THE SAWDUST AND RECYCLED PAPER POTENTIAL AS THE ALTERNATIVE ECO CONSTRUCTION MATERIAL FOR PRODUCT DESIGN

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by

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நிலையான ஆதரவு, அன்பு மற்றும் பிரார்த்தனைகளுக்காக எனது தாய், தந்தை

மற்றும் எனது குடும்பத்தினர் அனைவருக்கும்

நன்றி!

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In the name of God, the Most Merciful and the Most Gracious.

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TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

Page

LIST OF APPENDICES

POTENSI HABUK KAYU DAN KERTAS KITAR SEMULA SEBAGAI ALTERNATIF KEPADA BAHAN KONSTRUKTIF EKO UNTUK REKA BENTUK PRODUK

ABSTRAK

Kajian yang dijalankan ini adalah untuk membangunkan satu kaedah bagi menghasilkan biokomposit berasaskan habuk kayu dan kertas kitar semula sebagai alternatif kepada bahan konskruktif eko bagi reka bentuk produk. Sejak kebelakangan ini, pengurusan sisa pepejal di Malaysia menjadi agak mencabar kerana kepesatan ekonomi dan pertambahan bilangan penduduk. Kawasan pembuangan dan pelupusan sampah yang sesuai agak sukar diperoleh dan kawasan yang sedia ada juga semakin terancam. Walaupun habuk kayu dihasilkan secara berkala pada setiap tahun di Pulau Pinang, namun lebihan habuk kayu tersebut tidak digunakan secara sepenuhnya untuk memperoleh keuntungan. Banyak kajian sedang dijalankan untuk mengenal pasti kaedah yang efektif bagi mengguna pakai habuk kayu, serta mengitar semula bahan kertas yang terpakai. Kajian ini tertumpu kepada penggunaan habuk kayu dan bahan kertas kitar semula bagi menghasilkan bahan mentah alternatif dengan menggunakan pengikat eko. Habuk kayu dan kertas kitar semula dikumpul, direndam, dibasuh serta digiling secara berasingan untuk menghasilkan bahan mentah alternatif tersebut. Habuk kayu dan kertas kitar semula yang telah digiling dicampurkan dan dibahagikan kepada lima bahagian untuk dijadikan sampel. Acuan yang diperbuat daripada plaster paris digunakan untuk menyerap kandungan air daripada campuran tersebut. Hasil yang terbaik diperoleh daripada campuran 75% habuk kayu dengan 25% kertas kitar semula. Sampel ini dipilih untuk lenturan skala kecil menggunakan

papan kayu fleksibel dan venir kayu melalui kaedah berlapisan. Lenturan skala kecil diperoleh daripada gabungan venir kayu dan biokomposit. Oleh itu, penyelidikan ini bertujuan untuk mengembangkan kaedah untuk memilih dan menggunakan bahan berasaskan eko untuk meminimumkan pembaziran dan mendorong rakyat untuk menyokong gaya hidup lestari. Bahan buangan hijau seperti habuk kayu mempunyai potensi yang luas untuk dijadikan sebagai alternatif kepada bahan berasa kayu kerana sifatnya yang serupa jika ia dihibridkan dengan kertas kitar semula. Penggabungan habuk kayu dan kertas buangan sebagai biokomposit bukan sahaja dapat mengurangkan masalah alam sekitar tetapi ia juga meningkatkan industri pembuatan produk ke arah lelestarian, keuntungan dan kesejahteraan.

THE SAWDUST AND RECYCLED PAPER POTENTIAL AS THE ALTERNATIVE ECO CONSTRUCTION MATERIAL FOR PRODUCT DESIGN

ABSTRACT

The study was conducted to develop a method of creating bio composite strips based on sawdust and waste recycled paper, as the potential constructive eco-material product. In Malaysia, solid waste management has become a challenging task to accomplish in recent years due to economic development and population growth. Appropriate dumping sites are becoming increasingly difficult to obtain and most of the existing ones are nearly exhausted. Moreover, in Penang, wood excesses including sawdust are produced annually and these are usually not put into profitable use. Studies are being directed at the search for possible effective ways of utilising sawdust as well as conceivable ways of recycling paper materials. This study focuses on the use of sawdust and waste paper in the production of alternative raw materials using an eco-based binder. In the production, the sawdust and waste paper were collected, soaked in liquid, washed and ball-milled separately. The two mixture were mixed together into 5 samples. Plaster of Paris's moulds were used to absorb the water content of the mixture. 75 % sawdust and 25 % of the waste paper mixture had shown the best result. This sample was selected for small scale bending using flexible plywood and wood veneer sandwich method. The small scale bending was obtained from the combination of wood veneer and bio composite strips. Therefore, this research aimed at developing methods to select and use eco based materials to minimise wastage and encourage people to support sustainable lifestyle. Green waste materials such as sawdust have

significant potentials to be the alternative to the wood materials in product making due to their similar properties when hybrid with waste paper. The integration of sawdust and waste paper as the bio composite is not only reducing the environmental issue but most importantly can boost the industry of product manufacturing towards sustainability, profitability and welfare.

