Development of oil absorption fabric coated with vegetable waste

By

Priya.T

(16PTF006)

A Thesis Submitted to the

Avinashiligam Institute for Home science and Higher Education for Women, Coimbatore-641 043.

In Partial Fulfilment of the Requirements for the

Degree ofMaster of Science

in

Textiles and Fashion Apparel

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Certified as Bonafide Research Work

Signature of the Head of the Department

Signature of the Guide

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INTRODUCTION

1 INTRODUCTION

The Textile industry is one of the oldest sector in India. Our country economy is largely dependent on textile manufacturing, exports and it contributes to nearly 30% of the total exports. Textile industry provides second largest employment after agriculture (Sekhri, 2011).The industry plays significant contributor too many national economies, encompassing both small and large scale operations worldwide. In the last 40 years consumption of natural resources has increased dramatically to overcome environmental degradation (Karthik *et al*., 2014)

Oil is one of the most important resource of energy and raw materials for chemicals and synthetic polymers. The risk of oil spillage is mainly due to exploration, transportation and storage. Major oil pollution happened due to transportation related activities, spill from tanking loading, pipeline damage may be due to industrial waste as leakage from engines. The annual influx of petroleum is about 10 million metric tons (Hussein et al.,2009).

The worldwide consumption of oil and petroleum products for 2016 is predicted to be ~94 million barrels per day. Large amount of oil consumption leads to increased threat of oil pollution (Zeiger *et al*., 2016).

There is lot of oil pollution caused by textile, petro chemical and food industries due to often oil spill accidents. During offshore oil production or marine transportation has caused a great loss of energy source and damaging effects on the ecological environment (Wang *et al.,* 2015).

Spillage of oil causes pertaining effects to environment, economy and living organisms, therefore it is considerable to find effective, simple and inexpensive method to treat this calamity. (Sathasivam *et al.,* 2010). It is important to construct and develop techniques of oil removal form the water environment in order to apply the appropriate procedure to the cleanup of oil pollutants (Moriwaki *et al.,* 2009). One of the solutions for removing massive spilled oil is use of adsorbents due to its high absorbing efficiency, cost effectiveness, easy and simple operation and feasibility for large scale production (Linh *et al.,* 2016).

Most sorbents are used to collect spilled oil and absorb large amount of water in addition to oil and have limited oil absorption capacity. To overcome these problems, materials with special wetting properties, i.e. which repel water while absorbing oil alone (super hydrophobic and oleophilic) are required (Zeiger *et al.,* 2016).

The common measures used to remove oil in water involve dispersants, skimmers, oil booms, and sorbents, etc. Various types of materials such as organic natural materials, inorganic mineral materials and synthetic organic materials have been used (Wang *et al.,* 2012)

Some natural sorbents are mostly cellulosic and hydrophilic in nature. However, because of the hydroxyl groups it is not widely recommended for oil spills, therefore hydrophobic modification is required to make the natural sorbent into oleophilic. Natural inorganic sorbents such as clay, perlite, vermiculite, glass wool, sand, and volcanic ash can absorbs up to 20 times their weights.

Natural organic sorbents include peat moss, straw, sawdust, feathers, corncobs, cotton and kapok fibres etc., Synthetic polymeric materials such as polyurethane, polyethylene, polypropylene (Hoai *et al*., 2016). Among the various sorbents used, natural organic sorbents appear to be the most preferred materials in terms of low cost, potentially good oil sorption performance, ecofriendly characteristics and abundant resource supply in nature (Li *et al*., 2013).

Some natural fibres have hydrophobic nature due to higher percent of wax present on their surfaces. Kapok and milkweed fibres have large and non – collapsing lumen that gives greater volume for adsorption. Natural fibres have the advantage of low density, low cost, and biodegradability. These fibres can be modified to be hydrophobic. Chemical treatments including alkali, silane, acetylation, Benzoylation, acylation, maleated coupling agents, isocyanates, permanganate. Biologically modified corn stalk fibre are treated with cellulase as enzymes to reduce the disadvantage of chemically treated fibre. (Peng *et al.,* 2013) and (Li *et al*., 2007)

Fabric substrate may be treated with one or more components to make into hydrophobic and oleophilic. In recent year's synthetic fabric materials such as polyesters, polypropylene, polyethylene, polyamide, and polytetrafluoroethylene have been used, but the major disadvantage is non – biodegradable in nature. (Novak, 1998).

Background of the study

This Study have been conducted on the basis of utilization of vegetable waste for oil absorption. Agriculture is the backbone of Indian economy. The waste generated in the market are mainly disposed in municipal sites or in dumping grounds. Utilization of waste products by recycling of waste. The total amount of fruit and vegetable waste is coming around 90 tons per day. In India, fruit vegetable waste constitute about 5.6 million tons annually and currently these waste area disposed by a dumping on the outskirts of cities. Some residual waste matters can be converted into raw materials for secondary processes of making commercial products (Arvanitoyannis *et al*., 2008).

Onion is an important fresh vegetable consumed all over the world. As Maharashtra is major state contributes to the total production of onion (33 per cent) and export (80 - 85 per cent) of India (Immanuelraj *et al*., 2014).The production rate of garlic was estimated to be approximately 425 thousand metric tons. India leads in banana production with the annual output of about 14.2 million tones. With the production of vegetable and fruits almost 2 to 3 % is considered as waste.

Instead of treating them as waste it can used for making value added products by recycling. In this study, the oil absorbent materials were developed using vegetable (agro) waste such as garlic, onion, banana peel also cellulosic fibres were tried, because of hydrophilic nature, it is not preferred for oil absorption materials, and therefore modification of natural fibre is necessary to make the fibres into hydrophobic. Hence, the fibres has been modified by treating it with chemical treatment. The products were developed with the combination of modified fibre and agro wastes.

