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COMPREHENSIVE DESIGN AND ANALYSIS OF ALTERNATIVE MATERIAL FOR DUSTBIN

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Abstract

Waste is a global issue and if not properly dealt with, poses threats to both public health and the environment. Storing of mixed wastes especially from homes, enables biodegradable materials to rot and decompose under improper, unhygienic and uncontrolled conditions. The study aimed at developing an ecofriendly waste bin for effective household solid waste storage, segregation and composting of the biodegradable wastes. Composites are combinations of two materials in which one of the material is called the reinforcing phase, is in the form of fibers, sheets, or particles, and is embedded in the other material called the matrix phase. Composites exist in nature. A piece of wood is a composite, with long cellulose fibres held together by a substance called lignin. Composite materials are formed by combining two or more materials that have quite different properties, and they do not dissolve or blend into each other. The different materials in the composite work together to give the composite unique properties.

Keywords: Dustbin, Alternate material, Composite, Cellulose

1. Introduction

For the sake of simplicity, however, composites can be grouped into categories based on the nature of the matrix each type possesses. Methods of fabrication also vary according to physical and chemical properties of the matrices and reinforcing fibers

(a) Metal Matrix Composites (MMCs)

Metal matrix composites, as the name implies, have a metal matrix. Examples of matrices in such composites include aluminium, magnesium and titanium. The typical fiber includes carbon and silicon carbide. Metals are mainly reinforced to suit the needs of design. For example, the elastic stiffness and strength of metals can be increased, while large co-efficient of thermal expansion, and thermal and electrical conductivities of metals can be reduced by the addition of fibers such as silicon carbide

(b) Ceramic Matrix Composites (CMCs)

Ceramic matrix composites have ceramic matrix such as alumina, calcium, alumina silicate reinforced by silicon carbide. The advantages of CMC include high strength, hardness, high service temperature limits for ceramics, chemical inertness and low density. Naturally resistant to high temperature, ceramic materials have a tendency to become brittle and to fracture. Composites successfully made with ceramic matrices are reinforced with silicon carbide fibers. These composites offer the same high temperature tolerance of super alloys but without such a high density. The brittle nature of ceramics makes composite fabrication difficult. Usually most CMC production procedures involve starting materials in powder form. There are four classes of ceramics matrices: glass (easy to fabricate because of low softening temperatures, include borosilicate and alumino silicates), conventional ceramics (silicon carbide, silicon nitride, aluminium oxide and zirconium oxide are fully crystalline), cement and concreted carbon components.

(C) Polymer Matrix Composites (PMC)

Most commonly used matrix materials are polymeric. The reasons for this are two-fold. In general the mechanical properties of polymers are inadequate for many structural purposes. In particular their strength and stiffness are low compared to metals and ceramics. These difficulties are overcome by reinforcing other materials with polymers. Secondly the processing of polymer matrix composites need not involve high pressure and does not require high temperature. Also equipments required for manufacturing polymer matrix composites are simpler. For this reason polymer composites developed rapidly and soon became popular for structural applications. Polymer composites are used because overall properties of the composites are superior to those of the individual polymers. They have a greater elastic modulus than the neat polymer but are not as brittle as ceramics. Polymeric matrix composites are composed of a matrix from thermoset (unsaturated polyester, epoxy or thermoplastic polycarbonate, polyvinylchloride, nylon, polystyrene and embedded glass, carbon, steel or Kevlar fibers (dispersed phase).

The potential applications of polymer composites include consumer goods (sewing machines, doors, bathtubs, tables, chairs, computers, printers, etc), sporting goods industry (golf shafts, tennis rackets, snow skis, fishing rods, etc.), aerospace industry (doors, horizontal and vertical stabilizers, wing skins, fin boxes, flaps, and various other structural components), marine applications (passenger ferries, power boats, buoys, etc.), automotive industry (bumper beam, seat/load floor, hood radiator support, roof panel and land transport systems like cars, trucks and bus bodies, railway coach components, containers and two and three wheelers), construction and civil structures (bridges, columns doors, windows and partitions and for translucent roofing sheets, prefabricated modular houses and buildings etc.), industrial applications

Two main kinds of polymers are thermosets and thermoplastics. Thermosets have qualities such as a wellbonded three-dimensional molecular structure after curing. They decompose instead of melting on hardening. Merely changing the basic composition of the resin is enough to alter the conditions suitably for curing and determine its other characteristics. They can be retained in a partially cured condition too over prolonged periods of time, rendering Thermosets very flexible. Thus, they are most suited as matrix bases for advanced conditions fiber reinforced composites. Thermosets find wide ranging applications in the chopped fiber composites form particularly when a premixed or moulding compound with fibers of specific quality and aspect ratio happens to be starting material as in epoxy, polymer and phenolic polyamide resins.