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter describes the importance of sawdust and waste paper as the key product components which play an essential role in reducing environmental impacts and its relation to forestation and recycling. Due to the rapid growth in population the amount of waste produced around the globe has been increased exponentially. This rapid increase has created many problems for all living creatures such as humans and animals. The waste has created the problems of air pollution, water pollution, and other environmental issues. To face these issues and problems the waste management systems are introduced in the wood industries. It has impacted these industries in an enormous way. Through this now they are able to reduce the risks of problems caused by waste, and also they can ensure the higher profits for the industry by providing a safe and clean environment.

Similarly, the sustainable lifestyle is related to the concern of preserving the environments. Current day businesses all aim to produce goods at a low cost while maintaining quality, meeting user preference for more environmental friendly products and remaining competitive in the worldwide market. In order to help the businesses to meet these challenges, application of environmental considerations into the design process is an important key point. Design that suits the environmental ensures that raw material withdrawal and processing of reusable materials are done using materials and processes which are not dangerous to the environment. This comprises the minimization of waste and dangerous by-products, air pollution, land pollution, energy costs and other factors. Thus, this chapter outlines the research significance,

background of the problem, problem statements, research objectives, research questions, the scope of the research, the conceptual framework and the thesis structure.

Since the industrial revolution, we have witnessed a considerable amount of wood being harvested from forest trees on a large scale, for industrial wood production. These woods are used for a variety of applications, such as furniture construction and building applications. The rapid development of the wood-based industry has played a crucial role in the socio-economic development of many countries throughout the world. In this context, the contribution of the wood product industry to the Malaysian economy is also undeniable, as the sector has unfailingly contributed almost 4% to the gross domestic product (GDP) since the early 1980s (*NATIP National Timber Industry Policy 2009-2020*, 2009). In the same way as mentioned before the problems of sawdust has been increased exponentially. Sawdust or wood dust is composed of fine particles of wood. It is a by-product or waste product of wood which comes through the activities of wood-based industries. These processes can be done by woodworking machinery, the use of portable power tools and by use of hand tools such as the hand saw. Particleboard is normally made out of sawdust. During woodworking processes such as milling, sanding and sawing, two waste products are produced which are chip and dust. In Malaysia, the greatest challenge to the wood industries is to address and overcome the declining supplies of raw material and to maximize the utilization of available resources by investing in wood processing innovation. This is primarily driven by the increased awareness among the public about the value of the preserved and conserved environment. It is important to note that in order to ensure the timber forest resources are secured for the future generation, the Forest Protection Act has to be tightened.

Woods have been the preferred source of raw materials for furniture manufacturing in Malaysia. Over time, the wood-based industries in Malaysia have been affected by the lack of timber resources and increased timber prices. Furthermore, the existing reserves of wood materials are depleting. It is, therefore, important to find an alternative source of raw materials to replace the considerable use of wood in the manufacturing industry.

The report prepared by (*NATIP National Timber Industry Policy 2009-2020*), highlighted that Malaysia is one of the world's largest exporters and producers of tropical timber in the form of sawn timber, panel products (plywood, medium-density fibreboard and particleboard), flooring, doors and other joinery products. Thus, these timber industries normally generate big amounts of sawdust, which generally are regarded as worthless and always dumped at the land fields without people realizing its value. Paper, waste wood, sawdust, plastics and other biomass fibres are some of the major components of municipal solid waste. According to Hamid, Hussein, and Chu (2010) from the School of Communication, USM Penang, Malaysia, inappropriate solid waste management causes pollution such as soil, water and air pollution and health problems. Yet these materials offer great opportunities as recycled ingredients in wood composite. In line with the current environmental issues, the development of biodegradable products is crucial in sustaining a clean environment.

1.2 Research Significance

The significance of the study extends the research design further into ecological awareness investigation, primarily within the context of product design development. The significance of the study includes:

a. New knowledge of material science by incorporating hybrid bio-composites materials, created from sawdust and recycled paper, into the design research.

b. The findings contribute to the timber-based industries by broadening the knowledge of material science research in terms of product design.

1.3 Background of the Problem

Our environment is continuously changing and our earth is currently facing a massive amount of environmental distresses. Environmental problems such as global warming, pollutions, waste disposal, climate change and many more affect every living thing on this planet. Due to the fact that the increasing concerns about the effects on the environment, leading researchers are now on developing alternative energy resources from biomass that discharge less pollution to the environment.

Solid waste is by far one of the most critical environmental issues in every country due to rapid economic development and population growth. Open dumping, landfilling and open burning are the main disposal methods that were found to be used in Malaysia (Johari, Alkali, Hashim, Ahmed, & Mat, 2014). This disposal approach creates various environmental and health problems. The strong leachates are detrimental to the surface of the earth and the decompositions of organic materials produce methane gas, which can cause fire and explosions and consequently contributes to global warming (Sridevi, Modi, Ch, Lakshmi, & Kesavarao, 2012).

