# STUDY OF THE POSSIBILITY OF MANUFACTURE OF INDUSTRIAL PRODUCTS USING LOCAL AGRICULTURAL RESIDUES

**By**

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B.SC. ENG. Al Azhar Universtity, 1982
Diploma, in Environmental Science, Ain Shams University, 1997
Master in Environmental Sci., Ain Shams University,2003

**A Thesis Submitted in Partial Fulfillment**
**of**
**The Requirement for the Doctor of Philosophy**
**In**
**Environmental Science**

**Department of Engineering**
**Institute of Environmental Studies & Research**
**Ain Shams University**

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APPROVAL SHEET

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# CHAPTER 1

# INTRODUCTION

## 1.1 Sustainable Materials Management

The past two centuries have seen unprecedented growth in human population and economic well-being. This growth has been fed by equally unprecedented material resource consumption and its associated negative environmental impacts.

Economic and trade integration among countries has enlarged the size of markets, allowed greater specialization and mobility in production, increased the role of multinational enterprises and led to an overall increase in international flows in raw materials and manufactured goods.

Making sure that material resources are managed sustain ably and used efficiently through their life-cycle is vital to economic growth, environmental quality and sustainable development. It would also help reduce the negative environmental impacts, associated with the production, consumption and end-of-life management of material resources [16] .

## 1.2 Definition of the Renewable Material Resources

Materials can be classified as renewable and non-renewable as seen in Fig. 1.1 [21].

The renewable material resources (RMR) are those resources of biological origin, sometimes called biomaterials.

