-grade Ordinary Portland cement, which can be found in the nearby market. The cement used for all experiments comes from a single batch. The cement has undergone several tests in accordance with IS: 4031-1988 to evaluate its various properties, and it has been determined that it meets the various specifications outlined in IS: 12269-1987.The cement had a specific gravity of 3.15 and a specific surface area of 225 m^2/g, with an initial setting time of 150 minutes and a final setting time of 250 minutes.

4. **Fine aggregate:**

We use fine aggregate that conforms to Zone-I according to IS: 383-2016.It has a specific gravity of 2.60 and a bulk density of 1.45 g/cc.

5. **Coarse aggregate:**

In this study, crushed angular aggregates from a nearby quarry are utilized as the coarse aggregate. The coarse aggregate is meticulously cleaned and subjected to several tests, including specific gravity, fineness modulus, bulk modulus, among others, in accordance with the IS: 2386-1963 and IS 383:2016 standards to determine its physical characteristics.

6. Bacteria:

Bacteria are uncomplicated unicellular life forms. In this study, Bacillus pasteurii was utilized, which has the unique capacity to induce calcium carbonate precipitation when exposed to any carbonate source. This bacterium was chosen to enhance the strength of concrete test samples, and its utilization resulted in improved specimen durability. The species of bacteria employed in this research belong to the Bacillus genus. Through inorganic crystal precipitation, these microbes promote the self- healing of concrete cracks, enabling it to endure various temperature conditions.

7. Mix proportions:

The aim of this study is to assess the impact of incorporating the ideal bacterial concentration on the compressive strength and split tensile strength of standard-grade concrete (M20). A total of twelve sets of concrete cubes measuring 150mm x 150mm x 150mm are prepared, and their compressive strength is examined under axial compression at intervals of 7, 14, and 28 days. Following the 28-day period, an additional nine sets of cylindrical specimens are created and analyzed for their split tensile strength.

8. Results and Conclusion:

Concrete specimens were subjected to testing in accordance with IS: 516-1956. To examine the compressive strength and split tensile strength of concrete, an investigation was conducted. Table 1 presents the data for the ordinary grade concrete's compressive strength at 7, 14, and 28 days.

Table 1 shows the impact of adding bacteria to ordinary (M20) grade concrete.

Effect of the Bacteria Addition on Ordinary (M20) Grade Concrete

Age	Compressive Strength	
(No. of days)	Conventional Concrete, MPa	Bacterial Concrete, MPa
7	14.5	16
14	17	19.5
28	25.5	27.6

Table 2 shows how adding bacteria affects the strength of concrete of average grade in terms of splitting tensile.Table

Age (No. of days)	Split Tensile Strength	
	Conventional Concrete, MPa	Bacterial Concrete, MPa
28	4.45	5.75

Conclusion:

The compressive strength of ordinary grade concrete at 7, 14, and 28 days is shown in Table

1. The findings show that the addition of bacteria significantly increased the compressive strength of concrete, especially at day 28, when the improvement was 4.24%. As concrete ages, its compressive strength changes by a range of 7.60% to 4.24%.
The Split Tensile Strength of typical cylindrical specimens of ordinary-grade concrete at 28 days is shown in Table 2. The results show that the addition of bacteria significantly increased the tensile strength, especially at day 28, when the increase was29%.

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A Real-Time Control and Operating System of UnmannedAerial Vehicles (UAV)

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Abstract:

This article is a study of the research of remotely piloted drones and unmanned aerial vehicles (UAVs). In order to guarantee that activities are done in the allotted amount of time, real-time control systems create more deterministic responses. Drones today have higher expectations for functionality; hence this system characteristic is greatly sought after. The reviewed materials were chosen with the real-time operation of drones and the incorporation of technology utilized in diverse drone applications in mind. The development of highly agile unmanned aerial vehicles (UAVs) has allowed for their use in a variety of fields, including surveillance, aerial navigation, military operations, agriculture, and more. However, there are a number of difficulties associated with the control of these highly agile unmanned vehicles. In an effort to enhance drone efficiency, this article will examine the real-time nature of control and the use of Real-Time Flight Control Systems (RTFCS).