Considering the above facts in mind the investigator selected to study on "**Development of oil absorption fabric coated with vegetable waste** "with following objectives:

- To reduce utilization of synthetic materials and develop biodegradable sorbents materials.
- To develop sorbent product using utilized vegetable waste for oil absorbency.
- To study oil absorbency characteristics of the developed product.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Reviews of literature for the present study on "**Development of oil absorption fabric coated with vegetable waste"** are discussed under the following headings:

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2.1.1 History of Oil

2.1.2 Lubricating and Other Oils

2.1.3 Chemical Composition of Oil

2.1.4 Different Grades of Oil

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2.1 Oil

Oil is a naturally occurring substance. The decay of animals and plants are converted by heat and pressure into petroleum it is one of the most sources of energy and raw material for synthetic polymers and chemicals worldwide. Oil has been a part of the natural environment for millions of years. Oil spills occurs over the seas, water bodies and land surface due to tanker disaster, wars, operation failures and equipment breaking down, accidents, and naturally disaster during the production, storage, transportation. From last decades serious problem arises to remove crude oil and petroleum products spillage in the sea areas (Karan *et al*., 2011).

2.1.1 History of Oil

The origin of oil from the decay of bodies of countless tiny sea creatures that have been trapped under layers of rock. There are many areas on the earth where oil can be found on under land (Matthews, 2003). Oil is found in shallow reservoirs and seeps that contains gases, salt water and mechanical impurities (Sharma, 1997). Oil has been used for lighting purpose for, many thousands of years. Chinese used natural gas to boil water and the written sources from 500 B.C was shown in the famous site oracle of Delphi was built around 1000 B.C. Later in 1859 "Colonel Edwin Drake" drilled the first successful oil well, with the sole purpose of finding oil and the drake well was located in northwestern Pennsylvania. Soon, oil has been replaced as fuels for motorized transport. At the end of 19th century quickly oil adopted as fuels for automobile industry (Devold, 2013).

2.1.2 Lubricating and Other Oils

Lubricating oil is the most valuable component in a barrel of crude oil. When it is drained from the engine, it contains a variety of contaminants which are environmentally hazardous (Hussein *et al*., 2011). Waste lubricating oils are generated from vehicles and machineries. The waste lubricating oils has higher values of ash, carbon residues, asphaltenic materials, metals, water and other dirty materials (Jabbar *et al*., 2010). All grades of lubricating oils are used for diesel engines. Diesel and automobile oils are manufactured by mixing purified residual and distillate oils. Petroleum processing industry manufactures mineral oils of various varieties such as motor oil, industrial oils, turbine oils, electro insulating oils, compressor oils, etc (Sharma, 1997).

2.1.3 Chemical Composition of oil

Oil is a complex substance with each hydrocarbon molecules consisting of many atoms of carbon, hydrogen and oxygen others. The atoms in each hydrocarbon molecules are strongly chemically bonded together. (Angaitkar *et al.*, 2013). Crude oil is a complex mixture consisting of 200 or more different organic compounds, mostly alkanes (single bond hydrocarbons) and smaller fraction aromatics (benzenes) (Devold, 2013).

2.1.4 Different grades of oil

Viscosity and density are important physical properties of crude oil. Crude oil is classified as light or heavy oil based on different physical properties, such as molecular weight, viscosity, density, and API gravity (Alomair *et al.,* 2015). The API (American Petroleum Institute) gravity for a particular crude is merely a measure of its specific gravity or density). Gravity and viscosity are the two standards used to classify light, heavy, and extra-heavy oils, which are exemplified below: (1) Light oil: °API > 22, viscosity < 100 cP, density < 934kg/m3; (2) Heavy oil: °API 10-22, viscosity > 100 cP, density 934-1000Kg/m3 and (3) Extra-heavy oil (bitumen): °API < 10, viscosity > 10.000 cP and density > 1000 Kg/m3 (Santos *et al.,*2017).Hydrocarbon proportions ranges from 50% to 98% for very light oil to heavy crude oils (Din *et al.*, 2017).

2.2 Technologies used for Oil Spill Removal

The technologies used for oil spill removal are classified into three methods: Chemical, Biological, Physical or mechanical. In situ burning, dispersion and solidifiers are chemically used method to cleanup oil spill. Sorbents, skimmers and bommers are physically used method to remove oil. Under biological methods certain bacteria are used to remove oil spills.

2.2.1 Chemical Methods

In chemical methods, in situ burning is performed as soon as possible after the spill, before the oil stain will begin to evaporate into volatile components and disperse. Dispersion is efficient method of removal of large scale oil spills with the use of surface – active agents called surfactants (it is possible to spray dispersants from helicopter). Solidifiers are generally dry, granular, hydrophobic organic polymers that react with oil to form a monolithic solid that floats on water. The formed solid can be easily removed from the water surface. (Bandura *et al.,* 2017).

2.2.2 Biological Methods

In biological application oil-degrading bacteria and nutrients to contaminated shorelines to enhance the process of natural degradation (karan *et al*., 2011).

2.2.3 Mechanical Method

Mechanical methods such as sorbents, skimmers and bommers are used. .Each method has its own exploration requirements, advantages, along with limitations and concerns. Skimmers collects a large volume of oil- contaminated water that must be transported from sites. The use of natural sorbents to clean up oil spill in an ecofriendly and cost effective way. (Abdelwahab *et al*., 2013). Among all these existing techniques, the use of sorbents is generally considered to be one of the most efficient techniques for the removal of oil and polycyclic aromatic hydrocarbons (PAHs), because it is an easy and most preferred method, environmentally friendly and low cost.(Denizceylan *et al*., 2009).

2.3 Oil Sorbents Materials

Sorbents are materials with high attractions for oil and water repellent. Both absorption and adsorption mechanisms are used to recover oil (Idris *et al*., 2014) Adsorbents allow oil to penetrate into pore space in the material, while adsorbents attract oil to their surfaces but do not allow it to penetrate into the material (karan *et al*., 2011).The sorbents should have high oleophilic or hydrophobicity properties, large oil removal capacity and high rate of uptake capacity of oil, good buoyancy properties, retention over time, nontoxic, biodegradable (Teli *et al*., 2012).