Thermoplastics have one- or two-dimensional molecular structure and they tend to at an elevated temperature and show exaggerated melting point. Another advantage is that the process of softening at elevated temperatures can reversed to regain its properties during cooling, facilitating applications of conventional compress techniques to mould the compounds.

1.2 Introduction to Reinforcements

Reinforcements for the composites can be fibers, fabrics particles or whiskers. Fibers are essentially characterized by one very long axis with other two axes either often circular or near circular. Particles have no preferred orientation and so does their shape. Whiskers have a preferred shape but are small both in diameter and length as compared to fibers.

Reinforcing constituents in composites, as the word indicates, provide the strength that makes the composite what it is. But they also serve certain additional purposes of heat resistance or conduction, resistance to corrosion and provide rigidity. Reinforcement can be made to perform all or one of these functions as per the requirements Natural Fiber Reinforced Composites Fiber-reinforced polymer composites have played a dominant role for a long time in a variety of applications for their high specific strength and modulus. The manufacture, use and removal of traditional fiber–reinforced plastic, usually made of glass, carbon or aramid fibers–reinforced thermoplastic and thermoset resins are considered critically because of environmental problems. By natural fiber composites we mean a composite material that is reinforced with fibers, particles or platelets from natural or renewable resources, in contrast to for example carbon or aramid fibers that have to be synthesized. Natural fibers include those made from plant, animal and mineral sources. plant, animal and mineral sources.

1.2.1 Animal Fiber

Animal fiber generally comprise proteins; examples mohair, wool, silk, alpaca, angora. Animal hair (wool or hair) are the fibers taken from animals or hairy mammals. E.g. Sheep's wool, goat hair (cashmere, mohair),alpaca hair, horse hair, etc. Silk fiber are the fibers collected from dried saliva of bugs or insects during the preparation of cocoons. Examples include silk from silk worms. Avian fiber are the fibers from birds, e.g. feathers and feather fiber.

1.2.2 Mineral fiber

Mineral fibers are naturally occurring fiber or slightly modified fiber procured from minerals. These can be categorized into the following categories: Asbestos is the only naturally occurring mineral fiber. Variations are serpentine and amphiboles, anthophyllite. Ceramic fibers includes glass fibers (Glass wood and Quartz), aluminium oxide, silicon carbide, and boron carbide. Metal fibers includes aluminium fibers.

1.2.3 Plant fiber

Plant fibers are generally comprised mainly of cellulose: examples include cotton, jute, flax, ramie, sisal and hemp. Cellulose fibers serve in the manufacture of paper and cloth. This fiber can be further categorizes into following as Seed fiber are the fibers collected from the seed and seed case e.g. cotton and kapok. Leaf fiber are the fibers collected from the leaves e.g. sisal and agave. Skin fiber are the fibers are collected from the skin or bast surrounding the stem of their respective plant. These fibers have higher tensile strength than other fibers. Therefore, these fibers are used for durable yarn, fabric, packaging, and paper. Some examples are flax, jute, banana, hemp, and soybean. Fruit fiber are the fibers are collected from the fruit of the plant, e.g.

coconut (coir) fiber.

Stalk fiber are the fibers are actually the stalks of the plant. E.g. straws of wheat, rice, barley and other crops including bamboo and grass. Tree wood is also such a fiber.

Natural fiber composites are by no means new to mankind. Already the ancient Egyptians used clay that was reinforced by straw to build walls. In the beginning of the 20th century wood- or cotton fiber reinforced phenol- or melamine formaldehyde resins were fabricated and used in electrical applications for their non-conductive and heat-resistant properties. At present day natural fiber composites are mainly found in automotive and building industry and then mostly in applications where load bearing capacity and dimensional stability under moist and high thermal conditions are of second order importance. For example, flax fiber reinforced polyolefins are extensively used today in the automotive industry, but the fiber acts mainly as filler material in non-structural interior panels. Natural fiber composites used for structural purposes do exist, but then usually with synthetic thermoset matrices which of course limit the environmental benefits. Natural fibers such as jute, sisal, pineapple, abaca and coir have been studied as a reinforcement and filler in composites.