Keywords: Unmanned aerial vehicles, Drones, Real-time operating system, Global positioning system, inertial measurement unit.

Introduction:

A drone, or UAV, is a form of aircraft that does not require a human pilot to fly it [1]. Micro Electro-Mechanically (MEMS) sensors, High-Energy Lithium Polymer (LiPo) batteries, Microprocessors, and more compact and efficient actuators have all contributed to the exponential expansion of unmanned aerial vehicles (drones) during the past few decades [2]. They have a wide range of applications, from monitoring pipelines and power lines to fighting in the military to farming to delivering medicine to remote locations to charting the skies [3]. The literature [4] extensively discusses how the changeable dynamics of the robotic arm add difficulty to the control of UAVs. UAV use is on the rise, and UAV solutions are being developed at a breakneck pace to meet the ever-expanding list of possible applications [5]. The drone's features are determined by the commercial market's level of competition and the UAV's intended use [6]. Recent UAV uses in the cryo-sphere were analyzed. Unlike conventional space-based systems [7].

Controller Mechanism

Drones and other UAVs require an accurate and dependable controller to maintain altitude speed and heading [8]. By isolating the sub-synchronous component of the measured signal's voltage and current, [9] network noise can be reduced. The UAV is controlled by the altitude controller during takeoff and landing so that it maintains a set altitude. Controlling the UAV's heading and velocity can fly between waypoints [10]. Fuzzy logic, sliding mode, proportional integral derivative, linear quadratic regulator, neural network, etc.
[11] is only some of the control systems that can be employed to suit the control needs. Parametric uncertainty and external interference are two of the main challenges that control systems have been developed to address. Uncertainties in propeller rotation, blade flapping, speed changes, and the placement of the center of mass necessitate a dependable nonlinear controller for multi-rotor UAVs [12]. A combination of the Non-Linear Sliding-Mode Control, a robust Back-stepping controller, and a Non-Linear Disturbance Observer (NDO) were used to achieve both robustness and compensation for system non-uniformities. The SMC controls the quad rotor‘s rotation, while the back-stepping controller keeps the translational motion stable [13].

UAV real-time control implementation:

Before real-time control capabilities for UAVs can be implemented, however, tasks must be established. For the purposes of task scheduling, inter-task communication, and resource management (including memory and power consumption), an RTOS is required [14]. The stack in the microprocessor is where the data for each job is stored. The multi-threading functionality in the RTOS kernel is responsible for this. Tasks are scheduled and prioritized, and sensors that provide data for tasks are routinely updated [15] to guarantee that application time limitations are met. We also test the battery cells for fault tolerance in both battery drive and hybrid driving using a GCU battery [16]. Quad-copters use RT-Thread, an embedded real-time operating system, to address problems with latency, heavy processing loads, and command and control. Using a PID control algorithm [17], the RT-Thread control system responded instantly in real-world tests to ensure a stable flight of the quad-copter. Obtaining attitude data, fusing attitude data, and PID control are the application-based tasks in this work. The primary purpose of this program is to manage quad-copters. The RT-Processing Operating System (RT-Thread) serves as its foundation; it is run by a similar type of microprocessor to that found in the quad copter [18]. This CPU has a high-performance ARMC Cortex-M4 core, 1 MB of Flash memory, a Floating-Point Unit (FPU), 168 MHz of maximum system frequency (MHz), and 192 MB of static random-access memory. The Controller-Area Network (CAN) bus and Direct Memory Access (DMA) are among the many peripherals it supports [19]. The quad-copter has a high operating frequency and a large memory, providing it with a high level of computational capability that enables it to do complex calculations. Surplus peripherals can be used to lessen the computational burden on the microprocessor and remove the need for external integrated circuits [20]. The system implementation makes use of a cluster of two

processors. The bespoke quad-copter used in this experiment is controlled by two processors, one of which handles telemetry. Data collecting from sensors, data transmission to the General Communication System (GCS), and reconfiguration and tracking data transmission via GPS are all software activities performed by the telemetry part of the system [21]. A real-time operating system (RTOS) manages the tasks, and C /OS-IITM makes it happen.