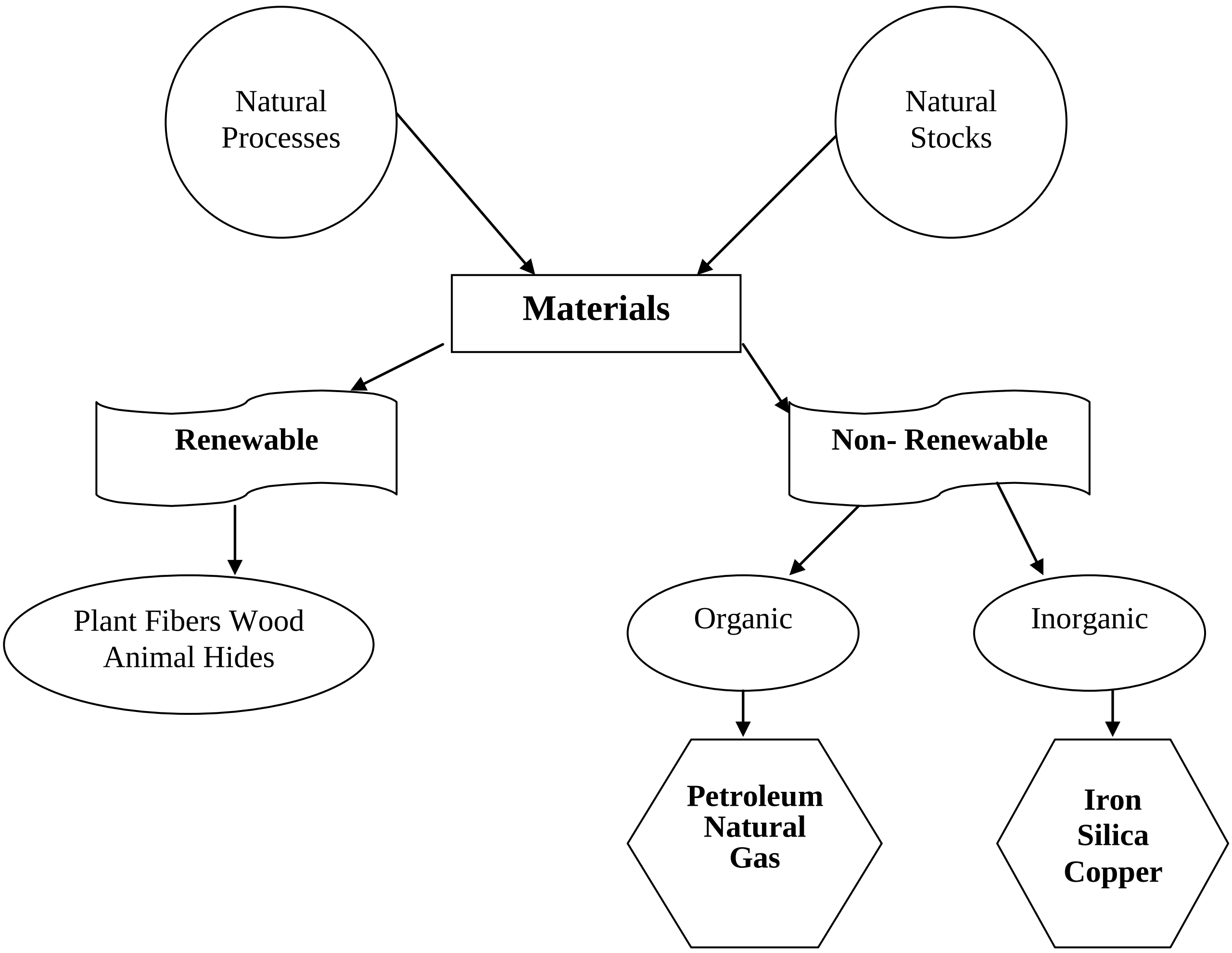


**Fig. 1.1. Classification of raw materials [21].**

The renewable materials include plant and animal fibers, hides and wood. The non-renewable materials are derived from two kinds of materials, those classified as organic materials (petroleum, natural gas and coal) and as inorganic materials (e.g., iron, silica, copper). Derived from ecosystems, the raw materials or natural resources can be seen as part of the ecosphere that is useful for human kind. For example, both tropical forests and a specific crop or tree are considered to be resources**.** Therefore, actual renew ability is conditional in the sense that it depends on human influences upon ecosystems **[13].**

## 1.3 Forest Loss

Forests actively contribute to the world's environmental stability and are used as economic resources to produce subsistence and industrial forest products. In addition, they have cultural and recreational resources to perform multiple roles, such as preventing soil degradation and erosion, protecting watersheds or value mountainous areas. They limit the greenhouse effect contributing to global warming, by absorbing $CO_2$ (the main greenhouse gas). Inversely, forest degradation increases CO2 emission. According to some experts, forests serve as natural habitats to almost two thirds of all Earth's species, therefore acting as a stronghold to sateguard biodiversity. On an economic level, forests may be used as direct source of energy or raw materials. Finally, forests play a cultural role in almost all societies, as mythical sceneries or historical backgrounds and as living habitats for about 60 million people worldwide: indigenous and non indigenous [19].

## 1.4 The Agricultural Residues

The agricultural residues (AGR) is a new term, and a response to market rationality putting emphasis only on the primary products of the renewable material resources. According to Fig. 1.2, the agricultural residues are byproducts of the agricultural activity. Most of these residues are being burnt in the open field to clear the fields for the next crops or are used as a fuel at very low efficiency or for the production of charcoal**[14].**