1.2.4 Manufacturing Processes of Composite Material

Manufacturing of a composite material is to combine the polymeric resin system with the fiber reinforcement. Since the orientation of the fibers is critical to the end properties of the composite, manufacturing process is utmost important to align the fibers in desired direction. A good manufacturing process will produce a higher, uniform fiber volume fraction along with a higher production of a large volume of parts economically and have repeatable dimensional tolerances.

The composite manufacturing techniques can be classified into two categories:

5.1:Open mould process:

a) Hand lay-up process

b) Spray up process

c) Vacuum-bag auto clave process

a) Filament winding process Compression moulding

b) Injection moulding

c) Sheet moulding compound (SMC) process

d) Continuous pultrusion process

2. Methods and Materials

This chapter describes the details of processing of the composites and the experimental procedures followed for their mechanical characterization. The raw materials used in this work are

2.1. MATERIALS USED

2.1.1 Epoxy resin (LY-556)

2.1.2 Hardener(HY-951)

2.1.3 Natural Fibers (Sisal,banana, Areca , Coconut Coir,Jute mat)

2.1.4 NaoH Solution

2.1.1 Epoxy resin (LY-556)

Features of Epoxy

- Light weight
- Resists most alkalis and acids
- Resists stress cracking
- Retains stiffness and flexibility
- Low moisture absorption
- Non-staining
- Easily fabricated

Applications of Epoxy Structural applications

- Industrial tooling and composites
- Electrical system and electronics

2.1.2. Hardener (HY-951)

Hardener is a curing agent for epoxy or fiberglass. Epoxy resin requires a hardener to initiate curing; it is also called as catalyst, the substance that hardens the adhesive when mixed with resin. It is the specific selection and combination of the epoxy and hardener components that determines the final characteristics and suitability of the epoxy coating for given environment.

6.1.3 Natural fibers such as Sisal/Banana/Coconut coir/Areca nut/

Jute mat

Fiber-reinforced polymer composites have played a dominant role for a long time in a variety of applications for their high specific strength and modulus. The manufacture, use and removal of traditional fiber– reinforced plastic, usually made of glass, carbon or aramid fibers– reinforced thermoplastic and thermoset resins are considered critically because of environmental problems. By natural fiber composites we mean a composite material that is reinforced with fibers, particles or platelets from natural or renewable resources, in contrast to for example carbon or aramide fibers that have to be synthesized

Why use natural fibers

- Renewable energy
- Low density
- Low cost
- Excellent specific strength
- Recyclable
- Bio remediation
- Low cost compared to synthetic fiber
- Low environmental effect

Advantages of Natural Fibers

Comparing to conventional reinforcing fibers like glass, carbon and Kevlar, natural fibers have the following advantages: Environmentally friendly

Fully biodegradable

Non toxic

Easy to handle

Non abrasive during processing and use

Low density/light weight

Source of income for rural/agricultural community

Renewable, abundant and continuous supply of raw materials

Low cost

Free from health hazard (cause no skin irritations)

High toughness

Good thermal properties

2.1.4 NaOH Solution

Sodium Hydroxide(NaOH) is a alkaline solution used to enhance the surface morphology of natural fibers

2.2 JUTE FIBRE

- Jute is a long, soft, shiny vegetable fiber that can be spun into coarse, strong threads.
- Jute is one of the most affordable natural fibers and is second only to cotton in amount produced and variety of uses of vegetable fibers.
- Jute is in great demand due to its cheapness, softness, length, luster and uniformity of its fiber. It is also called the 'golden fiber' due to its versatile nature .It is called the 'brown paper bag' as it is also used to store rice, wheat, grains, etc.

Features

- Jute fiber is 100% biodegradable and recyclable - and thus environmentally friendly.
- Jute has low pesticide and fertilizer needs.
- It is a natural fiber with golden and silky shine and hence - called The Golden Fiber.
- It is the cheapest vegetable fiber procured from the bast or skin of the plant's stem.

2.2 EPOXY RESIN

- Epoxy resins are polymeric or semi polymeric materials.
- Epoxy resins are low molecular weight pre polymers or higher molecular weight polymers which normally contain at least two epoxide groups.

