INTRODUCTION

CHAPTER I

INTRODUCTION

"Change and adaption gradually leads to Betterment"

Our environment is a combination of living and non-living things, which need utmost care in terms of conservation and utilization. There are however, many factors that affect the environment and thus affect the living organisms within it. Among these many factors, Noise is a critical factor. Noise is regarded as air pollutant under the Prevention and Control of Pollution Act, 1981. It has been defined as an unwanted sound or excessive sound which has adverse effects on human health and environmental quality. According to the World Health Organization, sound levels less than 70 dB are not damaging to living organisms, regardless of how long or consistent the exposure is. Exposure for more than 8 hours to constant noise beyond 85 dB may be hazardous. More than the purely medical effects of noise pollution on the individual, there is a significant social and economic impact. Since noise pollution leads to sleep disturbance, hypertension and cardiovascular disease, it affects the individual's work performance. Amongst many solutions to avoid noise pollution, one solution is to maintain a level of around 35 dB at night, and around 40 dB in your surrounding during the day. Population growth and destruction of natural resources like trees and plants has an impact on increased rate of pollution in our country. In India, pollution is increasing majorly due to rapid urbanization, where each individual has conditional and unconditional demands like easy transportation and communication mode, entertainment and leisure activities, carefree utilization of resources, etc. These demands have now converting into alarming issue as they are hazardous for the human beings. According to the Central Pollution Control Board (CPCB), Government bodies are constantly working towards controlling or reduction of noise level at residential, commercial and/or industrial areas in all major cities like Delhi, Hyderabad, Kolkata, Mumbai, Lucknow, Bangalore, and Chennai, etc. by constant monitoring. The larger areas are taken care of but still some solutions are needed for the indoor noise reduction as it deteriorates the working capacity and healthy lifestyle.

Excessive noise interferes with people's daily activities at school, at work, at home and during leisure time. Jamir, L., Nongkynrih, B. and Gupta.S., (2014), analyzed that the duration spent by us depends on the kind of work we are connected with, the

level and kind of noise we are surrounded with and an individual's capacity to withstand it. Noise invariably causes short-term and long-term health problems which affects the well-being of an individual. Thus, it has become essentially important to develop eco-friendly products as a solution for noise level reduction for enclosed areas. People have started hiring architects for the concept of having healthier living within work places that can be created within economical budget and with the required aesthetics. The utilization of less explored fiber, expansion of green, ecofriendly and aesthetical interiors and its awareness has increased the demand of innovative products for healthier environment.

The natural fibers are utilized for manufacturing of the textiles, which began before recorded history. Around 7^{th} and 6^{th} Centuries BCE, it could be traced that the discovery of flax and wool fabrics was probably started at excavation sites of the Swiss lake dwellers. Several vegetable fibres were also used by prehistoric people. Hemp, the oldest cultivated fibre plant was originated in Southeast Asia around 4500 BCE, then China also started cultivating it. By 3400 BCE, the art of weaving and spinning linen was already well developed in Egypt, indicating that flax was cultivated before that. Cotton in India can be traced back around 3000 BCE. While, manufacturing of silk and silk products originated by the Chinese; the invention and development of sericulture (cultivation of silkworms for raw-silk production) and of methods to spin silk date from 2640 BCE.

With improved transportation and communication, highly localized skills and arts connected with textile manufacture spread to other countries and were adapted to local needs and capabilities. New fibre plants were also discovered and their use explored. In the 18th and 19th centuries, the Industrial Revolution encouraged the further invention of machines for use in processing various natural fibres, resulting in a tremendous upsurge in fibre production. The introduction of regenerated cellulosic fibres (fibres formed of cellulose material that has been dissolved, purified, and extruded), such as rayon, followed by the invention of completely synthetic fibres, such as nylon, challenged the monopoly of natural fibres for textile and industrial use. A variety of synthetic fibres having specific desirable properties began to penetrate and dominate markets previously monopolized by natural fibres.