PID Controller:

The control processor, as depicted in Figure 1, runs the PID controller algorithm to stabilize and guide the quad copter. Several jobs were assigned to the control processor, which allowed this to be completed [22]. The following diagrams depict the PID controllers actually put into practice. Implementing the Yaw, Roll, Pitch, and Altitude PID control loops, as well as interpreting data from the GPS, compass, IMU, altitude sensor, and telemetry processor, are all part of the tasks at hand. The CAN bus [23] also relays reconfiguration and monitoring data to the telemetry processor. For the equation describing the relationship between the PID controller's feedback error and the resulting time- domain control signal for the plant, see below.

$$ut = Kpet + Kie \int etdt + Kddedt \qquad (1)$$

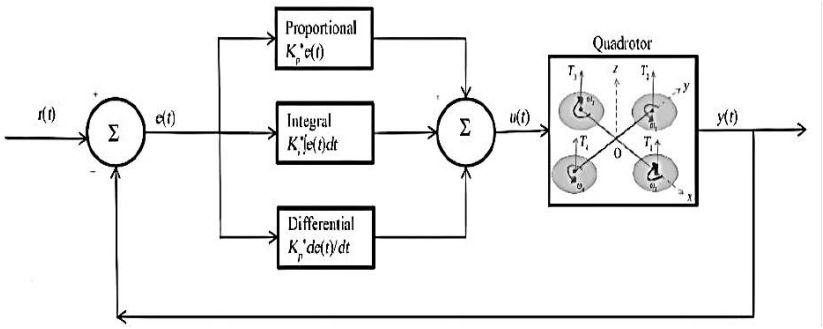

Fig. 1. Block diagram of PID controller for Quad-rotor

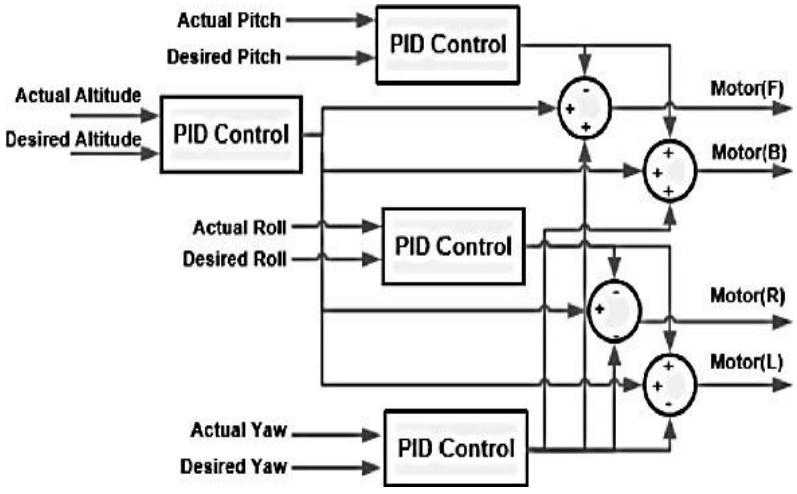

Fig. 2 The control processor loops of PID control

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Linear-Quadratic-Gauge (LQR) Technique

Figure 3 when the linear-quadratic-gauge (LQR) method is combined with the linear-qe and the Kalman filter; it becomes the linear-quadratic-Gaussian method. This method works for systems with both complete and incomplete state information and Gaussian noise. Integral action was used to steady the CA's inclination during hover mode, and the results were good. The integrated LQG controllers have the benefit of not requiring complete state information for implementation [24]. Integrator output, which is the difference between system input and output as a dynamic system, refers to equation (2) [25], and isthe result of adding the integrator and inserting error status (e).