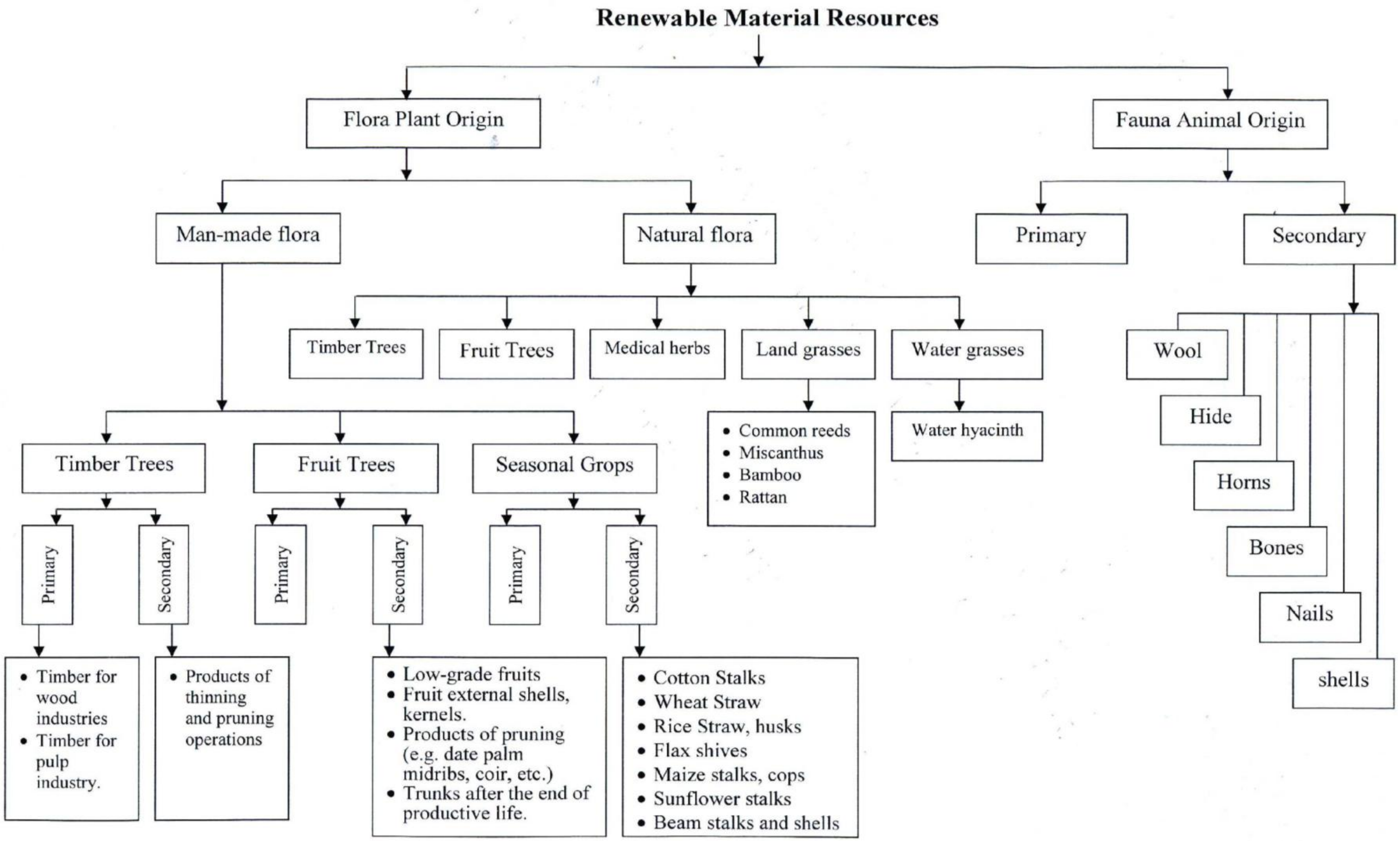


**Fig. 1.2 Classification of RMR [14].**

## 1.5 Significance of Agricultural Residues

The agricultural residues are easily accessible to people without necessarily the intervention of the government or transnational. They are simply on the surface of the earth and don't need sophisticated equipment for their extraction. The agricultural residues are annually renewable material resources. Therefore, they have a very strong availability potential as compared, for example, with timber. Besides, they are extremely cheap in most cases. Their cost in most cases is confined to the cost of their processing and transportation until the site of industrial utilization. Besides, due to their biodegradability and / or bulky character, their prices are safe from the fluctuation of prices in the national and international markets **[30].** The economic use of the agricultural residues improves the added value of farmers, since they could sell their primary products, as well as their secondary products, i.e., agricultural residues. The economic use of the agricultural residues provides a very practical environment- friendly mean for the preservation of the environment in rural areas, where these residues are produced. Therefore, we could avoid fire occurring, for example, in unpruned palm gardens. We need not burn cotton stalks or use pesticides to combat against the cotton pink worm in case when we use cotton stalks as an industrial material.

