

Chapter -1

INTRODUCTION

Precious Fiber from the petiole of nation's flower - symbol of spirituality, purity, divine beauty & enlightenment

India is a country of wetland ecosystem. It has a very diverse and productive system for environment, social and cultural value. As per the U.S Fish and Wildlife services, wetlands are defined as transitional land between the terrestrial and aquatic ecosystem in which water table is at or near the surface of the land that is covered by shallow water (Source : [Wetlands Classification System | U.S. Fish & Wildlife Service \(fws.gov\)](#)). Wetland is called as “Kidneys of the Earth”. Wetland is the important component of the environment due to the biological, ecological, socio-cultural and economic values Bhuyan, M.J. (2016).

Wetland is distributed in various geographical regions from Himalayan to Deccan plateau. The variation in climatic conditions and topography is responsible for the remarkable diversity in the wetlands. Wetlands are classified in different types on the basis of vegetation, origin and it is also based on thermal characteristic – tectonic wetlands, glaciatic wetlands, oxbow wetlands, crater wetlands, lagoons, saltwater wetlands, ponds/tanks reservoirs, urban wetlands, mangroves, creeks and coral reliefs. Wetland provide numerous benefits – production of food, fish, fodder, fuel and other materials, it helps in regulation of biogeochemical cycles, regulation in climate change, formation of soil, supporting biodiversity. It also provides aesthetics, recreational and spiritual services (Source : Policy brief – of wetland conservation : <https://www.apn-gcr.org/wp-content/uploads/2020/09/0ea8b42961e6a5efbede3b81e11793dd.pdf>).

A significant number of flora in wetlands are considered as a bio-resources. There are major and minor plant resources cultivated from the wetlands of rural India Mishra, M. et.al. (2010). Three basic needs of the human civilization are food, shelter and clothing.

NATURAL FIBERS

The natural fibre segment is expected to grow the most with a CAGR of 5.6 per cent in terms of volume during the period 2022-2027. Diverse range of natural fibers is produced in India which provides an important source of livelihood for farmers and local communities (Source: <https://www.eoiparis.gov.in/content/1662552445Sep%2022.pdf> E-Magazine Handloom export promotion council 2022).

One of the major challenges in working towards new sources of natural fibers is the systematic processing lines. Natural fibers suffer from extensive manual operations and use of semi-automatic primitive machinery. (Source: <https://www.fiberjournal.com/reversing-the-shift-back-to-natural-fibers/>). The aims of National fiber policy 2010-2011 is to increase the fiber availability in the country and resolve all the problems associated with the different fibers. The policy includes strengthening of modernization and technological upgradation in the processing of different fibers (Natural & Man-made). (Source: <https://www.ijma.org/acts-rules-policies/policies/national-fibre-policy-2010-11.pdf>)

BAST FIBERS

Nature has gifted us wide and diverse range of plants that are grown in various agro-climatic zones that has potential for extraction of fibers from stems. There are many plants which are not highly explored or cultivated specially for fibers. Till now many of such fibers are unknown. There are many issues related to the production and processing of bast fibers – sustainable retting technique, use of sustainable chemicals, and implementation of suitable degumming process. In many cases extraction of fibers from the plant material is complex and time consuming. Processing of natural fibers includes chemicals and higher energy consumption to convert into yarn. Toxic gases released from processing is also an alarming issue for the greenhouse gases. To make the bast fiber industry sustainable, one needs to be focusing on following points: sustainable processing method of fibers, awareness of the global market, supply chain management, consistency in supply of product to the market, excellent logistics and packaging, collaboration, clustering of the bast fiber industry, diversification and online marketing. Veit, D. (2022).

Many agrowaste fibers in the terrestrial regions have been explored, but the aquatic waste needs to be explored. Looking to present scenario of environment protection and bio-based economy there will be a great market demand of sustainable environmental friendly fabrics from natural fibers by 2030.

1.1.CONTEXT OF THE STUDY

LOTUS

Taxonomically, Lotus belongs to genus *Nelumbo* of *Nelumbonaceace* family. Indian Lotus called as *Nelumbo nucifera Gaertn.* is considered sacred due to the religious significance of Buddhism and Hinduism (Chandra, L. 2020). It is one of the oldest perennial aquatic herbs consumed throughout the Asia. Various pharmacological studies revealed that entire plant has antidiabetic, antipyretic, anti-inflammatory, anticancerous, antipyretic, hypoglycemic, immunomodulatory, antioxidant, aphrodisiac, lipolytic, antiviral, antimicrobial and anti-obesity properties Venkatesh, B., & Dorai, A. (2011) and Sheikh, S. (2014).