Malaysia, like other developing countries, has been facing considerable difficulties in dealing with the problem of municipal solid waste and its management. According to Johari et al. (2014), in their article entitled “Municipal solid waste management and potential revenue from recycling in Malaysia”, about 90-95% of the

collected waste are still being disposed of in landfills. Despite the fact that 70-80% of the waste is recyclable, only 5-10% have been recycled. In Malaysia, the main component of solid waste is organic. Food waste, paper waste and plastic waste covered about 70% of the total amount of solid waste produced in Malaysia (Johari et al., 2014).

Apart from being regarded as mere municipal solid waste, agro waste can in actual fact be considered as potential recycling material. Malaysia is among the topmost important palm oil producers in the world. It is listed that the production of palm oil comprises only 10% of the total biomass produced and the remaining 90% of biomass is unwanted waste and it is considered as one of the promising potential materials that can be recycled (Awalludin, Sulaiman, Hashim, & Nadhari, 2015). Meanwhile, Ghani, Abdullah, Loung, Ho, and Matori (2008) stressed that agro wastes such as rice husk, palm kernel and coconut shell are also suitable for recycling as construction materials.

In brief, waste has become an acute problem in Malaysia. Since most of the landfills in Malaysia have reached their lifespan, incineration and composting would be a better choice to reduce the quantity of the wastes being disposed of using the landfill method and it will also minimize the environmental effects (Johari et al., 2014).

1.4 Problem Statement

In the wood-based industries, sawdust is considered a waste product. Wood waste is often generated from the by-products of wood-related activities and from non-commercial wood resources. According to Shafie, Othman, and Hami (2017), wood waste can be classified into two types of biomass energy namely waste from forest and wood waste from wood-based mills. In 2010, the wood industries in Peninsular Malaysia generated 152,3073 cubic meters of wood waste from the forest and wood-based mills (Shafie et al., 2017). Despite its massive amount, these agricultural and

wood waste have yet to be fully utilized (Antwi-Boasiako & Acheampong, 2016). The Malaysian Peninsular harvested about 1.2 million tonnes of wood logs per year which is equivalent to 60-65% of the total harvesting area and the remaining wood and wood waste being left to rot and burn.

Figure 1.1: An example of excess wood waste in the industry that involves dumping and land burial. (Self-creation)

Figure 1.1 illustrates sizable heaps of sawdust surrounding the locations of sawmilling and timber industry. Picture labelled A, taken from official website of Benwood Industry, Bukit Mertajam, Pulau Pinang and picture labelled B taken by researcher from a dumping site in Pulau Pinang. The non-utilization of the sawdust creates the disposal problem. A preliminary study conducted by Ibrahim (2006) on the potential of using Malaysian wood waste as a secondary raw material for pulping discovered that the Malaysian tropical hardwood has never been used as a raw material before. Similarly, the paper waste has also been a topic of debate around the globe since many years. Paper is a common recyclable material. It is a thin flexible sheet made out of fibres of cellulose pulp which is derived from wood and grasses. Paper is also a useful material with many uses such as for writing, printing, packaging and many other industrial and construction processes. Papers come in many distinct forms. Old

magazines, newspapers, cardboard, tissue paper, printed office papers are some of the recyclable papers.

The overpopulation has impacted the environment badly. More people need more space for living purposes. To fulfill these requirements they are trying to remove the forests and are covering the agricultural lands to get settled. Their settlement in the agricultural lands is creating several issues like lack of food resources, reduction in exports, and so on. In the same way, the elimination of forests has risen many issues, such as the shortage of wood for manufacturing, buildings, and fuel (Nathan, 2011). The deforesting has affected the lives of plants and animals. These deforesting practices has contributed in wood waste production in enormous way. It is observed as one of the prime source of producing wood waste. Nowadays, every manufacturing industry is coming out with newer and innovative wood products that looks far better than the existing ones. Due, to these practices the wood waste issues have been increased exponentially and become a topic of debate since many years. The main reasons behind the rapid increase in technology are the rapid growth in economy, urbanization, and the increased demands of wood materials.

Due to the scarcity of raw material alternatives and the abundance of industrial and municipal waste that contributes to the environmental problem, the potential of using sawdust and paper waste as eco-based composite material was explored. The utilization of sawdust and paper waste as a hybrid material was to reduce the amount of waste abundance. This study focuses on the hybridisation of the sawdust and waste paper as an alternative construction material for product design. By utilizing the sawdust and paper waste, it encourages environmental sustainability, decreases the greenhouse effect and solves the waste disposal problem by transforming the available biomass resources into innovative and value-added products.

1.5 Research Objectives

The objectives of the study are as follows:

a. To study the potential and limitation of the sawdust and waste paper material as alternative eco raw materials.

b. To identify a techniques of converting the sawdust and waste paper mixture into fibre strips/sheets.

c. To evaluate the standard bending strength of the designed fibre strips/sheets.

d. To propose a product design concept based on the experiment of the designed fibre strips/sheets.

1.6 Research Questions

a. What are the potential and limitation of sawdust and waste paper material's as an alternative eco raw material?

b. What are the techniques to converting the sawdust and waste paper mixture into fibre strips/sheets.?

c. What is the standard bending strength of the designed fibre strips/sheets?

d. What is the product design concept can be proposed based on the experiment of the designed fibre strips/sheets?