$$x^{\cdot} = Dx+Euy = Gxu = -K'x+kI'ee = r-y = r-Gx \quad (2)$$

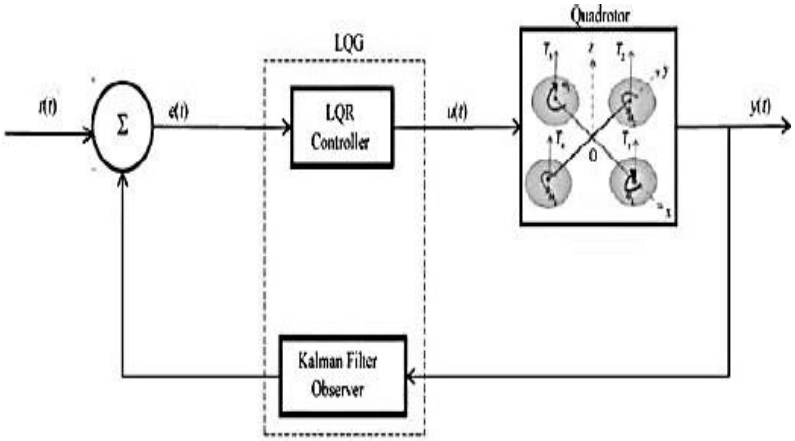

Fig. 3. Block diagram of LQG controller for Quad-rotor

Fuzzy Logic and Artificial Neural Networks controller

Figure 4 demonstrate that in both scenarios, there was convergence in both airspeed and yaw angle [26]. In addition to injecting current and voltage components, sub-synchronized frequency component current is injected into the line to promote network damping. The measured system signal is broken down into the current and voltage components of a sub-synchronized component. [27] Feedback-linearized control was compared to sliding mode control (SMC) with a flexible control mode.

The feedback controller was extremely vulnerable to sensor noise and lacked robustness even when the dynamics were simplified. The SMC worked admirably under harsh environmental circumstances, and its flexibility allowed for precise prediction of uncertainty (including ground effect). A nonlinear, feedback-linearized technique for control offers high tracking but poor disturbance rejection as a result. Good outcomes can be attained when a less noise-sensitive strategy is also used.

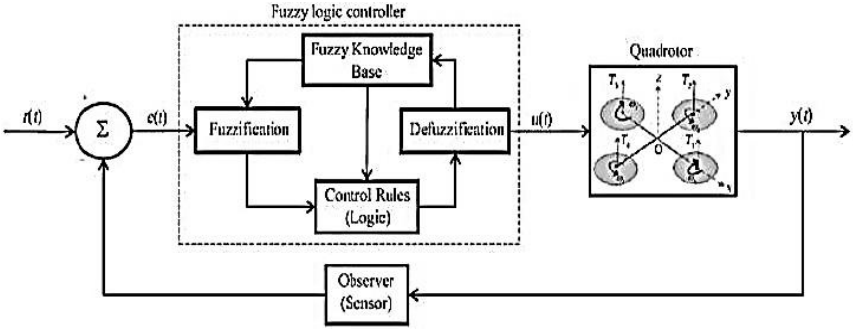

Fig. 4. Block diagram of a Fuzzy Logic Controller for Quad-rotor

Real-time Operating System

Few studies on the scheduling of UAVs have been published, and even fewer deal with the implementation of real-time drone control systems. An embedded remote-control operating system (RTOS), also known as a UAV operation system (UAS) [28], is necessary for real-time execution in the governor of a drone. Various types of motors, including induction motors, direct current motors, permanent magnet synchronous motors (PMSMs), etc., use FOC and DTC for operation. [29].

The microcontroller's control database is run on a real-time operating system known as an RTOS [29]. The real-time kernel uses the UAV scheduling system to guarantee that application tasks are done on time. Therefore, a UAV must have access to a real-time operating system (RTOS) that can support several duty scenarios. [30]. The Free RTOS is the most extensively used RTMS for UAVs. To assess the functional changes made to the Free RTOS over time, an empirical study was done. The examination of Free RTOS covered 85 different versions, from V2.2.2 all the way up to the current 10.0.0.

As shown in Figure 5, the on-board processing unit of a UAV is the microcontroller, which is responsible for computing and monitoring the state of the UAV. The microcontroller is chosen to meet the application task requirements [31]. It is necessary to take into account factors such as computational speed and communication with the aboard sensors. The reduction in SSR is accomplished by increasing the network damping for frequencies near the Torsional Mode Frequency (TMF) [32]. The Crazy Lie 2.0 Quad Rotor was equipped with hardware and software that enabled it to track objects up to 27 grams in size as part of a commercial COTS Quad Rotor system.