Extracts of different parts of the Lotus plant – buds, flowers, stamens, fruits, stalks, rhizomes and roots are used as a herbal medicines for the treatment of many diseases like cancer, depression, heart problems, diarrhea and insomnia. The plant also produces essential secondary metabolics-steroids, alkaloids, flavonoids, triterpenoids, glycosides and polyphenols. The entire plant is considered as a traditional medicine with the tremendous health benefits. It is used to treat sunstroke, dysentery, hemorrhoids, dizziness, vomiting with blood, uterine bleeding, skin disorders, controlling the burning sensation, cough, hypertension, fever, Hematemesis, Hemoptysis, Hematuria, Epistaxis and Metrorrhagia. The plant consists of unique characteristics – a). Capacity to regulate temperature b). Seeds consist of long viability period c). The surface of the leaf has a water –repellency property that is called as Lotus effect Sheikh, S. (2014).

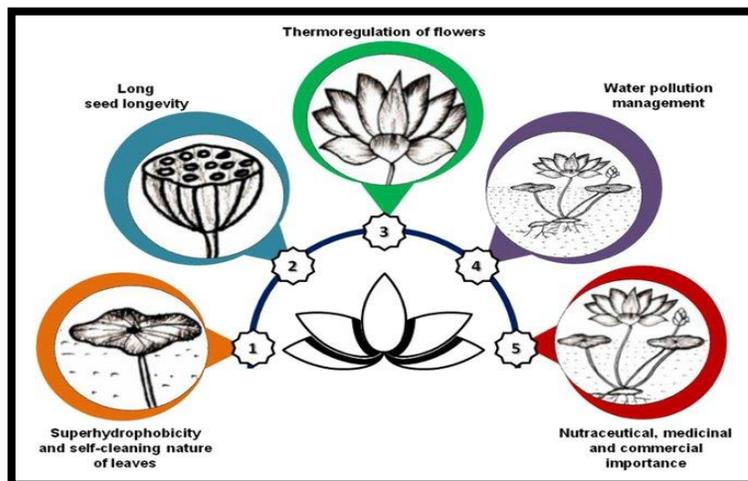


Plate 1.1: Properties of the Lotus Plant

Source: Gowthami, R. et.al. (2021)

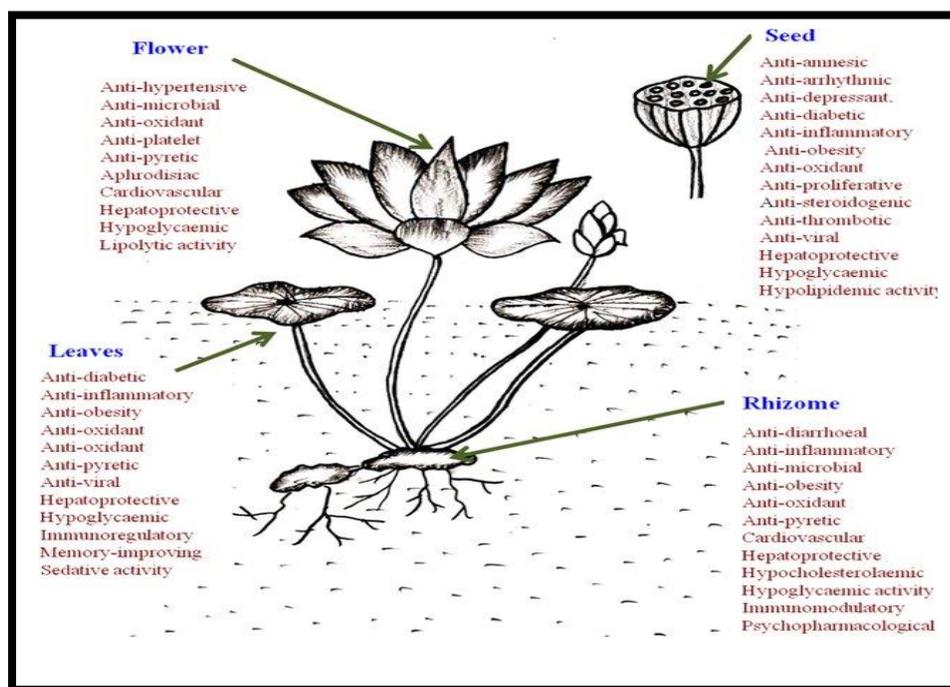


Plate 1.2: Functional properties of the different parts of Lotus Plant

Source: Gowthami, R. et.al. (2021)