1.7 Scope of Research

This is a design research that mainly focuses on the study of creating a combination of sawdust and waste paper materials through a series of experiments. This research also focuses on the conceptual design of a lampshade which derives from the strength test validation.

1.8 Conceptual Framework

The conceptual framework presents the understanding, insight, knowledge and abstraction of the thesis. The framework was constructed based on the connections between sustainability, the efficiency of using recycling materials and the adaptation of the selected materials to demonstrate the significance of recycling, material hybridization and product design. Figure 1.2 illustrates the conceptual framework.

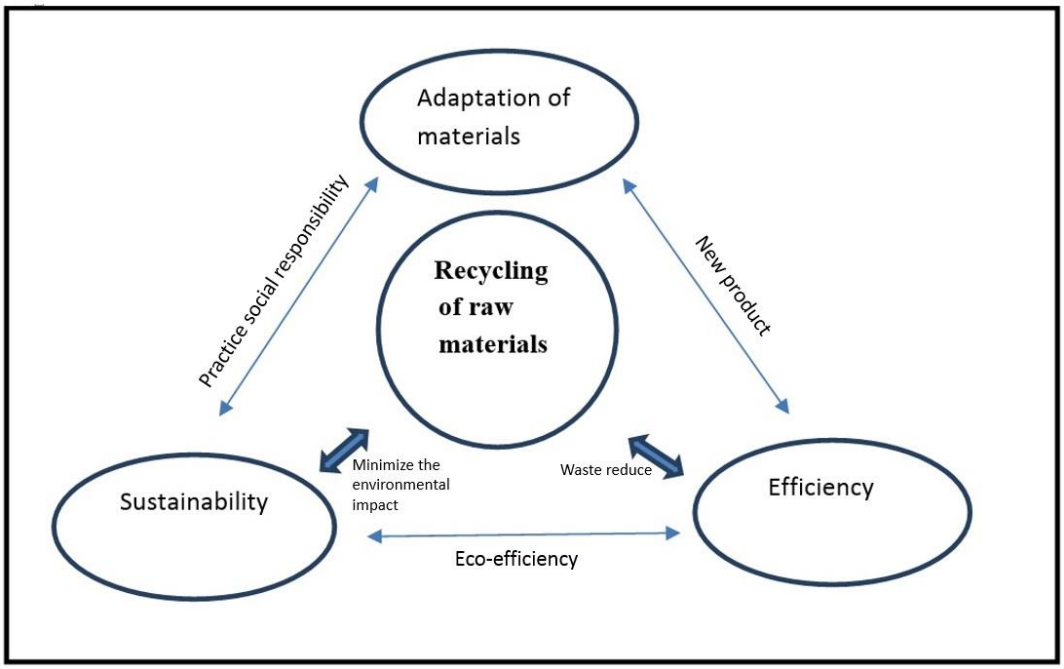

Figure 1.2: The research conceptual framework. (Self-creation)

Based on Figure 1.2, the recycling of raw material is the key concept behind the construction of the research framework. There are two key points related to the recycling of raw materials. The recycling of available resources and waste materials is an important part of sustainability because it reduces the negative human impact on the environment and helps reduce the pressure on natural resources. Meanwhile, the adaptation of materials, especially the recycling of raw materials will eventually motivate Malaysians to practise social responsibility. The successful implementation of the recycling concepts can lead to the creation of new products, processes, software and technology solutions.

1.9 Thesis Structure

Chapter 1: Presents a brief introduction to the research significance, background to the problem, problem statement, research objectives, research questions, the scope of the research and conceptual framework. This chapter also describes the surrounding issues and discusses the research design.

Chapter 2: Provides the foundation of the research concept and context, the research gap and the potential for further improvement based on literary reviews. The chapter also discusses the design aspect that can showcase the potential use of alternative eco-friendly raw materials. This chapter is all about the literature review that has been the helping tool for the research.

Chapter 3: Describes the research methodology of the thesis and provides details about the research processes, the experiment based on the mixed-method research and the validation method involved in the study that features a series of tests. This chapter also focuses on the design of a product that utilised the sawdust and paper waste bio composite strips. Additionally, this chapter elucidates the design process that includes the design concept, idea and development and product functioning. The conceptual models of product design is created using software based on the specific data collected from the results of the experiments.

Chapter 4: Includes the experimental results and analysis of the bio composite strips of sawdust and paper waste. This chapter also emphases on major findings and data interpretation of the experiment that carried out on sawdust and paper waste.

Chapter 5: Concludes the overall thesis of on the evaluated bio composite strips. Then, the chapter further discusses the importance of the research for academics and

industries. Finally, recommendations for further research potential related to this study are proposed.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Many journal articles, books and data have been reviewed to identify key ideas and gaps in the current study. The main difficulty encountered when sourcing the information about alternative eco-based materials for product design is the lack of design elements in the research articles. Two different fields such as material science and arts are rationally immanent in this researcher's research. This chapter provides the background regarding the process of recycling particularly in Malaysia, composite materials, natural fibres, hybrid materials as well as product applications and experiments related to value-added bio composites wastes. The reviewed literature also explains the theoretical framework that will subsequently form the foundation for this research. The theoretical framework is employed in order to achieve the research objectives and to display the significance of the waste materials from the wood industries and municipal wastes research in relation to the study of design.