2.4 Types of Sorbents

2.4.1 Organic Vegetable Sorbents

Natural agro – based sorbents such as milkweed and cotton have greater potential for oil spills cleanup as they are able to absorb more oil compared to the commercial synthetic sorbent materials. Some of the natural sorbents such as coconut shells, hay, gorse, dried palm fronds, bagasse, corn hubs , saw dust, silkworm cocoon, kapok (Idris *et al*., 2014) raw luffa, banana pith, sugarcane bagasse, corn hubs (Abdelwahab, 2014)sphagnum moss (Olga *et al*., 2014), walnut shell media, corn stalk, wheat straw (Li *et al*., 2013).

Different plant fibrous materials were used as sorbents, namely, cotton, cotton grass, kenaf (Moriwaki *et al*., 2009), milkweed, sisal, silk-floss, coir (Annunciado *et al*., 2005), jute (Teli *et al*., 2012) and, banana. Natural organic sorbents are considered to be effective, easy available, cheap, low cost and environmentally friendly (Teli *et al.*, 2013).

2.4.2 Organic Synthetic Sorbents

Synthetic polymer products such as polypropylene (Lin *et al.,* 2010), polyurethane, polyethylene, nylon (Hussien *et al*., 2011) polyacrylate, polystyrene (Lin *et al.,* 2012) are the most widely used sorbents for oil spill cleanup because of their highly oleophilic and hydrophobic properties. Polymer adsorbents exhibit hydrophobic properties, low bulk density and large sorption capacity with respect to petroleum derivatives. Due to their buoyancy and hydrophobicity they are mainly used in aqueous media and for the removal of oil spills. Polypropylene are mostly used nonwoven sorbents have high oil sorption capacity and low water uptake, and hence these sorbents are ideal materials for oil recovery from the water surface, but one of their main disadvantage is their non-biodegradability.

2.4.3 Inorganic Mineral Sorbents

Mineral adsorbents have many advantage such as non-flammability, chemical inertness, relatively low cost and easy availability. Most mineral adsorbents are raw materials of natural origin which are used in a powder or granular form. Their particle size may range from nm to mm (not more than 3 mm). The mineral products used as oil sorbents include perlite, exfoliated graphite, vermiculites, organ clay, zeolites, silica aerogel, and diatomite. Most of them have poor buoyancy and oil sorption capacity. Nearly 6.35 kg of clay absorbs 3.78 litre oil (Bandura *et al*., 2017).

2.4.4 Cost Effective Natural Sorbents for Oil Spill Clean Up

Abdelwahab *et al*., (2013) reported raw luffa, an agricultural waste, was used as a sorbent material for oil spill cleanup. The mechanism of oil sorption in the presence of the macrospores structure in the fibre surface and capillary action through its cavities. The large capillaries in fibres showing its excellent hydrophobicity and oleophilicity characters.

Kumagai *et al*., (2007) used raw and refined rice husks were pyrolyzed in a vacuum at 300- 800ºc for 1-5 h to impact superior properties for use as an oil sorbents .Capillary action are important mechanisms in enhancing the oleophilicity properties if rice husk. The rice husk refined and then pyrolyzed at 600ºc for 5h and 700 ºC for 3h absorbed 6.0g of heavy oil.

Syed *et al*., (2005) investigated that agricultural wastes garlic and onion peel was treated with dodecyl benzene sulphonic acid was used to remove oil spills from the surface of saline water. The adsorption capacity was examined of three different types of materials: a sludge which is mainly composed of calcium aluminum silicate and formed in water clarification and filtration and in dissolved air floatation units in petroleum refineries and thermal power stations, and garlic and onion peel as agricultural wastes. Results showed that the adsorption capacities of the chemically treated sludge with 30 μg/mL dodecyl benzene sulphonic acid, untreated sludge and the thermally treated sludge at 1200ºC are 2, 1.388 and 0.8 g/g respectively, while garlic and onion peel have adsorption capacities of 0.385 and 0.455 g/g respectively.

Zeiger *et al*., (2016)investigated the floating plant Salvinia molesta and Pistia stratiotes can achieve super hydrophobic properties through their complex hierarchical surface structure .Salvinia species with fused trichrome structure plays a role in oil sorption capacity and they examine how the presence and morphology of trichromes affect the amount of oil absorbed by their surfaces.

Moriwaki *et al*., (2009) investigate utilization of Silkworm cocoon waste, such as pierced or stained cocoons where used as a sorbent material for removal of motor and vegetable oil from oily water. The cocoon waste exhibited a high sorption capacity (42–52 g/g for motor oil and 37–60 g/g for vegetable oil). Recovery of the oil by squeezing the material through squeezed material of the sorbent indicated an oil-sorption capacity of 15 g/g. The material performed well and it is low cost, inexpensive, making it an environmentally friendly sorbent for oil spill cleanup.

Zubaidy *et al.*, (2015) used biodegradable natural organic materials Massoda and Youda Arabic herbs as the sorbents for remediation of oil polluted water. The average oil sorption capacity of youda and masoofa were 6.281 and 5.415 g of oil adsorbed/g respectively. Other natural materials sugarcane bagasse were carbonized at 300ºC for 2 hr were found to have high performance for sorption, recovery and recycling of heavy oil , even the viscous ones. Different forms of date palm kernels powder were used for remediation of oil polluted water. Kernel powder activated with $ZnCl_2$ was found to be the best oil sorbent and the sorption capacity was equal to 4.48g/g. Natural sisal and sawdust achieved highest oil sorption capacity, it was equal to 6.4 g oil per gram of sorbent.

Nwadiogbu *et al.,* (2015) Biodegradable agricultural waste corn hubs were treated with acetic anhydride to increase their hydrophobic properties and enhanced the sorption behavior. The maximum sorption capacity were 0.0768 mg/g and 0.0043 mg/g for acetylated corn hubs and raw corn hubs respectively.

Jabbar *et al.,* (2010) investigated oil refining adsorption process by different adsorbent materials. Date palm kernel powder looks attractive process for treating waste oil with the contact time of 4h, egg shale powder with the addition of stabilized condensate and demulsifiers were achieved and acid activated bentonite has the best performance in treating the waste.