In the recent years, a substantial rise in the demand of cotton fibers has been observed. The constant threat of deteriorating situation of our environment with the

utilization of synthetic fibers, natural fibers are gaining importance. Which has also directed and raised the demand for scientist and researchers to explore newer natural fibers, better yielding process, eco-friendly production and processing method as well as modification in fiber to fabric properties for utility products. With an ongoing process of improvements at all the stages i.e. fiber to fabric, it has shown positive changes in the total production. But due to the low cost of the fiber and lesser man-power and time needed to produce bulk quantity these synthetic fibers are ruling the market. However, such fibres are hazardous for our environment.

The "Eco-friendly" movement has increased the need and demand to explore natural minor cellulosic fibers which are consumed less for the textile production. In our country, various minor fibers like sisal, hemp, kenaf, ramie, pineapple, etc. are abundantly available. The extraction process, to a great extent, is performed in cottage industry and only limited items are created. Consumption and exploration with such fibers are less due to tedious care and precise handling procedure, inadequate procurement details, complex manufacturing process and need of application of additional finishes for long-term usage of product. While, on one hand is the complex nature of the fiber and complex product manufacturing process, on the other hand, such fibers have certain inbuilt positive properties like porous cell structure, good strength, low density making it light weight, non-abrasive surface, renewable and biodegradable quality and being low cost, such fibers could be most suitable for functional textiles. Functional textiles are textiles with integrated functions of controlling or adjusting according to its application area. Functions such as temperature control, humidity control, sound absorption, etc. are such functions which are built upon manufacturing. The basic and most commonly used fibers are viscose (rayon) and polyester fibers.

1.1. Context of this Study

Amongst the minor fibers - sisal and ramie have excellent features like fiber strength, luster, good dye uptake, microbial and flame resistivity which are essential characteristics for sound resistant materials and has been the subject of this study. The stiffness and less cohesive nature of the fibers are gaining attention for further research thus, it demands for a sustainable and commercial pretreatment process. Considering all the advantages and drawbacks in totality, these fibers can be utilized for the production of various technical textiles. If so done, it will increase its utilization ratio as well as afford maximum availability of multi utility products in the market. On the social front, such efforts will add to employment generation, create entrepreneurial opportunities,

lead to upliftment of the farmers, enhance economic growth of our country and most critically, contribute to protection of the environment.

Deriving from the multiple benefits that natural fibers can add to if put to the right use, an effort has been made to study the structure of the fibers so as to derive an idea of the possible modifications required therein to increase its spinnability for an expanded product range. To create textiles with sound resisting properties, it was important to focus on attributes like - cluster of cells having various shapes, fiber diameter and hollow structure. Such attributes can be configured and used for making sound resisting materials which falls under the category of Hometech as well as Indutech of technical textiles.

Based on the perspective as above and to understand and formulate the objectives for the present study, following aspects have been discussed:

a. Hazardous health issues due to Noise Pollution

According to the World Health Organization, unwanted noise has various effects on human health like auditory damage, physiological and behavioral changes majorly observed in employees working in an office or industry. It also causes annoyance and aggression, hypertension, high stress levels, tinnitus, hearing loss, sleep disturbances, and other harmful effects. High noise levels can contribute towards cardiovascular diseases. Rise in blood pressure by five to ten points and increase in stress has been observed in the people who are constantly exposed to moderately high levels of noise for eight hours. Changes in the immune system and birth defects have been attributed due to noise exposure, but evidence are limited. Beyond these effects, elevated noise levels can create stress which causes accidents at workplace; stimulate aggression and other anti-social behaviors.