Lotus is an important cash crop used for about 7000 years in Asia. It is cultivated widely for its edible rhizomes, leaves, flowers and seeds. Lotus flower is widely available in India growing in lakes, ponds, gardens and homes. As per National Botanical Research Institute, there is a rise of commercial cultivation of aquatic plant majorly Lotus and it can lead to profitable floriculture industry (Source : <http://www.forbesindia.com>). In India Lotus farming is practiced nearly in all states. It is reported that some wetlands of central Gujarat like Ahmedabad, Kheda, Anand, Vadodara districts) and South Gujarat (Valsad and Navsari districts) have an impressive growth of lotus plants (Source: <https://www.dnaindia.com/ahmedabad/column-flowers-of-some-wetland-plants-elegance-personified-2748658>).

In Kashmir, Lotus is very popular for its edible rhizomes also called as “Nadru” which is integral part of Kashmiri feast in religious, social and cultural occasions. Lotus rhizome based cuisines called as Kashmiri Nadru is considered as one of the tourist attractions in Jammu and Kashmir state. It leads to economy and it is a source of livelihood for the people in Kashmir (Gouthami,K. et.al. 2019). Lotus plantation is safer and beneficial for the environment because it can tolerate alkaline and acidic water in the wetland. It has been proved that Lotus plant can absorb heavy metals from the environment Xiong,C. et.al. (2013).

It was observed that after picking the flowers, the petioles (part between rhizome and flower) are left in the pond as a “waste” or either if is taken out from the pond while picking flowers the rest of the petiole is throw away which is abandoned for the natural decay. Such waste can cause environmental hazards. The stem of a Lotus plant has two types of xylem cells, the tracheids and vessels. The tracheids are an elongated tubular cell with a hard, thick, woody wall and a large cell cavity. The vessels has a cylindrical tubular structure with thin lignified wall. These cells help in transportation of water and some nutrients from the roots to the leaves and also provide mechanical support to the plant (Source : <http://www.differencebetween.net/science/difference-between-vessel-elements-and-tracheids/>). Lotus fibers are arranged in these cells in the form of “Helix” Wu M., et.al. (2014). Cutting of the petioles leads to the fast growth of the plant and it also cleans and maintains the aquatic ecosystem. A healthy aquatic ecosystem works as natural filters for toxins.

Lotus cultivators used to sell flowers, seeds, fruits, rhizomes. But they are less aware about the petioles which are generally thrown away while cutting and bundling the flower and sometimes

also left in the pond during picking the flower. Manual extraction process of fibers is practiced only in very few places of world like Myanmar, Cambodia, Vietnam and Manipur in small quantity. The whole process is tedious and time consuming.

1.2. History of Lotus Fiber

Lotus has a long plantation history and majorly it is found in China and Myanmar. It is special cash crop with huge research value. Lotus has a high symbol of spiritual power and purity in Myanmar. Since 1910 extraction of fibers were practiced. In 1990s the designers of Japan has started the workshop to develop the foreign market for the fabric. But due to the low production and demand the fabric remained rare Tomar, S., & Yadav, N. (2019).

In Myanmar a century ago, a women weaver – Daw Sa Oo observed that there is a precious fibers present in the Lotus stem. She prepared a robe from fibers extracted from 200,000 Lotus stems for the Abbot of the local monastery. The task was spiritual undertaking and it is a symbol of devotion. After the death of Daw Sa Oo her family members tried to take the tradition forward. Lotus plant grow abundantly in the Inle lake of Myanmar due to the suitable geographical and climatic conditions. Extraction of fibers from Lotus stem is practiced in the Inle lake it attracts to the tourist visiting the place. Due to the silk like appearance the fabric is made in combination with silk to develop unique product because the pure Lotus fabric sounds expensive and luxurious due to tedious and time consuming factors. Quality also depends upon the skill of the extractor. In olden days there was a belief behind Lotus fiber extraction in Inle Lake at Myanmar. Fiber extraction from Lotus stems can be practiced only by the unmarried women and women in the menstrual period cannot extract fibers. But nowadays even the married women are also extracting fibers. Majorly the middle age women extract the fibers and teenager girls work together and train themselves for fiber extraction. The leftover stems after extraction are thrown in the pond that can work as a fertilizer and it can be advantageous for the pond Laishram, D., Sethi, B., & Tengli, M.B.