2.5 Natural fibres as sorbents

2.5.1 Fibre Content

The use of lignocellulosic fibres as the natural sorbents for oil spillage. Cellulose, hemicellulose, and lignin are the components of lignocellulosic fibres cell wall polymers (Rowell, 2010).

Cellulose

Cellulose is the semi crystalline polysaccharide with a large amount of hydroxyl groups present in cellulose is mainly responsible for hydrophilic nature of the plant fibre. (Bledzki *et al.*, 2008).

Hemicellulose

Hemicellulose is amorphous polysaccharides are a combination of five and six carbon ring, because of its open structure containing many hydroxyl and acetyl groups and it is partly soluble in water and hygroscopic.

Lignin

Lignin is hydrophobic, amorphous, highly complex, and mainly aromatic, polymers of phenyl propane units but have the least water sorption of the natural fibre components.

Pectin

Pectin is also one of the main components in plant fibres which is polysaccharide and its holds the fibres together. (Nawab *et al.,* 2016).

Table I, shows the composition of different natural fibres.

Table I

Composition of Natural Fibres

Fibres	**Cellulose**	**Hemicellulose**	**Lignin**
Bamboo	26-43	30	28
Banana	64	20	5
Coir	31-24	10-20	40-46
Cotton	95	2	1
Flax	70-73	18-20	2
Hemp	70	22	6
Jute	71	14	13
Kenaf	45-57	8-13	21.5
Oil palm	65	-	29
Pineapple	80	-	12.8
Ramie	68-76	13-15	1
Sisal	73	14	11

2.5.2 Natural Fibres Used in Oil Sorption

Rengasamy *et al.*, (2011) reported that the fibre assemblies made from kapok and milkweed have good oil sorption capacity but lower compared to that of polypropylene. Sorbents with high porosity could be achieved to obtain high oil sorption capacity but the sorption capacity might be lowered for large pores this may be due to capillary forces become insufficient to overcome the gravitational forces of the oil in these pores. All the fibres assemblies showed higher oil sorption capacity for high density oil as compared to the diesel oil.

Din *et al*., (2015) used (Hibiscus Cannabinus L) Kenaf fibre as the sorbents for oil sorption, sorbent produced from a 1.70 cm_2-sized kenaf fibers achieved the highest absorption value of 8.2327 g/g and saturation value of 0.0385 N/Mins respectively.

Wang *et al*., (2012) investigated that, acetylated kapok fibres have been used for oil spill clean-up. Acetylated kapok fibre exhibited a better oil sorption capacity than raw fibres for diesel and soybean oil. Raw kapok fibre (RKF) were acetylated by using NBS (NAKF- N-bromosuccinimide acetylated kapok fibre) and Pyridine (PAKF – Pyridine acetylated kapok fibre) as a catalyst. The oil sorption capacity of RKF (diesel 30.5 g/g, soybean oil 47.4 g/g), NAKF (diesel 34g/soybean oil 48.5 g/g) and PAKF (diesel 36.7 g/g, soybean oil 52.2 g/g).

Choi *et al*., (1993), examined gray cotton initially adsorbed more oil than polypropylene, cotton nonwovens retained 60% of their capacity to sorb oil. Needle punched cotton nonwoven were used as the sorbents for light crude oil than those of sorbents made from 100% polypropylene fibres. A small portion of PP fibres could be incorporated into nonwovens to increase mechanical strength properties and to maintain fabric integrity. Blend of gray cotton /PP and 100%gray cotton nonwoven fabrics were prepared by using needle punching and it is compared with 100% PP fibres as oil sorbents. Oil sorption of cotton fibre was controlled by adsorption on the fibre surface and capillary action through its lumen. Main mechanism for PP fibres was through the capillary bridges between fibres.

Payne *et al.,* (2012) used wood-derived cellulosic fibers to absorb simulated crude oil and oil spills. Dry bleached softwood kraft fibers show the highest sorption capacity (6 g/g of fiber), compared to hardwood bleached Kraft and softwood chemi-thermo-mechanical pulp (CTMP) fibers. Increased refining of CTMP fibers decreased their oil uptake capacity. The fibers were soaked in water before their exposure to oil, showing that the ability of the unmodified kraft fibers to sorb oil was markedly reduced. In general, wet CTMP fibers were more effective than wet kraft fibers. The pre-deposition of lignin onto the surfaces of bleached kraft fibers improved their ability to take up oil when wet. A better ability to sorb oil in wet state was achieved by pre-treating the kraft fibers with a hydrophobic sizing agent (alkenylsuccinic anhydride). The results indicate that cellulosic fibers have a potential to be used in oil sorption, even under wet conditions.

Wang *et al.,* (2012) investigated the effect of various solvents (Hcl, NaOH, NaClO2 and chloroform) treated kapok fiber for oil sorption. The results indicate that except the chloroform treated kapok fibers other solvents treated fibers showed enhanced oil sorption. The NaClO2-treated kapok fiber showed maximum oil sorption; with the increase percentage is found to be

35.5 g/g, 51.8 g/g, 34.8 g/g and 25.2 g/g for toluene, chloroform, n-hexane and xylene, respectively. The solvent treated kapok fiber exhibits excellent reusability and great potential for oil spill cleanup.

Hussein *et al.,* (2011) investigated the potential of low grade raw cotton fibers, to remove oil spills cleanup and recovery. The results show that, loose low grade cotton fibers and pad have an oil sorption capacity of 22.5 and 18.43 g/g. The sorbed oil removed by a simple mechanical press the sorbent can be used repeatedly in oil spill cleanup. It was found that loose fibres has a higher sorption capacity compared to the pad containing the low grade cotton fibres due to the higher surface area of the loose fibres.

2.6 Hydrophobicity Treatment for Natural Materials

Natural cellulose based environmentally friendly, degradable, and inexpensive materials are used, because of the hydroxyl groups on their cellulose structures, is mainly responsible for hydrophilic. Hydrophobic modification is required for natural materials so that they can be used as oil sorbents. Physical, chemical, biological treatment are followed to modify cellulosic fibres into hydrophobic.