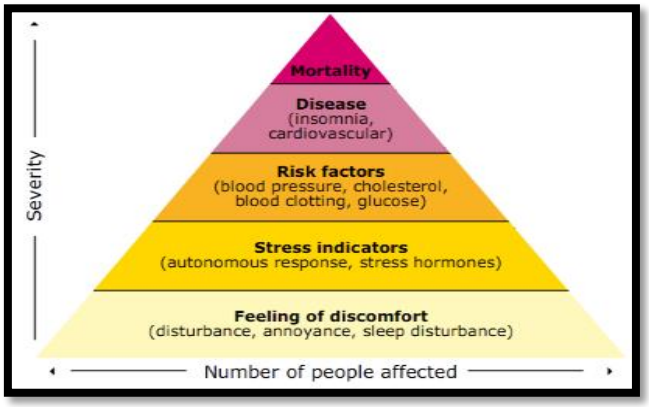

Plate 1.1: Pyramid of noise effects by World Health Organization (WHO)
Source: www.carreteros.org/explotacion/cedr/3_CEDR.pdf

Narkhedkar and Mundara (2018), describes the sources of noise with dB range to explain its effects on human at workplace and solution by simple engineering control. Noise is a common pollution found at occupational and leisure areas – industries, farms, cafeterias and restaurants, back office and conference room, schools, computer rooms, etc. Exposure to noise level more than 70 dB becomes unwanted noise for our ear, which, when reaches above 80 dB damages the ear. Extreme loud noise i.e. above 100 dB causes irreparable damage and leads to permanent hearing loss. With regular exposure to loud noise the ability to read, learn, understand, the problem solving capacity and recalling skills decrease over a period of time which is mostly seen in growing children. High intensity noise constricts the arteries thus disrupting blood pressure and raising cardiovascular diseases. Fatigue during working hours is caused by sleep disturbance and that decreases the work capacity of a person. 50-60 dB noise will hinder the communication of two people and lead to miscommunication or misunderstanding. Thus, a prolonged and constant noise will trigger headache, make people tense and violent, anxious, disturb emotional balance and may cause death.