2.2 Theoretical Framework

A theoretical framework is important to determine the research and design information produced. The theoretical framework of the sawdust and waste paper bio composite strips for product has been developed as illustrated in Figure 2.1.

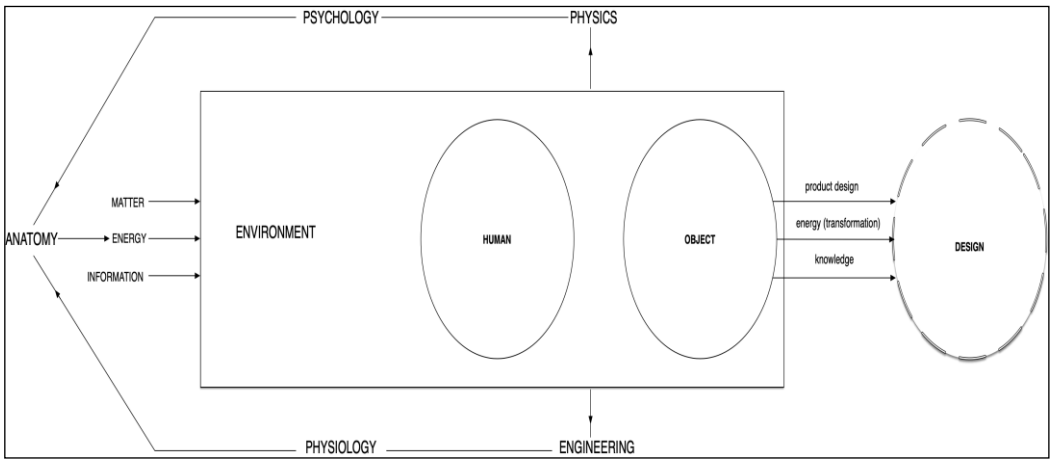

Figure 2.1: The ergosystem framework created by (Abdullah Sani, Mohamed Kamil, Azahari, & Sulaiman, 2019)

Ergonomics Ergosystem framework is a template for the optimisation of the system operation and can also be applied within the context of the product design. This framework was adopted and adapted by Abdullah Sani et al. (2019) from the structural ergonomics work system of Bridger (2009). Even though the ergosystem framework and this researcher's research framework are based on two distinct fields, some adaptation can be made and it can be synchronized. Based on the ergonomic ergosystem framework mentioned earlier, a fundamental product to design structure has been established. In other words, the researcher's investigation expands the contributing fundamental needed to subsequently fill the gap in this research. The key concept is anchored by the idea of incorporating the manufacturer and manufacturing needs in furniture production that contemporaneously engages environmental concerns and responds to the creation of potential environmental friendly material for the industry.

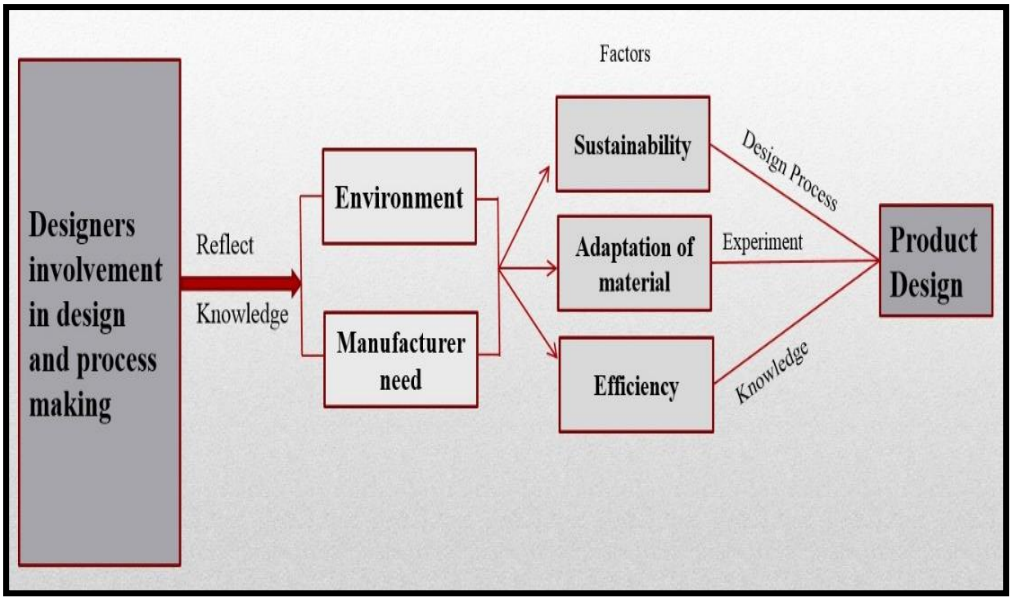

Figure 2.2: The theoretical framework of the sawdust and bio composite strips (Self-creation)

Figure 2.2 shows the framework of the research and design study involving the sawdust and paper bio composite strips that have been adopted and adapted for the purpose of this research.