2.6.1 Physical Treatment

Cellulosic materials can be physically modified by cold – plasma, coating and surface crystal growth treatment, for example, a cellulose aerogel surface can be treated with CCl4 cold plasma and nano cellulose coated with TiO_2 to change its hydrophobicity (Hoai *et al*., 2016).

2.6.2 ChemicalTreatment

Some chemical treatments including silane, acetylation, Benzoylation, Acrylation, Isocyanates and Permanganate. Chemical modification of natural fibres aimed at improving the hydrophobicity properties. Benzoylation treatment reduces the hydrophilic nature when the fibre reacts with benzoyl chloride includes benzoyl (C6H5C=0) (Nawab *et al.,* 2016).

Silane coupling agents may reduce the number of cellulose hydroxyl groups in the fibre .The silanol then reacts with the hydroxyl groups of the fibre , forming stable covalent bonds to the cell wall that are chemisorbed onto the fibre surface. It was found that untreated fibres absorbed the most water and 25% acrylonitrile –grafted sisal fibres absorbed the less water, suggesting that changes in fibre surface reduced the affinity of fibres to moisture. The hydrophilic tendency of fibres decreased as the KMnO4 concentration increased. The isocyanate functional group –N=C=O, reacts with the hydroxyl groups of cellulose and lignin in fibre.

Chemical treatment of cardanol derivative of toluene diisocyanate (CTDIC) in sisal fibre-LDPE composites. It was demonstrated that CTDIC reduced the hydrophilic nature of the sisal fibre (Li *et al*., 2007).

On acetylation, the overall percentage of cellulose was decreased; whereas hemicellulose and lignin which remain unaffected during the acetylation process. The hydroxyl groups are replaced by bulkier acetyl groups resulting in increase in hydrophobicity and also decrease in H-bonding. It also gives rise to increase in accessibility or amorphous content. Both these factors thus cause enhancement in oleophilicity which has been depicted by these results. The oil sorption capacity of raw banana fibre was 2.10 g/g and acetylated banana fibres was 18.12 g/g (Teli *et al*., 2013).The oil sorption capacity of raw jute fibre was 2.58g/g and acetylated jute sample (obtained by 1 hr acetylation at 120ºC by using 2% NBS as a catalyst) was 21.08g/g (Teli *et al*., 2013).

2.6.3 Biological Treatment

Peng *et al*., (2013) used new technology to produce low- cost, high-efficiency and biodegradable oil sorbent without using harmful chemicals. The sorbents are developed by using Cellulase as the enzymes to modified corn stalk (CMCS). Cellulase treatment of raw corn stalk (RCS) with enzyme loading of 100 U/g at 45ºC for 6 hr resulted in high oil sorption capacity. The sorption capacities of vegetable oil, diesel and crude oil by CMCS were 18.47, 16.15 and 27.23 g/respectively, the water/crude oil conditions, the sorption capacity of CMCS was 24.98 g/g.

2.7 Other Treatments for oil spill clean up

Wang *et al.,* (2013) prepared a super hydrophobic and oleophilic new kapok fiber coated with polybutylmethacrylate (PBMA) and hydrophobic silica (SiO2) for oil adsorption and investigated the sorption capacity, oil uptake rate and reusability of the PBMA/SiO2-coated fiber in pure oil and oil/water mixtures. The prepared fiber exhibited higher oil adsorption capacities in the oil/water mixtures. The oil adsorption capacities for n – hexane, toluene, chloroform, gasoline, diesel and soybean oil is 22.8, 30.4, 41.9, 34.1 38.1 and 49.1g/g respectively and the modified fibre for these oil can reach about 41.8, 56, 85.5, 50.5, 54.2, 59.8 g/g respectively. The coated fiber also exhibited excellent reusability (6 times), a fast oil uptake rate and high buoyancy for the removal of oil from seawater.

Lin *et al.,* (2012) developed a nonporous polystyrene fiber for oil sorbents that is highly efficient, selective and low cost for oil-spill cleanup. Nano porous polystyrene (PS) fibers prepared via a one-step electro-spinning process. The oleophilic–hydrophobic PS oil sorbent, with highly porous structures, shows motor oil, bean oil and sunflower oil sorption capacities of 113.87, 111.80 and 96.89 g/g respectively. The oil sorption mechanism of the PS sorbent and the sorption kinetics were also investigated. Nano porous material has immense potential for use in wastewater treatment and oil spill cleanup.

Feng *et al*., (2015) developed super hydrophobic advanced and cost effective sorbents are made of recycled cellulose aerogel from paper waste and kymene cross linker. It is coated with MTMS via chemical vapour deposition exhibit excellent oil sorption capacities, 0.25% wt. cellulose aerogel yields the maximum adsorption capacity of 95 $gg^{-1}$with the 5w40 motor oil. Cellulose aerogels yields the maximum absorption capacity at 50^{o}c.

Lin *et al.,* (2010) developed a composite material consisting of polypropylene (PP) fibers and waste tire powder for the cleanup and recovery of spilled oil; the oil sorption capacity of this composite was 85.6–103.3 g/g. This composite has now been used to clean over a 100 oil spills, and the cost of the material required to recover 1 ton of spilled oil is only approximately US$0.03.

Linh *et al*., (2016) used exfoliated graphite (EG) has known as excellent adsorbents in removing diesel oil,COFe2O4 nano particles were introduced into EG surfaces. Highest adsorption of diesel oil using EG/ COFe2O4 composites were synthesized via chemical methods.20g of diesel oil that allows where the adsorption times at 6 minutes, salinity of 3.5% and temperature at 30^{o}c were considered as important factors.

Zhao *et al*., (2013) reported that the manmade methacrylate series polymers were first introduce in 2006. Hydrophobic and oleophilic with moderate crosslinking have been increasingly used for oil spill clean-up .Polymethacrylate fibres with impressive absorbency and fast absorption are used as oil absorptive materials. To fabricate polymethacrylate post cross linking, low cross linking (physical cross linking or entanglement) approaches has to be followed. Because of hydrophobicity the fibres are floating on water can be made into oil absorptive ropes, pillows, rails for controlling the oil spills diffusion and also be used for oil – water separation.