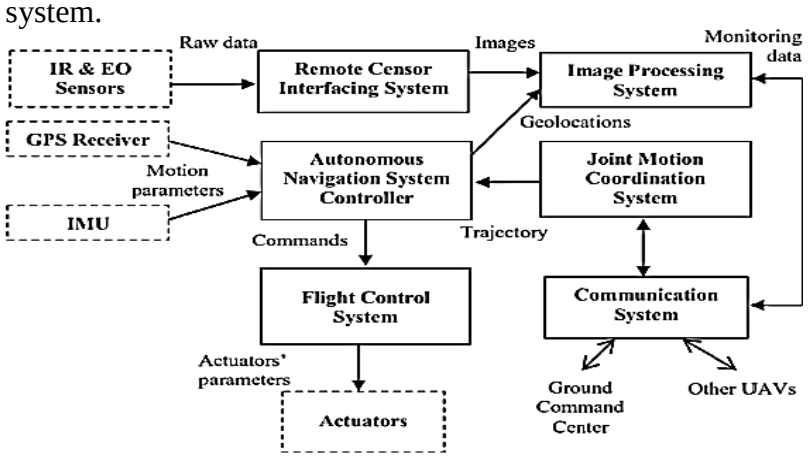

Fig. 5. Sensors with microcontroller

An STM32 F405 microcontroller, which acts as the primary on-board handling unit, and a Nordic NRF51 module, which is used for wireless communication, make up the backbone of the quad rotor platform [33]. The Standard Multithreaded Microcontroller (STM32) runs at 168 MHz [34] and is based on the 64-bit ARM architecture. The vehicle has

a 9-axis Integrated Measurement Unit (IMU) in the form of an MPU-9250 that includes an accelerometer, magnetometer, and gyroscope, as well as a pressure sensor, the ST LPS-25H, that is accurate to within around a meter on average.

Conclusion

An embedded Remote-Control Operating System (RTOS) is required for successful real-time control of drones. This real-time operating system (RTOS) has capabilities like multithreading, scheduling, and priority assignment that allow the drone's control system to react instantly to data from sensors like GPS and inertial measurement units (IMUs). The selected drone's motions are then completed via the application of the proper motor speeds by the control system. By performing activities in parallel, like position and alignment guidance, track scheduling, and control execution, multi-threading enables drones to respond in real-time. In addition, some tasks require the use of the results of earlier calculations. As a result of careful planning and prioritization, the microprocessor can allocate its limited processing resources to the most pressing tasks at any given time, such as obstacle avoidance.

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Design, development and experimental evaluation of micro channel using Soft Lithography

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Abstract:

Micro channels are one of the most crucial parts of a Lab on a Chip device. The creation of Micro Channels is a crucial task. Soft lithography is one of the most widely used methods for producing Micro Channels. The investigation into using a commercial CO2 laser system to make micro-channel molds out of acrylic material is covered in this article. The purpose of the pilot experiment is to examine how the LASER power and scanning speed affect the depth of the Micro Channel mold. With increasing LASER power and decreasing with increasing speed, it is observed that the channel depth increases linearly. Utilizing CO2 laser machining on PMMA, which can serve as a mold for the soft lithography process, the straight Micro Channel configuration with Y-shaped inlet and circular obstacles' (Split and Recombine approach, SAR) has been created. The experimentation of fluid flow through micro-channels of different geometries is done, and experimental results at various inlet velocities in all of the aforementioned micro- mixers are obtained in the micro fluidic laboratory. The results of the simulation will then be compared to the experimental results for flow pattern.

Keywords: CO2 LASER Machine, PMMA, Micro-Channel, Soft Lithography

Introduction

In many applications today, Micro Channel is one of the most crucial elements of Micro Total Analysis Systems (TAS), which also play a significant role in many applications. There are uses for micro channels in a number of industries, including biology, chemistry, diagnostics, and medicine [1] [2]. Comparing acrylic materials to commercially available materials like silicone, glass, and polymers, micro channel fabrication with acrylic is more cost-effective and efficient. Due to their low cost and ease of fabrication, these micro channels are frequently used in the engineering and medical fields [3] [4]. The Micro Channels can be manufactured using a variety of techniques, including hot embossing [5], [6], injection molding [7], [8,] micro milling [9], [10], [11], [12], and infrared laser ablation. For the creation of molds or direct Micro Channels, CO2 laser machining is a suitable alternative. Aside from

accelerating the manufacturing process, CO2 laser processing also makes it possible to react quickly to changes in the design. For micromachining, CO2 laser systems are therefore very beneficial. This study used CO2 laser machining with three different widths to create a Y-shaped Micro Channel with straight and circular obstacles. Input parameters are also changed to produce the various depths for the Micro Channel molds. A variety of micro-channel geometries are used in experiments to study fluid flow, and the results are obtained in micro.