The created framework refers to the discussion related to the objectives of the study and the review of related literature. All the keywords proposed, reflect the whole domains of product design to support the whole development of the study. The main idea of the theoretical framework is to demonstrate the theory used in explaining why the research problem examined in this study exists. There are three factors involved in the production of a product which are sustainability, the adaptation of the material and expertise of a designer to produce a product. General knowledge of materials is needed in order to produce a product and the designer's involvement in the design and process making of a product requires them to use the knowledge to balance between the environment and manufacturer's needs. The study of material processing and the design application of the materials are acknowledged.

It has been witnessed through several studies that the problem of wood waste has been rapidly increased due to the improper waste management. The wood waste producing industries have the essential needs to adopt innovation management for managing the wood waste. Most of the industries have introduced the innovations management systems, but they have faced several problems to accept it. If we analyse the innovation strategies closely, it is clear that innovation is completely unpredictable. This is because it can't be calculated nor distinct and for itself, it can be considered as an unclear experience (Meyer, 1999). One of the major reasons is that the dark corner of innovation is fully dependent upon diversity, which is offered by the players. The innovation process is using the way of social behaviors and cooperation of a specific culture from society. The whole process is working under social principals and their rules. These entire social rules can be analyzed, observed, and developed through the process. To achieve the development of the social system is the prime and important factor of innovation.

The main advantage is that through this we can enhance the traditional programs and strategies to focus on technology advancement and traditional behaviors. In order to meet the desired goals of innovation, we have to look after the cultural and social diversities among the innovators and labor involved in the process (Pohlmann, 2005). It is necessary to consider these factors for the effective and efficient process of formation and implementation. It is the reality that there is the only factor that defines the elements and parts of the process, and that is culture. It has a great impact on innovation. In order to analyze the cultural types of innovation systems, we require proper guidelines. In general, these requirements include:

It requires the proper reasoning and understanding for which the innovation is needed, the process through which the idea from the individual will be converted to the

system, the main contributors should be mentioned for the process of innovation, and either the prediction regarding innovation will be approached or not. The innovation system is affected by social systems. Culture has also a huge impact imposed on innovation. It is described by the culture in terms of identity and difference, knowledge, and the sets of values, norms, and beliefs of society (Pohlmann, 2005).

2.2.1 Environment

The sustainable lifestyle is related to the concern of preserving the environments. Current day businesses all aim to produce goods at a low cost while maintaining quality, meeting user preference for more environmental friendly products and remaining competitive in the worldwide market. In order to help the businesses to meet these challenges, application of environmental considerations into the design process is an important key point. Design that suits the environmental ensures that raw material withdrawal and processing of reusable materials are done using materials and processes which are not dangerous to the environment. This comprises the minimization of waste and dangerous by-products, air pollution, land pollution, energy costs and other factors.

Researchers from Department of Engineering Design and Manufacture Faculty of Engineering, University Malaya stated that, eco-design, design for the environment, design for recyclability, green supply chain, reverse logistics, product stewardship, and/or product take-back have been initiated in developed countries such as Japan, Australia and European countries. Strategic measures and initiatives in developing countries like Malaysia, on the other hand are still far behind. Incentives and initiatives by the government or the industry are still at infancy level (Taha, Sakundarini, Raja Ghazilla, & Gonzalez, 2009). The designer's involvement in the design and process

making should aim at adapting and developing methods to reduce wastage and ensure the highest life quality. Without doubt, the new design of sawdust and waste paper bio composite product are being required to inspire people to support a sustainable lifestyle in the next era.

There are several wood industries around the globe that are producing a large amount of wood waste that must be utilized, marketed properly, and should be disposed of effectively. In Nigeria, there are different practices for wood waste, these wastes are supposed to be burnt in open areas, dumping in water bodies or in open areas that cause the serious problems of environmental pollutions (Elegbede, 2016). Furthermore, the author has defined that the Nigeria is producing over 1,000,000 m3 of wood waste as recorded in 2010, in the same way almost 500 m3 wood waste was generated by plywood mills. In the same study the author has described that Nigeria is generating about 1.8 million tons of sawdust per year and along with this it is producing almost 5.2 million tons of wood waste annually. These inappropriate and ineffective methods of maintaining the wood waste creates several issues in the aquatic and terrestrial ecosystems. The waste that would not be disposed properly will create the problems of water pollution, air pollution, and many other problems that may harm the nature. The waste spread in the surrounding areas, especially in air and water that may harm the animals that use the water from rivers and canals. In the same way the wood waste that is supposed to burn in open areas, will create the health problems. As we know that while the burning of wood waste, it emits greenhouse gases into the atmosphere that cause many health issues to the living things. This study suggests that the effective use of wood waste through recycling or reusing can resolve many issues in Nigeria, such as the reuse or recycle of the wood waste will save the forests through limiting the needs of extra wood. In the same way by introducing the recycling plants, the job ratio

will be increased that will help Nigeria to get rid of poverty and unemployment (Owoyemi, 2016). This paper has provided some detailed methods and processes of food waste disposal in Nigeria that can be essential to control the issues as mentioned before.