1.3.Luxury

Currently there is a paradigm shift in the domain of luxury as a consumer. They are more concerned about social and environmental issues. These consumers majorly prefer ethical and green products that show the values and beliefs. The essential quality of the luxury goods is sustainability. Luxury goods consist of extraordinary design, creativity, good quality, rare,

expensive, and it is made of exceptional raw materials. Luxury products respect both people and planet. The luxury industry is highly profitable, potential and promising sector because it holds the bigger responsibility towards society in the creation of social and environmental value Hashmi, G. C. (2017).

1.4.Women empowerment

Women empowerment refers to increasing the spiritual, political, social, educational, gender, economic strength of the individuals and communities of the women. Women empowerment in India is heavily dependent on different variables including geographical local (rural/urban), educational status, social status, caste and age. Policies of women empowerment exist at the national, state and local (panchayat) levels in many sectors including health, education, economic opportunities, gender-based violence and political participation Sheikh, R.M. (2015). Women today are getting education and coming up in the workforce even for the defense services and in all the areas of the work equal to men. But still there are areas where women are not allowed to work and face difficulty in managing their livelihood and they lack in giving proper education to their upbringings. In such cases there is the importance to skill development because this is the way to end the unemployment that is said by honorable prime minister Narendra Modi. (Source : <https://www.azquotes.com/quotes/topics/skills-development.html>). Empowering rural women by creating employment opportunities by skill development can contribute inclusive and economic growth. The aim of the skill development, particularly in case of women is not merely to prepare them for the job but also to improve the performance of women workers by enhancing the quality of work in which they are engaged.

Thus, the study aims to fabricate machines (with different mechanism) for fiber extraction to solve the complicated process of extraction and reduce time. Evaluation and analysis of extracted fibers from machines for its strength, fineness, twist. Experimenting the manual extraction process by varieting number of petioles and further spinning yarns using Ambar charkha. Assessment of the dyeing properties of yarn and evaluating its color strength and fastness properties. Construction of woven fabrics using different types of developed yarns and testing the fabric properties. Finding the inherent functional properties of fibers for its applications in technical textiles (Hygiene products). Training the group of women for fiber extraction and

spinning. Recently in the fashion world there is demand for seamless knitted apparels, the attempt was also done to experiment 100 % Lotus yarns for developing circular knitted structure and testing its properties.

1.5.Purpose of the study

Entire nation is consistently working towards sustainable development goals which needs to be fulfilled by 2030. Lotus is the national flower of India. This precious fibers extracted from the petioles of national flower needs to be studied in the scientific manner. From the cited literature it was analyzed that, the very base line problem with the Lotus fiber is the time-consuming extraction process. Due to the various characteristics of the Lotus fiber – a). Fibers are extremely delicate b). Fibers in the petioles are not assembled together in a single chamber. Fibers are arranged in xylem cells that is tracheids and vessels and few fibers are also assembled in the outer portion or the wall of the xylem cells. C). Due to the extreme delicacy of the fibers to withstand strength on the machine was also critical. D). Variation in the nature and diameter of the petioles. E). Maintaining even tension during the extraction This draws attention to design and develop machines (with different mechanisms) for fiber extraction and yarn development keeping all these characteristics in the mind.

From the historical perspective, extracting of fibers from the Lotus fiber is the art and it also has its cultural significance with the Hinduism and Buddhism. India is known for its indigenous knowledge of hand spinning which has been taken in the consideration in the present context. Handspun hand woven (Khadi fabric) also called as revolutionary fabric has huge importance in India and it plays a major role in nation's economic strength after colonialism. Different kinds of fibers are used in Khadi fabrics – Raw silk Khadi, Matka Khadi, Poly Khadi, Wool Khadi etc. Efforts has been made to develop fine count range of 100 % Lotus hand spun yarns on Ambar charkha to bring novel fiber in the Khadi sector which can cater to premium and luxury consumers.