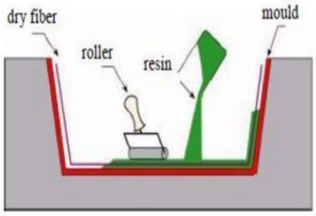
Applications : Epoxy has a wide range of applications,

- Including metal coatings,
- Use in electronics / electrical components,
- High tension electrical insulators, fiber-reinforced plastic materials .
- Adhesives and
- Composite materials such as those using carbon fiber and fiberglass reinforcement

PROPERTIES OF RAW MATERIAL

PROPERTIES	JUTE	EPOXY
Density (g/cm3)	1.3	1.08-1.2
Youngs Modulus	77	3.7
Moisture absorption at 24 hrs	6.9	-
Aspect ratio	152-365	-
Specific gravity (gm/cc)	1.3	1.8
Tensile strength (MN/m2)	3400	85
Specific modulus (GN/m2)	28.8	-

Hand Lay-up method



FABRICATION PROCESS

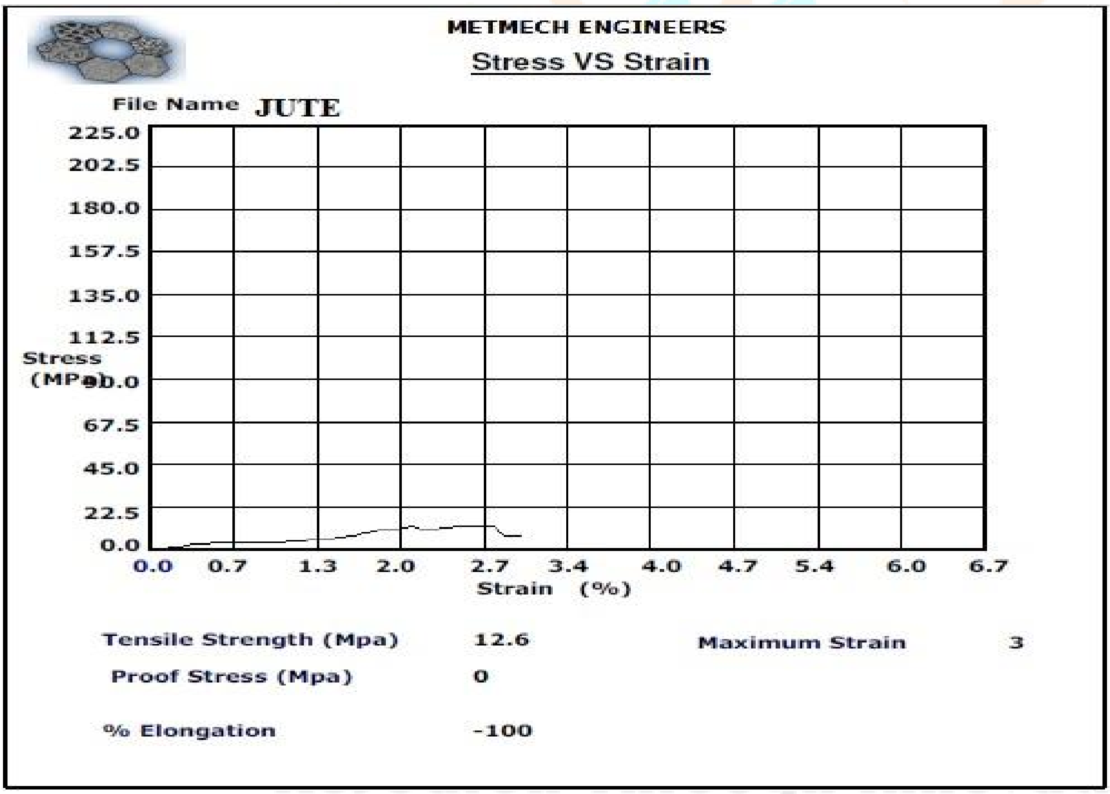
Raw materials used in hand lay-up method