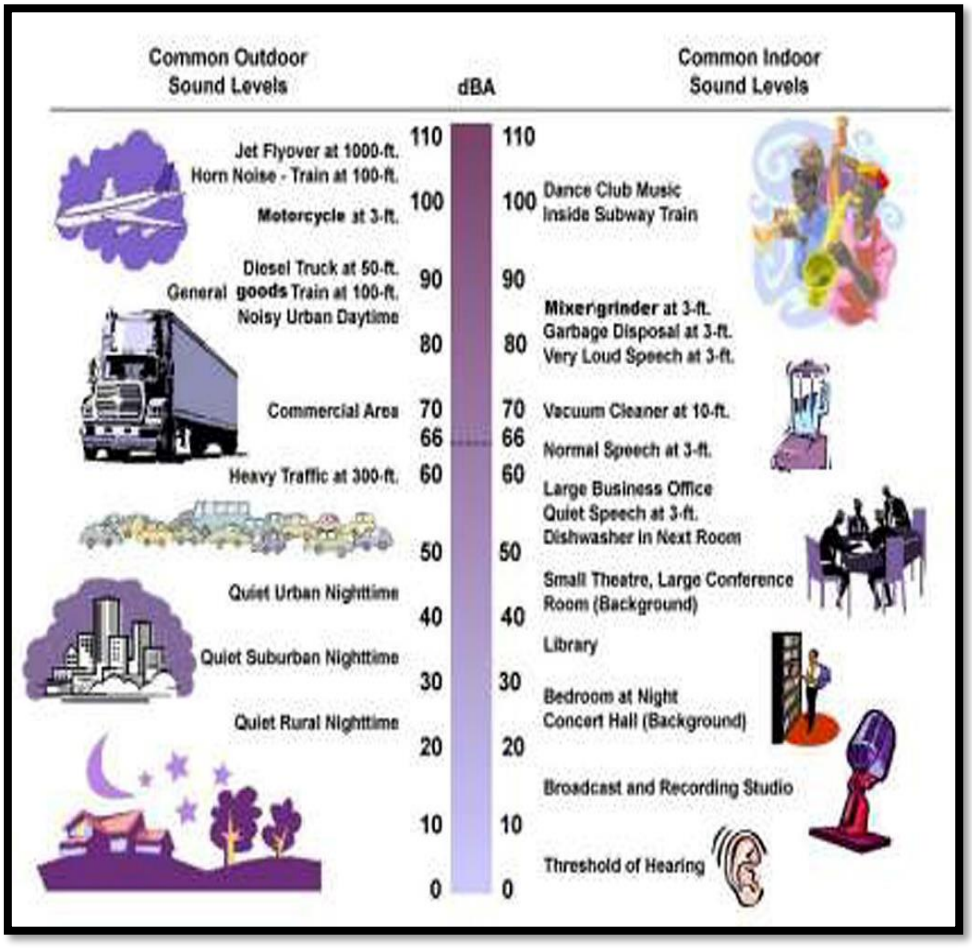

Plate 1.2: Noise level chart showing kind of sound at various dB levels
Source: http://parisaramahiti.kar.nic.in/PDF/publications/Noisepolution.pdf

Jamir, Nongkynrih and Gupta (2014), in their study, emphasized on health consequences due to pollution with some recommendations based on the analyses of various research conducted in different countries and different states/cities of India. As per the findings of this study, the workers exposed to road traffic in Brazil are facing hearing loss to an extent of 24.2% in low noise areas and 38.8% in noisier areas. Tinnitus and hearing loss amongst the traffic police of Bangladesh was observed in vis a vis their number of working years. 20% respondent working for 2-10 years had mild sensori-neural hearing loss while 28% respondent working for 11-20 years had mild to moderate sensori-neural hearing loss. Myocardial infraction issues increased in Stockholm, to the people associated with long term road traffic noise exposure of 50 dB or higher and long-term exposure with 65-75 dB caused cardiovascular diseases, other heart disease beyond hypertension. In Orissa, people experienced noise induced symptoms – headache, bad temper, hearing problem, loss of concentration, sleep disturbance but were unaware of the ill effects of the noise on health. Irritation (52%), hypertension (46%) and loss of sleep (48.6%) was reported by the people living near road sides and that created negative emotions which affected the concentration in ones work and gave rise to irritability in their nature.

b. Role of textiles as Sound resistance fabric

A textile is either acoustic absorbing or acoustic resistant. Textile designing or acoustic installation using textile can work as a diffuser of medium to high frequencies. While in case of absorption, the region of frequency is of interest. Tillberg (2012), stated that when it comes to diffusion, textile materials could be of advantage since it could be designed in an aesthetically pleasing way. The acoustic properties of textiles differ depending on how the textile structure is created - through knitting or weaving or other techniques. In the structure of textiles, small air pockets are formed which could affect the acoustic properties.

Pal.et.al. (2015), described role of textiles in sound absorption along with the details of absorption mechanism and its end application. Non-woven materials are highly used because of easy in manufacturing technique. The interlocking of fibers creates tortuous passage for sound wave to travel through and thus due to friction it gets converted into heat energy. Various parameters that influence are – fiber type and fineness, fiber cross-section and surface area, fiber orientation, porosity, tortuosity, air-gap, density of material, thickness and compression strength. These fabrics can be used

as face and/or backing materials which now, are mostly made up of synthetic fibers. Thus, the demand of research to explore knitted and woven materials is rising, which would serve both as functional and aesthetic features.

The research by Tayyaba and Goel (2013) highlighted on the exploration of structured materials created using knitting techniques for various applications like headliner, carpets, seats, door panels and other interior parts where pleasing appearance is required. Major parameters which influence the absorption are pore size and porosity. Limitation of yarn strength and elasticity are the main drawbacks, which leads the researcher towards the exploration with woven fabrics. Woven fabrics can be used as components of noise reduction assemblies made of textile materials as decorative cover of noise absorbers for various application depending upon sound coefficient. Sound absorption parameters are fiber content, yarn count, cover factor, thickness and air gap, alongwith aesthetical properties, but needs nonwovens as backing material.