Dolez *et al*., (2017) reported that the treatment provide a non-toxic, low cost to make the natural fibres into hydrophobic, the fibres and nonwovens are coated by using metal oxide nanoparticles namely, titanium dioxide(TiO_2) and Zinc oxide (ZnO),followed by the application of fatty acid. To make the jute fibres/nonwovens into hydrophobic, the fatty acids are directly applied to the fibre surface or an intermediate layer of metal oxide nanostructures below the fatty acid coating.TiO2 nanoparticles coated nonwovens becomes highly hydrophilic, it then turns strongly hydrophobic after further treatment with stearic acid. Before the treatment , the materials was hydrophilic with a water contact angle of 77^{o} and a water retention time of about 0.6 min,it becomes hydrophobic with a water contact angle in the range of 120^{o} when it is treated with stearic acid.

Patowary *et al.,* (2014) developed super hydrophobic and oleophilic commercially prepared barium sulfate powder. Water contact angle of $152\neq1^{o}$and maximum oil contact angle of $6\neq1^{o}$for crude oil and $11\neq1^{o}$for diesel oil. The hydrophobic and oleophilic nature of the fabricated powder was confirmed by various laboratory experiments and contact angle measurements. The powder also possesses high selectivity towards oil and sufficient buoyancy to serve as a potential candidate for oil spill clean-ups.

2.8 FT- IR Spectroscopy

FT-IR spectra of natural and synthetic materials were obtained in order to understand the nature of the functional groups present in natural and synthetic materials.

From the literature review Table II showed hydrophilic/ hydrophobic and oleophilic functional groups.

Table II

Functional Groups for Hydrophilic /Hydrophobic/Oleophilic Surface

S.No	Functional groups	Nature	Reference
1	CH – groups	Hydrophobic	Matejkova *et al.*, 2012
2	CO – groups	Hydrophilic	
3	Methyl groups (CH_3)	Oleophilic	Toyada *et al.*, 1995
4	Hydroxyl groups	Hydrophilic	
5	Acetyl groups and ester bonds	Increase oleophilicity Reduces hydrophillicity	Teli *et al*, 2013

2.9 Natural sources

2.9.1 Cotton

Cotton is a natural fibre of vegetable origin, like linen, jute and it is composed of cellulose. It is a variety of plants of the genus Gossypium, belonging to the family Malavacae family (Das *et al.,* 2010). Cotton is an important cash crop in many developing economies, supporting the livelihoods of millions of poor households. In some countries it contributes as much as 40 percent of merchandise exports and more than 5 percent of GDP. Cotton is also an important contributor to rural livelihoods in many countries (Baffes *et al.*, 2005).

2.9.2 Wood Pulp

Cellulose fibers from wood and plants constitute a relatively new and promising class of composite materials. Short fibers (1–5 mm), originating typically from wood species (e.g., spruce, pine, birch, eucalyptus). Long fibers (5–50 mm), originating typically from annual plant species (e.g., flax, hemp, jute) (Madsen *et al.*, 2013).

2.9.3 Sugarcane bagasse

Sugarcane is a versatile plant grown for sugar production, and its major by-product is bagasse. Bagasse is the residue obtained after sugarcane is milled for juice extraction. In sugarcane production, the bagasse retrieved from crops is roughly 27–28 dry weight % of plant biomass. It is a highly heterogeneous material that consists roughly of 20–30% lignin, and 40–45% cellulose and 30–35% hemicellulose. Furthermore, bagasse represents approximately 0.3 metric ton for every 1 metric ton of sugarcane1 grown and is oft en considered a waste stream (Bezerra *et al.,* 2016).

2.9.4 Onion peel

Bio-waste is defined as food and kitchen waste from households, caterers, and retail Premises, and comparable waste from food processing plants. Millions of tons of bio-waste are produced every month. Consequently, more than 500,000 tons of onion skin waste (OSW) are discarded every year within the European Union, where it has become an environmental problem. The waste includes the brown skin, the outer layers, roots and stalks, as well as onions that are not large enough for commercial use. This waste is not suitable as fodder for animals, and hence is usually dumped (Choi *et al.,* 2015).

2.9.5 Garlic peel

Garlic (Allium sativum L.), a spice of human life, is one of the important perennial bulb crops of the lily family (Liliaceae). Garlic is valued for its flavor .It is used widely in medicinal and application in food and pharmaceutical preparations. It has been cultivated for centuries all over the world on account of its culinary and medicinal properties. Large amount of garlic peel waste arise from pickle industries and other allied food processing industries (Manjunatha *et al.*, 2012).

2.9.6 Banana peel

Banana (Musaceae) is one of the world’s most important fruit crops that is widely cultivated in tropical countries for its valuable applications in food industry. Its mass cultivation and consumption in the recent decades made it the world second largest fruit crop with an estimated gross production exceeds 139 million tones (Padam *et al.,* 2012). Discarded peels of banana fruit from market area and household garbage generates waste in bulk quantity. Banana peels constitutes cellulose, hemicelluloses, lignin and pectin in its biomass containing functional groups like carboxyl, hydroxyl and amine (Deshmukh *et al*., 2017).

2.7 Poly vinyl alcohol

Polyvinyl alcohol for food use is an odourless and tasteless, translucent, white or cream colored granular powder. It is soluble in water, slightly soluble in ethanol, but insoluble in other organic solvents. Typically a 5% solution of polyvinyl alcohol exhibits a pH in the range of 5.0

to 6.5. Polyvinyl alcohol has a melting point of 180 to 190°C. It has a molecular weight of between 26,300 and 30,000, and a degree of hydrolysis of 86.5 to 89% (Saxena *et al.*, 2004).