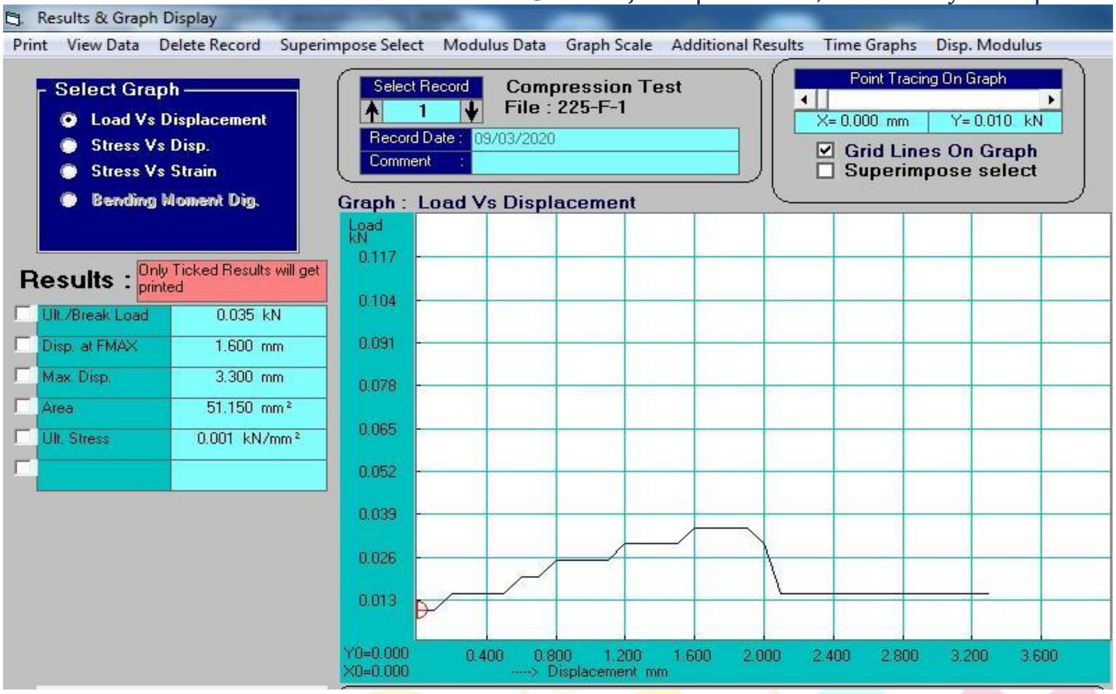
Materials used	
Matrix	Epoxy LY556
Reinforcement	Jute fiber
Hardener	Araldite HY951

Preparation of Epoxy and Hardener

The matrix used to fabricate the fiber specimen was epoxy LY556 of density 1.13 g/cm3 at 25°C mixed with hardener HY951 of density 0.97 to 0.99 g/cm3. The weight ratio of mixing epoxy and hardener was followed as per the supplier Norms that is 100ml of epoxy resin with 10ml.