Sancak (2015), created weft knitted fabrics using cotton and continuous acrylic yarns. Different structured knitted fabrics were manufactured on plain knitting machine and sound absorption test was conducted using Bruel and Kjaer tube instruments. As the thicker samples showed good absorbing, further analysis was conducted to identify the importance of yarn linear density and connecting yarn angle and porous structure in absorption. It was concluded that fabric thickness, micro porosity between fabric surfaces and yarn density are inter connected and has an impact on sound resistance behavior of the fabrics.

Ahmed (2016), experimented with three different fibres – glass wool, jute and waste fibres (glass wool, jute and polyester in different proportions) and created nonwoven fabrics with cross laid and needle punch technique. The end application of nonwoven fabrics was car interiors and for thermal insulation purpose. All the samples with different combinations were analysed and the observations say that the raw material and weight has an impact on the sound absorption coefficient, thermal insulation and air permeability. Jute samples showed highest results at the frequency range from 100 – 250 Hz and 4000 – 6300 Hz, while glass wool showed highest result at the frequency range from 315 – 3150 Hz. While in case of air permeability, samples from waste showed highest permeability followed by glass wool and jute. Thus, it was concluded that there is inversely proportional relation between the sound absorption coefficient vs thickness and between air permeability vs thickness. This means,

increasing the thickness leads to decreasing of sound absorption coefficient and air permeability.

Acoustic comfort is basic need which is affected by noise and creates interference with speech discrimination. To reduce the noise in room, textile materials are the one of the suitable sound absorptive materials. Alcaraz.et.al., (2018) published a research paper in which the researchers created woven textile using twill and terry towel weaves from microfiber yarns. Polyester microfiber was used to explore possible variations in fiber parameters such as shape and size of the cross section, curling or frizzling, hollow texture, polished or dull surface, as well as, resistance against fire and UV rays with the use of additives. Moreover, micro-fiber fabrics are better sound absorbers than regular fiber fabrics because of higher surface area of its fibers leading towards the contact area with the air to allow the dissipation of sound energy. Two different fabrics with twill and terry were used as top layer with nonwovens of various thickness. Analysis conducted using impedance tube method reveals that, the absorption depends on the type of fabric used. Fabrics with all floats running perpendicular to sound wave and having micro slits absorbs lower frequency, while terry towel having long loops were best for higher frequencies and both the fabrics showed coefficient ranging from 0.7 to 1. Hence, it was concluded that the weave, sound frequency, placement and combination of the samples, all depends on the area of installation and requirement of the sound absorption (dB).

c. Effects of different fabric structure on sound absorption

Martellotta. and Castiglione, (2011) analyzed sound absorption coefficient of three different paintings on canvas and cotton tapestry art work created by the students. Cotton canvas of two different GSM was finished by oil painting and embroidery with silkscreen paintings as covering of polyester fiber panel of 5cm and 10cm thickness. Jute canvas painted with special fabric colours were used as the cover of polyester fiber panel of 10cm thickness. All the three painted samples were investigated for sound absorption coefficient at various frequencies from 125Hz to 4k Hz. The large cotton tapestry of 9m was hung straight on a movable frame and tested by reverberation chamber method at various distance ranging from 5cm to 100cm, to investigate the effect of distance on sound absorption. The pores of the canvas were blocked by the paint and embroidery threads, but sound could pass through the embroidered sample and absorbed low frequency sound. The lightweight tapestry gave better absorption

simply by changing the distance from the wall. Thus, an appropriate surface ornamentation, finishes and placement can create an effective sound absorption in buildings.