## 1.6 The Modern Industrial Utilization of Agricultural Residues

Wheat straw chemical pulp was first produced in early 1827. Crop residues, such as bagasse (sugar cane residue) have long been used in making paper in China, India, Pakistan, Mexico, Brazil, and a number of other countries. In the U.S.A, the use of crop residues in paper marking dates back to world war II in the 1940s. 25 mills produced almost 1million tons of corrugating paper from wheat straw. Egypt, from 1960 to 1977, relied on agricultural residues as a source for a raw materials for industry: flax shives and bagasse for particleboard and rice straw for fiberboard. The 1990s have witnessed a surge of interest in the use of AGR in composite panel manufacture in USA and North America in general. In the mid 1990s North America "rediscovered" agri-fiber panels **[6].** The car industry in Europe has consumed a yearly amount 6000-7000 tons of natural plant fibers (NPF) within the period from 1900 to 2000 and 8500-10000 tons from 2000-2003 and the future estimates will increase considerably **[12].**

# CHAPTER 2

# COMPOSITE MATERIALS

## 2.1 Composite Materials

The aim of using composite materials is to find materials with right properties to meet the demands of design, service and economics. There is no universal accepted definition of composite materials, but we can define a composite material as a material system, composed of a mixture or combination of two or more macro constituents differing in form and/ or material composition and are essentially insoluble in each other.

## 2.2 The Advantages of Composites

Composites are light, stiff and strong, and allow both large and small series production at strongly reduced energy cost. The lightness of composites also increases energy efficiency during use in transportation, machinery or sporting goods. Any composite material consists of

1. **Matrix**: as a bonding.
2. **fiber** : as a reinforcing material.

The most traditional type of fibers was the glass fibers because of their high mechanical properties. Also there are other many types of fibers as shown Fig. 2.1. **[32].**

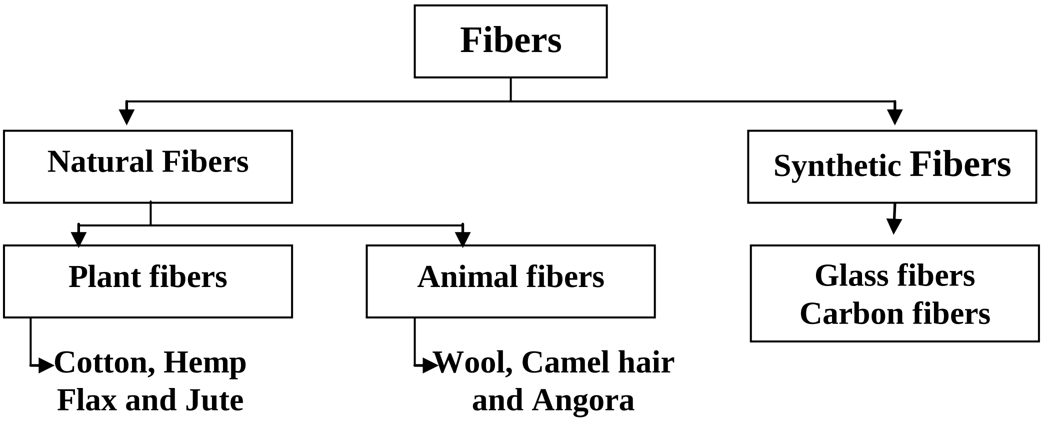


**Fig. 2.1 Classification of fibers [32].**

Fibers are classified as natural fibers and synthetic fibers. Among the natural fibers we find plant fibers like cotton, flax, hemp or jute, and animal fibers like wool or camel hair and angora. Recent reports indicate that plant-based natural fibers can very well be used as reinforcement in polymer composites, replacing to some extent more expensive and non-renewable synthetic fibers, such as glass.

## 2.3 The Disadvantages of Composites

- Variable quality, depending on unpredictable influences, such as weather.
- Moisture absorption, which causes swelling of the fibers.
- Restricted maximum processing temperature.
- Lower durability, fiber treatments can improve this considerably.
- Poor fire resistance.
- Price can fluctuate by harvest results or agricultural polices.

## 2.4 Fiber – Matrix Composites

The main factors influencing the quality of fiber matrix composites are fiber, matrix and bonding phase.

### 2.4.1 Fiber

The factors, which contribute to the engineering performance of the fibers are:

**A. <u>The Orientation</u>**

One dimensional reinforcement is more efficient in the direction of fibers (has maximum strength and modulus in the direction of fibers). Plane reinforcement exhibit different strengths in each directions of fiber orientation. The three-dimensional reinforcement exhibits lower strength in the three directions.