EXPERIMENTAL PROCEDURE

3. EXPERIMENTAL PROCEDURE

Experimental procedure pertaining to the study "**Development of oil absorption fabric coated with vegetable waste"** are discussed under the following headings:

3.1 Materials Used

3.1.1 Selection of Fibre, Fabric and Vegetable Waste

3.1.2 Selection of Chemicals

3.1.3 Selection of Oil

3.2 Experimental Instruments

3.2.1 Ultrasonicator

3.2.2 Centrifuge

3.2.3 Hot Air Oven

3.2.4 Magnetic Stirrer with Hot Plate

3.2.5 Ultrasonic Sealing

3.3 Preparation of Fibre

3.3.1 Cotton

3.3.2 Sugarcane

3.3.3 Wood Pulp

3.3.4 Polypropylene

3.4 Preparation of Vegetable Waste as Powder Granules

3.5 Chemical Treatment

3.5.1 Natural Fibres Treated with Chemicals

3.6 Preparation of Developed Materials

3.7 Water Absorbency Test

3.7.1 Free Swell Method

3.8 Oil Absorption Test

3.8.1 Probe Sonicator Method

3.8.2 Magnetic Stirrer Method

3.8 Oil Absorption of Developed Materials

3.8.1 Oil Absorbency Test by Dipping Method

3.1 Materials used

3.1.1 Selection of fibre, fabric and vegetables waste

The following raw materials were selected for the development of materials for oil absorption application, were shown in Table III.

TABLE III

Selection of raw materials

Fibre	**Description**	**Plates**
Cotton	The most commonly used fibre in textile industry. Seed based fibre, highly hydrophilic nature.	**PLATE I** 
Sugarcane (Bagasse)	Bagasse, a byproduct of the sugar industry and agricultural residues and it is mechanically extracted from sugarcane.	**PLATE II** 

Wood Pulp	Cellulosic fibre from softwood trees such as pine, spruce and hardwood tress such as eucalyptus, aspen etc.	**PLATE III** 
Onion peel	Onion peel, a major vegetable waste found in local market and home kitchens.	**PLATE IV** 
Garlic Peel	Garlic peel, a large amount of waste found in local vegetable market.	**PLATE V** 
Banana peel	Banana peel are fruit waste which only goes as fodder for animals.	**PLATE VI** 

3.1.2 Selection of Chemicals

In this experimental study, the following chemicals were selected for the modifying the natural fibres were shown in table V.

TABLE IV

Selection of chemicals

S.No	Materials	Grade
1	Stearic acid	LR Grade
2	Thionyl chloride	LR Grade
3	Chloroform	LR Grade
4	Methanol	LR Grade

3.1.3 Selection of Oil

Eastto hydraulic oil AW (68) grade were used in this study for testing and it is locally purchased from the priyadharshini chemicals, Coimbatore. Grade 68 machinery oil are generally suggested for non-critical all loss lubrication systems and other oiling applications by hand for lubrications of bearings ,open gears, light loaded slides and guide way of machine tools. They are widely used in textile mills for lubrication of looms, internal surfaces of various automotive and industrial equipment's. Hydraulic oil especially suitable for general hydraulic machines used at high pressure and high temperature. Antifriction characteristics, shear stability of viscosity, oxidation stability etc. suitable for hydraulic machines. The properties of hydraulic oil were shown in Table V.

TABLE V

PROPERTIES OF OIL

S.No	TEST	RESULTS
1	Appearance /Colour	Clear/Bright
2	Density at 19.5 ºc gm/ml	0.8690
3	Viscosity at 40ºc	67.50 cSt
4	Viscosity at 100ºc	9.12 cSt
5	Flash Point (PMCC)	>200ºc
6	Dimulsibility @54ºc	40-40-0(25 min)

3.2 Experimental Instruments

The following experimental instruments were used:-

3.2.1 Ultrasonicator

We have used ultrasonic cell crusher noise isolating chamber of lark innovation fine technology . It is an instrument which works on the principle of sound waves , it homogenisis any solution to its smallest particles.The prepared oil/water mixture was kept for 4 minutes in a sonicator to get a homogenisis solution.

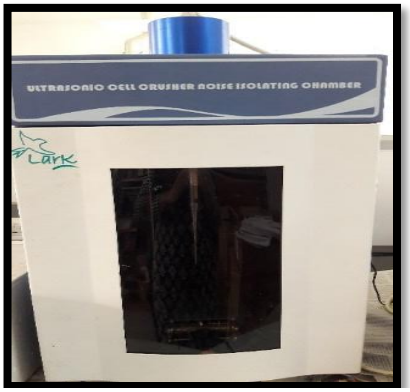


PLATE VII

Ultrasonicator

3.2.2 Centrifuge

We have used remi R8C laboratory centrifuge **.** It is an instrument which works on sedimentation principle ,helps in seprating the impurities from the solution.Keep the prepared solution under centrifuge for 10 min to get the impurtities free solution .

PLATE VIII

Centrifuge

3.2.3 Hot air oven

We have used Kemi -KOMS.4FD model oven with the temperature of 250ºC . It is an instrument which works on the principle of forced hot air convection. The tested samples were kept in hot air oven for 2 to 3 hr at 120ºC to remove the moisture of the sample.

PLATE IX

Hot air oven

3.2.4 Magnetic stirrer with hot plate

We have used remi 2MLH magnetic stirrer with hot plate.The magnetic stirrer is an equipment which is used to mix the solution.The prepared oil and water solution was kept on the hot plate and stirrered for 30 mintues.The sonicated oil/water was also kept in stirrer for 30 minutes.

PLATE X

Magnetic stirrer with hot plate

3.2.5 Ultrasonic sealing

Ultrasonic sealing is an equipment working on the principle of heating mechanism. Diffrennt sealing methods are used in packaging processes, such as conduction sealing, high frequency sealing. In this ultrasonic sealing method has been used for flexible packaging. Ultrasonic sealing has advatages for longitudinal seam sealing.