Design and Development of Micro-channels

A powerful laser is used to cut material using lasers, and this process is known as laser cutting. A high-quality surface finish results from the material melting, burning, evaporating, or being blown away by the gas jet. Utilizing CO-2 laser machining, the channel development process is completed.

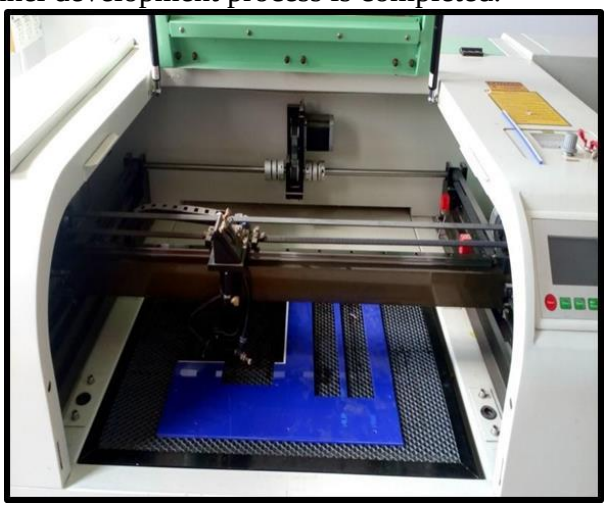

Fig. 1 CO2 Laser Machine

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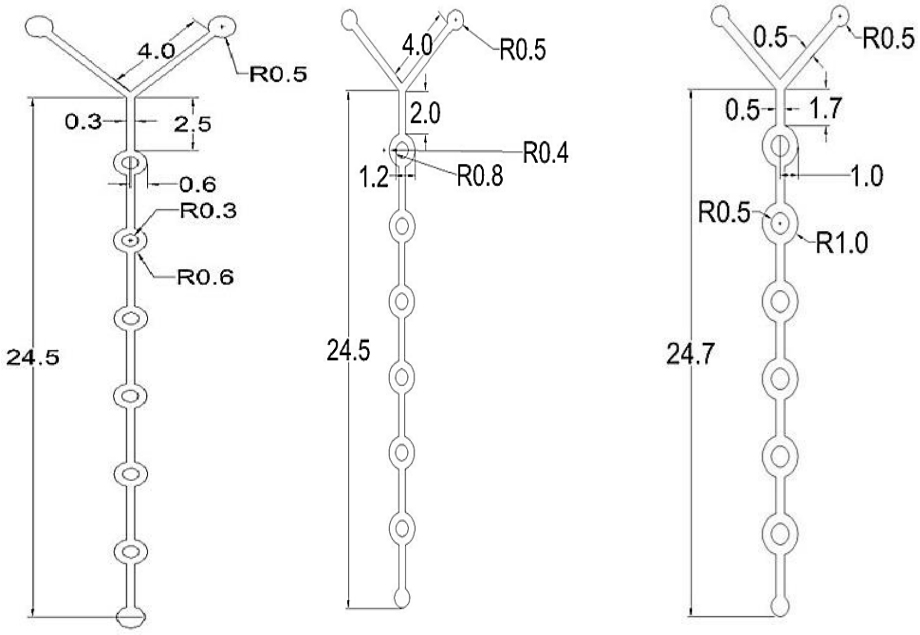
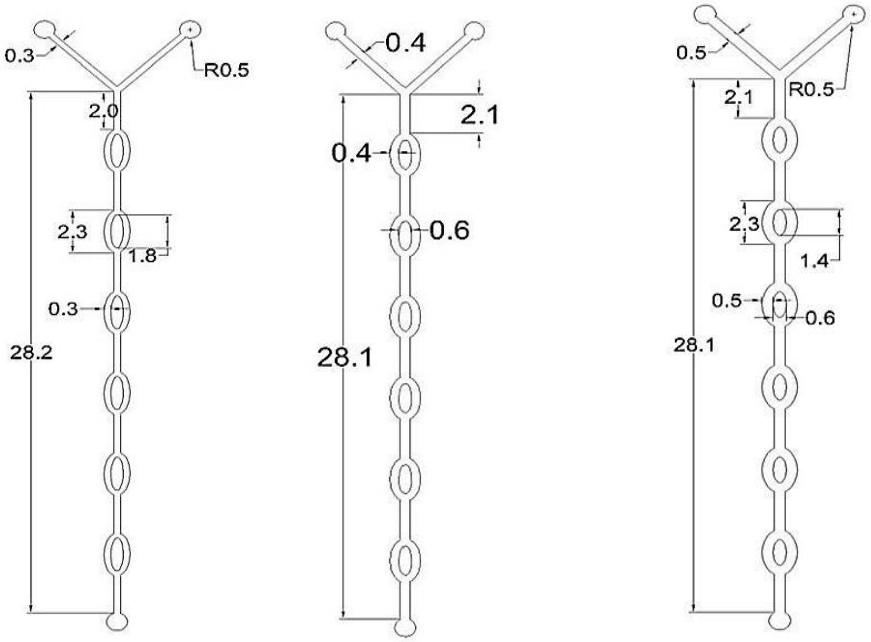
1.1 Design of Micro-channels:



Width - 0.3 mm **Width - 0.4mm** **Width- 0.5mm**

Fig. 2 Microchannel with Circular Obstacles



Width - 0.3 mm **Width - 0.4mm** **Width- 0.5mm**

Fig. 3 Vertical Elliptical Obstacles Microchannel

Fabrication of channels: Laser cutting machine permits you to form perplexing plans and exceedingly point by point trims with a low-cost, exceedingly productive tool. Attached to the computer similar to a printer, the framework will cut plans we make in most realistic program programs. imental Study

For the experimentation purpose the micro channels are prepared using Soft Lithography process and used for checking the mixing of fluids with different channels. The experimentation of fluid flow through micro-channel of various geometries is carried out and Experimental results obtained in micro fluidic laboratory at different inlet velocities in all mentioned micro-mixers.

1.2 Soft Lithography for Fabrication of PDMS Molds:

In order to create highlights with geometries characterized by the mold's relief structure, the delicate lithography process involves creating the elastomeric form, which is typically made of polydimethylsiloxane (PDMS). Following creation, PDMS forerunner is added to the ace form, which is then degassed under vacuum. To completely expel bubbles, this last step may be repeated several times. Finally, preparation allows for the treatment of the PDMS precedent arrangement. The PDMS shape can be used for stamping or small-scale molding after cooling to room temperature and being peeled off the substrate.

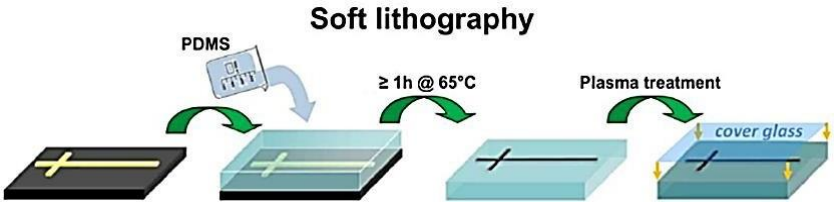


Fig. 6 Soft Lithography Process

Fig. 7 Pouring of PDMS into Mold cavity

1.3 Experimentation:

The experimentation of fluid flow through micro-channel of various geometries is carried out and Experimental results obtained in micro fluidic laboratory at different inlet velocities in all mentioned micro-mixers. To conduct the experiment, Blue Ink and Water was taken as the sample.

So the property of the fluid was nothing but the property of the ink only. Generally the density of water is 1000 kg/m3.