A study has defined the environmental consequences of different recycling alternatives for wood state. It has shown the complete framework of waste management in the EU (WFD) that was adopted in 2008. Further, it has set the target according to the expected results that defines that by 2020, the planning and preparations for the re-use and re-cycling of wood waste that may include the backfilling methods that may substitute the other materials, the safe and clean constructions and disposed waste except the naturally defined materials according to the category 17 05 04 in the list of waste is expected to be increased to a minimum of 70% according to the weight (Erlandsson, 2014). This paper aimed to provide the effective ways and techniques to assess the consequences of the WFD target mentioned above. This all was done according to resource management and diffused pollution depression. This study has achieved main conclusions which state that the EU recovery target does not ensure a sustainable waste recovery in its present form since it favours recycling of high density waste types. The mineral wastes has the minimum impacts on the environment but, it is offering maximum benefits to the society. It is observed that it is not favouring the sustainable recovery operations. Along with this, it is very sensitive to interpretations of what is considered as waste and waste recovery. To deal these issues the study has provided some possible recommendations. Such as according to it, the targets on the basis of general waste should be transformed to waste specific targets. For reporting progress we should use the recovery operations in the calculation.

Another research that is conducted by a well-known organization Defra in 2012. It describes the short review on wood waste, according to it the government policies of 2011 are not appropriate for the wood waste and that will put us in alarming situations. The government has committed to provide the green facilities by maintaining a good waste management. It is important for us to know that how we will face the consequences of wood waste through its management. It has been witnessed that the wood waste has created many problems throughout the history such as, material security, energy, climate change, global warming, and many other environmental problems.

This study has observed that there are several resources to generate the wood waste, it is produced by different sectors such as forests, mills, and other wood industries. This study has described the four categories of wood waste defined by the Wood Recyclers Associations. These are Grade A, Grade B, Grade C, and Grade D. In the UK, the recovery and reprocessing of Grade A and (probably) Grade B are well established, but routes to divert and recycle Grades C and D are less effective. The Grade A wood waste is considered as the clean and recycled wood. It has a huge market for the manufacture of products such as animal bedding, horticultural mulches, and the panel-board sector. Fuel in non WID installations, or manufacture of pellets/briquettes. The sources for raw material for these wood wastes can be distribution, retailing, packaging, secondary manufacturer e.g. journey, and pallets. The Grade B wood waste are the industrial feedstock that can be used for a feedstock for industrial wood processing operations such as the manufacturer of panel products including chipboard and medium density fibreboard. The important sources of raw material for recycling are the same as Grade A wood waste, plus construction and demolition operations, and

transfer stations. In the same way the Grade C is fuel grade and Grade D is hazardous waste that need immediate disposal at special facilities (Defra, 2012).

This research for Defra has summarized and compared the current information regarding the rapid growth of wood waste and also it has described that how these are affected by the seasonal and regional factors. It has provided the required data for the current situations of wood waste and also it has defined some strategic solutions for the control of wood waste and to ensure the effective waste management in the system according to the defined wood waste policies from the government.

Many of the studies have defined that to face the issues of all types of waste especially wood waste can be controlled through an effective waste management. It has been witnessed that human activities have been generating waste throughout history (Vandana, 2018). Before the current situation this was not a big issue because there was a small population. But, now the situation has been changed after the rapid growth in population. The exponential increase in waste has created many issues. For managing the waste there is a waste management system. It is the process that is responsible to perform the actions that are required to manage waste from its production to final disposal. These actions can include the collection, treatment, transportation, disposal of waste. Poor waste management causes serious issues like the impurity of water, soil, and atmosphere. It also has a great impact on human health by creating several diseases. Wood is considered as the prime factor of waste production. It is no doubt the wood is benefiting the society, but along with this it is creating several environmental issues that have been a topic of debate around the globe (Ozarska, 2009). It is emitting ammonia, greenhouse gases, and pathogens. Both developed and developing countries are trying their level best to overcome these issues. It has also created huge challenges in the wood industry, and for dealing with these

issues, the wood industry has adopted proper waste management processes. These processes have great impacts on these industries. This paper aimed to analyze the principals of waste management and its impacts on the wood industry. It will further evaluate the key advantages and disadvantages of waste management in the wood industry.

Many types of research have observed that there are several issues created by waste, but with effective waste management they can be overcome. Waste management is the process that allows the waste to be managed effectively. It includes the activities and actions that are necessary to control the issues created by waste. Such as they ensure the effective handling of waste through the proper collection from production places, transportation to the waste handling plans, their proper treatment at the plant, and the complete disposal according to desired needs (Richa, 2018). The process of waste management is monitored and regulated by the regulatory departments. The industries such as wood are supposed to follow the rules and regulations defined by the waste management. There are several types of waste, they can be solid, liquid, or gas. These types have different methods of control and disposal. Waste management is responsible to deal with all types of waste either they are industrial, biological, or household. In most cases waste creates serious issues for the environment. Such as air pollution due to the emission of dangerous gases, skin and other infectious diseases, and many other public health problems.