From the industrial perspective, spinning sector in India has evolved and progressed into a modern and globalized organization. Research and development sector of the industry also constantly take the efforts for the search of novel fibers. With the minor fibers it is very difficult to achieve the 100 % spun yarn and also in producing blended yarn with highest proportion of

minor fiber due to the inherent characteristics of particular fiber in terms of length, strength and stiffness. Rotor spinning is considered more productive as compared to ring spinning in terms of time and energy consumption. There is a particular count range from finer to coarser required for designing and developing different kinds of products. This draws attention to take Lotus fibers for Industrial spinning – Rotor open end yarn development by blending it with Cotton which can be used in heavy weight apparels – coats, denims and jackets.

Coloration is an important part of textile leading to aesthetics and popularity. For the application in apparels, fastness property plays an important role. Hence the purpose was to experiment dyeing of Lotus yarns with few known natural dyes. For the industrial perspective, Lotus yarn was experimented for dyeing with reactive dyes.

Handloom sector is next to agriculture so far employment is concerned. Handloom products are being positioned as niche product by innovative brand promotion. India is known for its prestigious hand-woven textiles which are woven by the artisan weavers. These weavers have a positive connect with the natural fibers and they are very keen to implement novel fibers especially natural fibers in the weaving besides keeping production point of view in mind. This draws attention to develop different Lotus ply yarns with other natural fibers – Cotton, Silk and Wool. By this effort it is easy for the weaver to do the warping process due to the strength of the component yarn in the ply structure. Also, the fabric will have more amounts of Lotus fibers in warp that is ply yarn and weft with 100 % Lotus yarns. The 100 % Lotus yarns was also used in developing union fabrics.

With the increasing population, the demand of the textiles has also increased. Due to this reason, the entire textile sector is only depending on Cotton as a natural fibers and synthetic fiber due to the cost factor. Across the length and breadth of the India there are many minor fibers which are not explored upto the mark due to the lack of infrastructure, awareness, technological upgradation and passion towards increasing its utility. Textiles, apparel sector has a highest amount of women work force. India is a developing country. Poverty has been an issue in India. As the researcher always have a keen interest in working with the women, inspiring, motivating, making them self reliant and giving a respectful work environment for them. The main thrust area of the research form the SDG (Social development group) of women for providing training in extraction and spinning process of Lotus fibers. The main purpose was to contribute to all the

three E's that is: Economy, Environment and Empowerment.

Entire Lotus plant is considered as medicinal herb. Many pharmaceutical studies revealed that extracts of each and every part of the Lotus is beneficial to health. After the co-vid pandemic, functional textile materials with antibacterial property is a need of an hour. Technical Textiles play a very essential role in nation's security. Nowadays consumers are more concern about the health they are more focused towards herbal textiles, antibacterial materials, lightweight and soft materials. India has vision of streamlining the technical textiles by 2047. Medical Textiles also called as Med Tech is an emerging field of the technical textiles. Medical textile is majorly fibrous based nonwoven products. Focusing on the medicinal properties of the plant, fibers were subjected for testing of the functional properties – antibacterial, water absorbency and Cytotoxicity. With the positive results it was used in hygiene medical textiles.

Powerloom is the key invention of the industrial revolution. It is one of the important segments of the textile industry in terms of production of fabric and generating employment. Any novel fiber should not only restrict to handlooms. The entire textile and fashion sector is very fast. Fashion changes in minutes. Designers and garment manufacturers always try to get the raw material that is fabric on time. The yarns should consist of certain characteristic for smooth production in powerloom weaving. Till now, the Lotus fibers are only used for handmade fabrics in few countries. By implementing Lotus fiber in powerloom weaving will open the wide opportunities to produce fabrics for various end uses. The main aim of the study was to develop good quality Lotus yarn which was produced from the fabricated machine. Majorly for the powerloom weaving minor fibers does not go in its pure form, the particular raw material needs to be processed and blending with the other fibers is required to withstand stress of powerloom weaving. The inherent quality of the Lotus fiber along with the technological implementation leads to successful fabric development on powerloom.

Knitting is the second largest and most frequent fabric manufacturing technique after weaving. Knitting technique eliminates lot of pre preparation like sizing and warping. Knitted fabrics provide distinct properties of stretch and recovery and flexibility. Currently there is a trend of seam less knitted apparels. In Knitting the quality of the yarn plays a prominent role. The yarn should be good in strength. Evenness is one of the most important characteristics because in knitting the yarns have to passed through number of needles. Uneven yarn can result to frequent

breakages which will result into uneven fabric appearance. Focusing on the inherent physical and functional properties along with the technological implementation of the fabricated machine to produce yarn has led to the development of circular knitted pure Lotus fabric.