1.3.1 Experimental Setup

Following are the equipment‘s are used for Experiment:

1. Twin Syringe Pump
2. Silicon Tubing
3. Fittings (Connectors)
4. Glass ware or beaker
5. Samples
6. USB Digital Microscope integrated with Computer

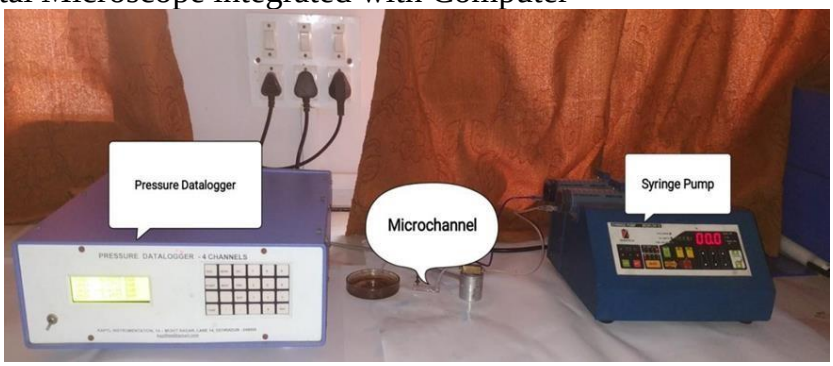


Fig. 8 Y- Experimental setup

Case I: Results of the experimental investigation in Y-shaped micro-channel

with circular obstacles for inlet velocity 5 mm/s are presented below.

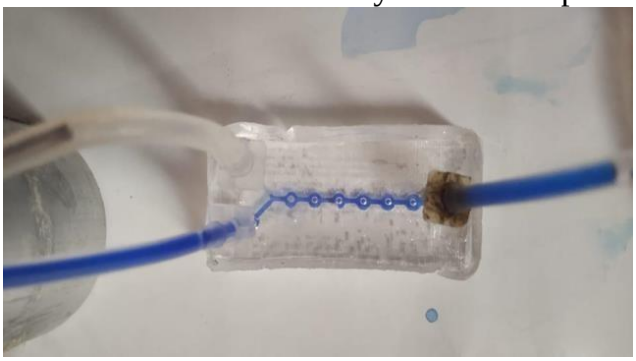


Fig. 9 Y- Shaped Microchannel with Circular obstacles

Case II: Results of the experimental investigation in Y-shaped micro-channel with vertical elliptical obstacles for inlet velocity 5 mm/s are presented below.

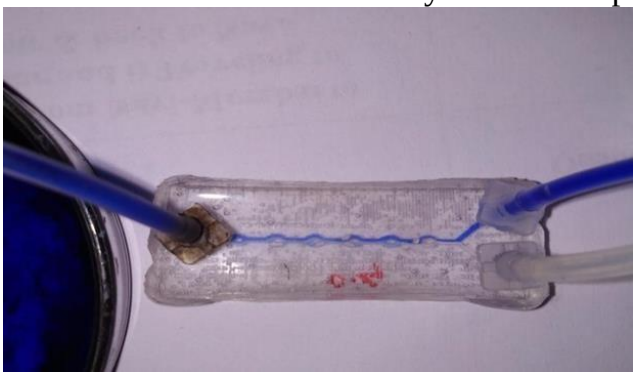


Fig. 10 Y- Shaped Microchannel with Vertical Elliptical obstacles

4. Conclusion

One of the fundamental elements in coordinating microfluidic frameworks for medicinal, organic, and chemical uses is the micro-channel. Using laser cut machining, Y-shaped micro-channels with various configurations, such as straight with circular impediments, have been manufactured. The molds are made with two different parametric conditions and three different widths. The recorded profundities are 0 point 5 and 0 point 52 mm. The molds that are produced can be used to create PDMS micro-channels using a careful preparation for lithography. Miniaturized scale blenders in the shape of a Y have been planned, featuring two distinct geometries: circular and curved. The miniature scale blender is shaped using CO2 laser machining. PDMS fabric creates the Y-shaped channel with curved and circular deterrents for exploration and investigation.

The effect of obstacles on the mixing length is studied. The effect of different parameter on micro mixer performance is concluded as:

- Reduced inlet velocities of incoming fluids are used to achieve the minimum mixing length of microchannels.
- In comparison to a Y-shaped micro mixer with circular obstacles, a Y- shaped microchannel with elliptical obstacles provides better mixing length.
- Micro-channel mixing time and length decrease with a reduction in channel width.

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