Wood and widely used polyester fiber were blended for creating composite fabrics and were investigated for sound absorbing characteristics by Peng.et.al., (2014). The chemical processing of polyester fibers has high impact on environment and are costly. Thus, wood fiber as a partial substitute of polyester fiber for sound absorbing composite materials was experimented. The microstructure of the material was analyzed to know the mechanism of the sound absorption using scanning electronic microscopy and tested using impedance tube method. Sound absorption coefficient increased with decrease in the airflow. When there were cavities behind the composite material, the sound absorbing peak value moved to lower frequencies. Thus, as the thickness of the cavities increased, sound absorption coefficient increased at low frequency.

Soltani and Mohammad, (2013) conducted the research on the structural parameters and air permeability properties of woven fabrics for acoustic performance. The sound absorption coefficient of plain weave fabric using polyester yarn was analyzed using Texsonic meter maintaining airspace of 4cms at the back of the sample. Also, air permeability at 100Pa was performed to evaluate the porous structure of the fabric. The results revealed that woven fabrics were less appropriate in terms of both technical and economic aspects for certain applications. Although, creating additional airspace at the back of woven fabrics was effectively absorbing the sound at lower level. Thus, combination of layered samples was analyzed for sound absorption including other parameters like pick density, fabric thickness and yarn twist. Hence, it was observed that all the mentioned parameters for woven fabrics plays important role in absorption, low twist yarns and higher pick density absorbs sound well and it confirmed with the lower air permeability of the woven fabrics.

Mankodi and Mistry, (2014) conducted a research on Woven Fabrics Combination for Acoustics of Building Interior. Based on the characteristics and manufacturing method of the fabrics like denim, jacquard, velvet, etc. were collected from market. The GSM and thickness of woven and polyester needle punched nonwoven fabrics were analyzed. Also, an experimental setup was created based on Steady State Method as per ASTM E336-71 to evaluate the sound reduction of the

fabrics. It was concluded that sound absorbing capacity was affected by the parameters like GSM, thickness, air permeability, nature of the fabric, distance and level of the sound. In case of cover fabric i.e woven fabrics, the compactness, design of the fabric and the application of surface finishes has an impact on sound absorption and air permeability properties. The fabrics were evaluated at various distance ranging from 5cm to 20cms from which 20cm distance gave the best results. One-sided laminated fabric in combination with backing material showed sound reduction between 10 to 15dB.

Acoustic textile: A new era of noise control by Pal.et.al., (2015) covered various details such as noise control strategy, method of noise control, sound absorptive materials, mechanism of sound absorption in fibrous materials, factors influencing sound absorption by nonwoven, woven and knitted fabrics and placement and application of sound absorptive materials. Most of the materials were created using synthetic fibers and future needs were analyzed by the researcher. Apart from the testing parameters and various applications of the products, a need for studying various fabric manufacturing techniques such as woven and knitted fabrics using different fiber type, size, shape and structure was felt.

Hence, an intensive exploration with different fibers and to manufacture cost-effective fabrics having aesthetic features will have great demand in future.

1.2. Purpose of the study

The above cited literature and research studies indicate that fiber type and diameter, fabric structure and thickness are the major parameters influencing sound absorption capacity of textiles. Certain combinations of these parameters could create effective sound resistant materials incorporating aesthetic features for indoor applications.

While looking at the history of textiles, one would find the traces of different natural fiber products. It created a special link between the natural and social environment. Natural fibers had potential market, but due to some inherent properties and technological limitation in past, standardized process was difficult for bulk production resulting in reduction in utilization of these fibers.

Rapid urbanization has an adverse impact on natural resources and pollution level in our country. This alarming situation has created consciousness in the consumers to

consume eco-friendly products made out of the right combination and structure of natural fibers. This essentially will show major improvements/growth in the agricultural and textile industry thereby contributing to the overall growth in Indian economy. A material which can be lighter, thinner and easily installed having other additional properties like resistance to microbes, flame, etc. and are cost effective will have high demand in the coming years. Such revolutionary trends emerging, have expanded the opportunities to explore the unexplored fibers for various applications.