Hence the investigator proposed to work on “An Experimental study on extraction of fibers and uses of Lotus Petiole- A byproduct”. The study will open up new avenues for Lotus fiber cultivators along with the flowers, seeds, rhizomes, leaves they can also sell the petioles for extraction of fibers. Fiber is one of the basic units of the Textiles. The study has resolved the base line problem of Lotus fiber extraction and yarn development along with the successful experimentation in different fabric development – Woven (Khadi, Handloom & Powerloom), Nonwoven and Knitted fabrics.

1.6.Rationale of the study

The largest portion of the biosphere is the aquatic ecosystem. Ponds are considered as an integral component of hydrological systems and it performs diverse roles in biosphere. To fulfill the United Nations Sustainable Development Goals (SDGs) it is very necessary to save the planet's aquatic ecosystems Kumar, M., & Padhya, K. (2015). India is a country of wetland eco-systems which is most diverse and productive eco-systems. Wetlands are rich in flora and fauna. The major ecosystem services that wetlands provide include fish, fiber, water supply, water purification, climate regulation, flood regulation, coastal protection, recreational opportunities, and tourism (Source : <https://archive.epa.gov/ncer/events/calendar/archive/web/pdf/millennium.pdf>).

Asian lotus (*Nelumbo nucifera Gaertn.*) is one of the most aesthetic ornamental aquatic indigenous species, endowed with unique biological and nutritional traits. While scientific attention on various aspects ranging from basic botany to genome sequencing in lotus is increasing worldwide, India has somewhat lagged behind in taking due scientific, agronomic initiatives Goswami et.al. (2021). From the biological evidence, Netlak, P., & Imsabaia, W. (2016) it is found that “the bud of the flower fails to open if the cut stems are left in the water”. This bio-waste is composed of fibers that are produced in bulk. Extracted fibers can be explored for diversified uses in textiles.

1.7. Statement of problem

In Lotus plant, the petiole shows indefinite growth and thus always keeps the leaves floating in the water. Cultivators generally pick the flowers with little length of the petiole leaving the rest entire as a waste. This bio-waste is produced in bulk which can be explored for its potential to be a textile fiber in a scientific manner. Manual extraction of fiber is very tedious and time consuming. Moving to the bulk production point of view, machines (with different mechanisms) were fabricated to ease the manual labour. Fibers were explored for its inherent functional properties for the application in hygiene medical textiles. Yarns were developed using different spinning techniques for the application in woven and knitted fabric structure.

1.8. Broad objective

Cultivators generally pick the flowers with little length of the petiole leaving the rest of the portion or petiole as a waste. This bio-waste is accumulated in bulk which needs to be studied in the scientific manner for its diversified applications in textiles.

1.9. Specific objectives

1.9.1. To experiment the extraction process of Lotus fiber :-

- a). Manual extraction of fiber (Number of petioles – one, two and three).
- b). Fiber web for non-woven.

1.9.2. To experiment the spinning of extracted fibers by different techniques and test its properties.

1.9.3. To design and fabricate the machines (with different mechanisms) for fiber extraction and study the yield with respect to speed and man power involvement.

1.9.4. To develop yarns from the fabricated machines and test its properties for denier, strength, twist.

1.9.5. To prepare blended yarns (with other natural fibers) and test its properties (both fiber stage and yarn stage).

1.9.6. To study the dyeability of Lotus yarn and assess its color strength and fastness properties.

1.9.7. To prepare woven fabrics – Khadi, Handloom and Powerloom and test its properties.

1.9.8. To prepare circular knitted fabrics and test its properties.

1.9.9. To study the Lotus fibers for its functional properties: - Absorbency, Antibacterial and Cytotoxicity.

1.9.10. To develop non-woven fabric for technical applications – Hygiene medical textiles.

1.9.11. To train the group of Women for fiber extraction and spinning.

1.10. Delimitations

1.10.1. The study is limited to only one species: Lotus (Pink form) *Nelumbo nucifera gaertn.*

1.10.2. Waste petioles were collected from near and around Vadodara district of Gujarat