3. Results and Discussion

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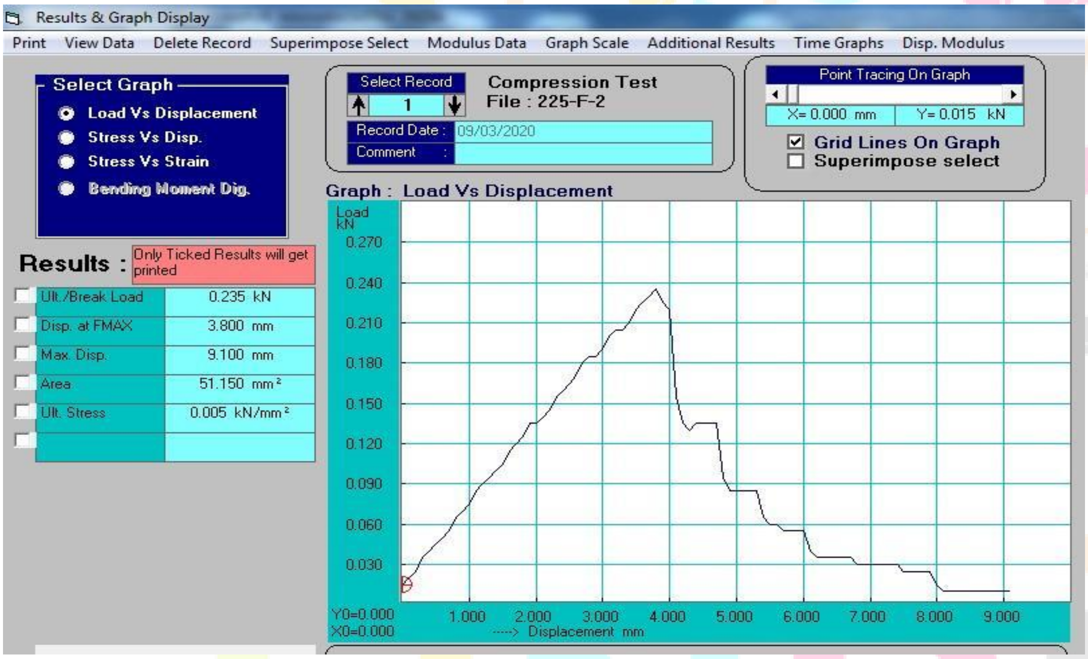
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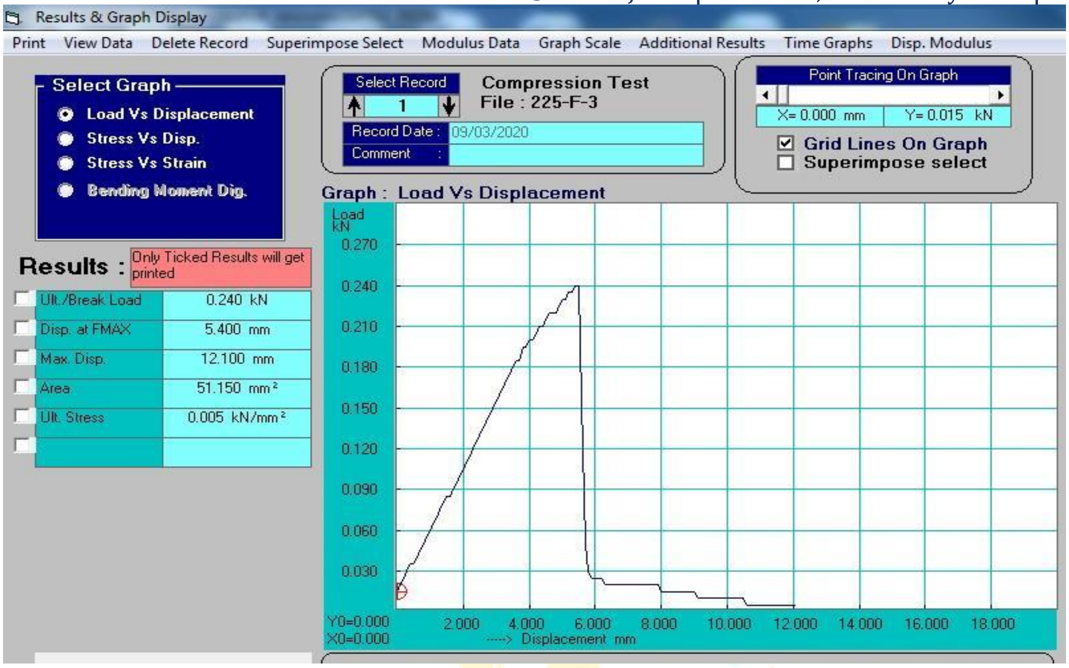

ADVANTAGES:

- Consumption of plastics can be reduced.
- Eco-friendly.
- Material cost is less.
- Friendly processing, no wear of tools, and no skin irritation.
- Manufacturing process is very simple.

12.DISADVANTAGES:

- Less durability due to high moisture and chemical absorption.
- Lower strength, especially impact strength.
- Variable quality, influenced by weather.
- Complex shaped products can't be made.
- Poor fire resistance.

13.APPLICATIONS:

Application of composite materials reinforced with natural fibers (green composites) In general, the use of natural fibres as reinforcement for thermoplastic components is a relatively new phenomenon (about 1995). Firstly they were used in automotive industry in German. Nowadays, natural fibers are applied in:

a) automotive interior components (common use as door and boot liners and parcel shelves).

b) parts in aerospace.

c) domestic insulation.

d) textile applications.

e) building industry.

f) packaging industries.

4. Conclusion

The fabricated bin which can be made at affordable costs is quite easy to use and maintained. In addition, households can save the cost of engaging private service for their waste disposal as this bin allows for easy segregation of solid wastes at source in one device, including composting of the biodegradable materials. We recommend that the use of this bin should be adopted at household, community and institutional levels for management of solid waste, view to reducing the associated public health challenges.