The purpose of study is focused on establishing the commercial viability of a complete eco-friendly process right from fiber to fabric. The main aim of the study is to utilize the structure of minor fibers and to expand its functional as well as aesthetical usage for niche product for a niche market. Sisal and ramie cellulosic minor fiber were selected based on its hollow structure and resistance to microbes and flame. These fibers are less utilized due to its stiffness, which was modified using enzyme treatment.

Extraction and processing of minor fiber is a tedious occupation, as the enzyme treatment has to be done in small quantity. Due to such a lengthy and time-consuming process lesser number and variety of utility products made from natural fibers are available in the market. This, draws attention to design and assemble tools/instruments, which can be easily installed in rural areas nearer to the cultivation areas of natural fibers. This will help farmers to cultivate more fiber and produce more fabric to fulfill the rising demand in the market.

The available sound resistant materials are made up of synthetic or man-made fibers or blended fibers having some kind of chemical reagents for binding. Mostly, glass fibers are used as base materials which are stiffer, thicker and non-biodegradable. They are known for bulk and easy production, long-term usage and are most efficient absorbers but are hazardous to human health as well as our environment. Thus, making materials from fibers which are renewable, biodegradable, eco-friendly, needs a thoughtful exploration to have functional cum aesthetical appropriate products for indoor applications.

Hence, the investigator proposed to work on “An Experimental Study of Fabric Structure using Minor Fibers for Sound Resistant Materials”. The need for using eco-friendly products has raised the importance of natural fibers and the need for a

sustainable process of creating product from such fibers. This study will further open the doors for other similar fibers to be used for apparel and many technical textiles.

With wide varieties of natural fibers grown in the country, Indian researchers have been exploring to develop composite textiles for automobile, aircraft, industrial and other such end applications. Efforts for application in indoor - residential and office areas to create an ambience for healthy working have been limited so far. Moreover, all such materials are nonwoven based having negligible aesthetics. The woven fabrics using various structures, combination of different yarns and adding any surface ornamentation and finishes will absorb sound as well as it will enhance the area of installation. Different aspects like the growth in utilization ratio of minor fibers, opportunity for handloom weavers to enter technical textile market and economic development of the farmers and our country will be focused under the study.

1.3. Objectives of the study

1. To study the chemical and physical properties of the ramie and sisal fibers.
2. To optimize the process of treating the fibers with enzymes for softening.
3. To prepare spun yarns of the untreated and treated fibers.
4. To develop hand woven fabrics with various weave structures and measure their effect on sound absorption.
5. To develop lab scale facility for the testing and analysis of sound absorption.
6. To evaluate the sound absorption properties of various unfinished and finished fabrics.
7. To assess the performance properties of the fabrics as per the end use requirements.

1.4. Delimitation of the study

1. The study was limited in its scope of utilizing only two cellulosic minor fibers i.e. Sisal and Ramie.
2. The study was limited to only woven fabric structures as front layer using different weaves i.e. Plain weave, Twill weave, Double cloth.
3. The study was also limited in terms of the application of only natural resin on the woven samples.

1.5. Scope of the study

- The main motto is to provide eco-friendly products which can resist or absorb the sound, also fulfills the aesthetic needs and having wider range of application. To increase the women empowerment and handloom sector.
- Eco-friendly process to enhance the fiber properties which makes it softer and pliable.
- Increase in consumption of minor fibers with eco-friendly fiber to fabric process will bring change in working environment as well as farmer's standard of living.
- Fabrication of small tools and machines for easy and speedy process at fiber stage, will increase employment near the fiber cultivation centers.
- Further creating a handloom product will increase the possibilities of artisans to enter the technical textile sector using minor fibers.
- Manufacturing products from minor fibers and developing the set up can be utilized in small cottage industry which will motivate people around those areas and bring overall change in the standard of living of our country.

Here, the insight of various researchers and reports used as the base of this study as well as the experimental details and its results to fulfill the framed objectives, has been divided and discussed in chapters that follow.