**B. <u>The Length</u>**

1-Short fibers. 2-Long fibers. 3-Continuous fibers.

**C. <u>The Shape</u>**

The fiber may be of circular cross section, hexagonal, rectangular and irregular cross section.

**D. <u>The Composition of the Fiber</u>**

Both organic and inorganic fibers are available. Examples of the organic fibers are cellulose, polypropylene and graphite. They are characterized in general by light weight flexibility, elasticity and heat sensitivity.

Examples of the Inorganic fibers are glass fibers, tungsten and ceramics. They are characterized in general by high strength, and heat resistance. They are rigid and low in energy absorption and fatigue resistance, elastic and heat sensitive.

### 2.4.2 Matrix

It serves two very important functions. It holds the fibrous phase in place and under an applied load it deforms sand distributes the stress to the high-modulus fibrous constituents.

The choice of the matrix is limited by the requirement that it has greater elongation than the fibers (at least 1% more than the fiber). The matrix also must transmit the force to the fibers and change shape as required to accomplish this.

### 2.4.3 Bonding

It means the integrity and the bonding between fibers and matrix. Fiber composites are able to withstand higher stress than either of their individual constituents, because the fiber and matrix interact and redistribute the stresses. The ability of these two constituents to exchange stresses depends critically on the effectiveness of the coupling and bonding between them. Such bonding can be attained by direct contact of two phases, but usually a specially treated fiber must be used to ensure a receptive adherent surface. Chemical and mechanical bonding (interaction) occur. Voids are harmful, because portions of the fiber passing through the voids are not supported by surrounding resin under load. Weak and incomplete bonding between the fibers and the matrix is another cause of early failure. Coupling agents can be used to strengthen the bonds[**10**].

## 2.5 Alternatives of Fiber Matrix Combinations

### 2.5.1 Organic fiber in organic matrix.

Plastics and rubber have a low specific gravity. They are often used in weight-critical applications (good flexibility). Strengthening of this light-weight materials is important. Tires resist stresses, because of the nylon and rayon fiber, bonded into the tire rubber. Wood (cellulose) fibers in matrix of rigid thermosetting plastics are low cost, of good strength to weight ratio and easy in processing (high flexibility). The graphite fibers are used in plastics to improve their heat resistance, since graphite fibers are good heat conductors. They dissipate heat, applied to the matrix, but they have lower flexibility.

### 2.5.2 Inorganic fiber in organic matrix

This combination has great potential for light weight high strength composites. Glass fiber plastic composites, have the following advantages,: good physical properties, high strength to weight ratio, resistance to chemicals and moderate resistance to high temperatures.

### 2.5.3 Inorganic fiber in inorganic matrix

The aim is to achieve high working temperature not possible with organic materials. Examples are metal, reinforced with alumina whiskers: (silver matrix with aluminum whiskers, ceramics whiskers, alumimina and silicon whisker, Silicon nitride whiskers, and silicon carbides whiskers) [**10**].

Whiskers can be incorporated into composites by several techniques:

- Slip casting.
- Powder metallurgy.

### 2.5.4 Organic fiber in inorganic matrix

Light weight graphite fibers are also used to improve the thermal-shock resistance of ceramics. Examples are fiber-fiber composite: (organic-organic) or (organic-inorganic). A good deal of textile engineering is being done with fiber-fiber composite (nylon-cotton, polyester-cotton and acrylic-polyester).

## 2.6 Polymer Matrix Composites

The polymer matrix composites are the most popular composites as compared with the metal matrix and ceramic matrix composites. The fiber reinforced polymers (FRP) have witnessed a steady expansion in uses and volume. Showing excellent potentials for light weight structures, fiber reinforced polymers were able to meet the challenges of the aerospace sector by cutting cost and weight in replacing the aluminum fuselage construction by the carbon fiber reinforced polymers FRP [**12**]. Now there are new applications in the field of traffic engineering to decrease the final consumption of fuel replacing metal by FRP having higher specific strength and stiffness in components of passenger cars, buses and railway coaches. FRP can be used to increase the performance to resist explosive impacts, in fan blades and pressure bulkheads. Table 2.1 illustrates that the polyester FRP supersedes stainless steel in tensile strength, flexural strength and izod impact [**12**].