The waste hierarchy defines 3-Rs that are reduce, reuse, and recycle. The purpose of the waste hierarchy is to ensure the maximum profits from the products and produce the minimum amount of waste. This hierarchy can be represented as a pyramid, and its basic function is to reduce the production of waste by taking important measures. In the second step it is responsible to ensure the effective use of waste at

other alternatives, in other words to re-use it. The final stage is to recycle waste through proper disposal. The final step can't be prevented and recovered (Jaspal, 2018).

This is the same process of waste management is followed in the wood industries. As it is mentioned before that the wood industries are the prime contributor to produce waste. They produce tons of waste on daily bases, and these wastes have negative impacts on the industry such as; the animals get affected by many diseases, there are several deaths of animals from wood industry recorded every year that are caused by the waste like plastics and rubbers. The animals use to eat the waste that causes many harms to them. In the same way the waste materials can be tangled around the bodies of animals like heads that cause serious injuries to them. These wastes also cause many diseases to the human around wood industries (Suttie, 2004). Such as the garbage cause the increase in risks of contacting the dangerous bacteria that can cause typhoid fever, food poisoning, enteric fever, other major illnesses. So to get rid of these issues and problems, it is important to have a proper waste management system. It will reduce the risks and ensure the safe environment in the wood industry for both animals and humans around it. They are responsible to handle the waste produced in the wood industry effectively and efficiently.

There are several impacts of waste management on the wood industry. It has offered many benefits to the industry. Such as it has made it easy for the wood industry to manage the huge amount of waste through efficient ways. The waste management ensures the quick and safe collection of waste from wood industries that help them to minimize the negative effects of waste on the wood industry. Through this they can avoid the health risks and problems created by waste. Through proper waste management the wood industry can ensure higher productions and profits by providing a clean and safe environment to the workers and customers. Due to the poor waste

management the wood industry faces many challenges such as the workers do not take a serious interest in working due to the lack of cleanliness and safety (Fernando, 2010). The waste creates significant challenges for the employees and customers as mentioned before. So it is important for the industry to ensure the effective waste management process to face the issues. Through effective and efficient waste management processes the wood industry will be able to save their animals from the dangerous impacts of waste. It can help the industry to increase its overall revenue by attracting more customers and stakeholders. Along with this it is also a prime responsibility of the wood industry to reduce the impacts of waste on the environment. Through a proper waste management system the industry can ensure the safety of the environment around it. The problems created by waste like air pollution, water pollution, and other environmental issues can be mitigated through an effective waste management system. The emission of dangerous gases and reducing the flow of dangerous water to the canals and rivers can be dangerous for human lives and agricultural lands. So it is the utmost need for the wood industry to adopt an effective and efficient waste management system to overcome the issues.

Due to the rapid growth in population the amount of waste produced around the globe has been increased exponentially. This rapid increase has created many problems for all living creatures such as humans and animals. The waste has created the problems of air pollution, water pollution, and other environmental issues. Wood industries are also the main sources of waste production. To face these issues and problems the waste management systems are introduced in the wood industries. It has impacted these industries in an enormous way. Through this now they are able to reduce the risks of problems caused by waste, and also they can ensure the higher profits for the industry by providing a safe and clean environment (Daian, 2009).

Wood bending has also contributed to the environmental hazards by generating wood waste. It has been an ancient craft that is considered as one of the important factor in many industries. These methods are used to produce the curved parts of wood. It is among the most economical procedure to meet the desires (Won-Tek, 1999). This technique is used since ancient times to process the wood for effective usage, such as making of boat, barrel, violin, and applied mechanics in wheel-making. The Europe has been using this technique since ancient times for making of chairs that can be shown through their ancient paintings. They used a simple method for this technique, at first they used to completely trim the wood according to desired lengths and volumes, after that it was put in a pot where it used to get steam, and after getting steam, the wood became very flexible and at that time it was easy for the manufacturer to press and turn the shape of wood according his desires. These processes have caused a huge number of wood waste that created several environmental issues.

It is observed by many studies that the use of wood bending and other types of materials has created many waste problems in the environment. Unlike this, the usage of synthetic materials in composites has resolved the issue of wood waste in enormous way. Bio-composite materials are produced with natural fibres or natural resins instead of synthesized fibres (carbon, glass, etc. fibres) or resins (poly vinyl alcohol, epoxy, etc. resins). The bio-based fibres such as jute, sisal, flax, hemp, bamboo, hair, wool, silk etc. (Ozcanli, 2018). Their properties that are very compatible have gained interest among industries. However, due to the environment, health and sustainability issues, the current generation has witnessed remarkable achievements in green technology through the development of bio composites. Bio composite's properties are influenced by fibre type, environmental conditions, processing methods and any modification of the fibre. These bio composite materials introduce many