PLATE XI

Ultrasonic Sealing

3.3 Preparation of fibres

3.3.1 Cotton

Cotton is the purest natural fiber with 90% of fibers are cellulose by nature. The average length of cotton fibre was 26.5 mm. Shankar grade cotton fibre were used in this study and sourced from local market. The cotton fibres having little moisture content were kept in hot air oven for 2 to 3 hrs to get fully dried before they are treated with chemicals.

3.3.2 Sugarcane

The sugar cane waste bagasse were collected from a local market (Coimbatore) was dried in sunlight for 2-3 days. The fibres were soaked in water for 2 days to loosen the fibres, manual retting process has to be carried out to separate the individual fibres. The extracted bagasse fibres were treated with sodium hydroxide to remove impurities present in the fibre. The treated fibres were kept in hot air oven for 2 to 3 hrs to get fully dried before they are treated with chemicals.

Plate XII

Plate XIII

Preparation of sugarcane for extraction Extracted sugarcane fibre

Plate XIV

NaOH treated sugarcane fibre

3.3.3 Wood pulp

Wood pulp fibre is a cellulosic materials usually obtained from wood, fibre crops and waste paper. In this study chlorine free fully treated wood pulp were used and it is sourced from local market. The raw wood pulp fibres having little moisture content were kept in hot air oven for 2 to 3 hrs to get fully dried before they are treated with chemicals.

3.3.4 Polypropylene

In this study 25, gsm spun bond white colour polypropylene fabric were used and it is purchased from local market.

3.4 Preparation of vegetable waste as powder granules

Table VI shows the preparation of vegetable waste into granules for oil absorption application.

TABLE VI

Preparation of powder granules

Source (Vegetable waste)	Description	PLATES

Onion peel	Waste onion peel were collected from local market, it was dried under sunlight for 2 days to remove the moisture content. Further it is placed in oven for 6-7 hr at 80°C to make it completely dried. The dried onion peel converted into powder form.	**PLATE XV** 
Garlic peel	Garlic peel were collected from the local market ,it was cleaned with water to remove the dirt particles .Further the peel was kept in oven at 80°C for 8-9 hr to make it dry. The dried garlic peel converted to make into fine powder.	**PLATE XVI** 
Banana Peel	Banana peel were collected form the local available market in Kerala. The peel was cleaned and washed with water to remove the unwanted dirt particles, left to dry in sunlight for 4-5 days. Further it is dried in oven for 80° Cfor 2 days to make into fine powdered granules.	**PLATE XVII** 

3.5 Chemical treatment

Natural cellulosic fibres are hydrophilic in nature, it is not recommended for the development of oil absorption materials. Therefore hydrophobic modification is necessary to make a product. Hence, chemical treatment are to be carried out to treat the natural fibres such as cotton, wood pulp, sugarcane (bagasse).

3.5.1 Natural fibres treated with chemicals

Natural cotton, wood pulp, and bagasse fibres were treated with 25 g of stearic acid. For 5g of fibre in the presence of Thionyl chloride as a catalyst and chloroform as a solvent to completely dip in the fibre. The reaction was carried out in refluxed apparatus at 70 – 80 °c with 450-550 rpm .The treated fibre was washed periodically with methanol to remove the remaining trashes of chemicals and then the fibres were dried in oven at 70 °c for 1-2 hr. Chemical treated natural fibres were shown in table VII.

TABLE VII

Natural fibres treated with chemicals

PLATE XVIII

Treated Cotton

PLATE XIX

Treated wood pulp

PLATE XX

Treated bagasse

3.6 Preparation of developed materials

Oil absorbent material was developed by using treated fibres and vegetable agro waste sorbents such as (onion, garlic and banana peel) was coated onto plain polypropylene. The agro waste adsorbent is used in powder form to coat the materials. Powdered granules was coated onto the plain polypropylene sheet with an adhesive agent, such as PVA (Poly Vinyl Alcohol) which promotes adhesion of the agro waste sorbents. Overall 1% of PVA was used to fix the powdered granules onto the surface to avoid the agglomeration.

To develop the oil absorbent bag, vegetable waste coated materials was sealed by using ultrasonic sealing equipment's to make the complete oil absorbents fabric. Since PVA is water soluble, during the reaction PVA gets

dissolved in water and the granules (vegetable waste) reacts with the oil spill and the absorption takes place.

PLATE XXI

Garlic coated fabric

PLATE XXII

Onion peel coated fabric

PLATE XXIII

Banana peel coated fabric

PLATE XXIV

Onion/Garlic/Banana peel coated fabric

3.7 Water absorbency test

Water absorbency test method was carried out to identify the difference in water absorbency level of treated and untreated cotton, wood pulp and bagasse fibre.

3.7.1 Free swell method

According to wsp240.3 (10) standard free swell water absorbency test method was carried out at laboratory condition of RH and room temperature. Prepare small bag to keep the sample for testing and weight each bag to get the initial weight. Treated and untreated samples are individually kept in bags. All the bags were hanged on to glass rod with the help of hooks and place the glass rod onto the surface of the beaker. Then filled the beaker with water till the $3/4^{th}$ of the height of the bags. Allow the bags to absorb water for 30 min. Take out the bags from the water and allow the left over water from the bags to drain for 10 min. To get the (t-wet) value final wetted sample weight has to be taken.

$$\textbf{Absorbency \%} = T_{wet} - I_W - S_W / S_W$$

T_{wet} = Final weight of the sample

I_W = Empty bag weight

S_W = (Bag wgt – sorbents wgt)

Plate XXV

Water absorption of

Treated and untreated cotton

Plate XXVI

Water absorption of

Treated and untreated bagasse

Plate XXVII

Dried sample of treated and untreated cotton

3.8 Oil absorption test

Oil absorption test method was carried out to identify the oil absorbency level of treated and untreated cotton, wood pulp, and bagasse.

3.8.1 Probe sonicator method

The hydraulic oil was mixed with 30 ml of water inside a 100 ml beaker for 30 min at 450 - 500 rpm on a magnetic stirrer with the temperature of 60º C. The amount of hydraulic oil used in the range of 3 to 3.5 g. The solution was kept in sonicator for 3 to 4 minutes to get final mixture.

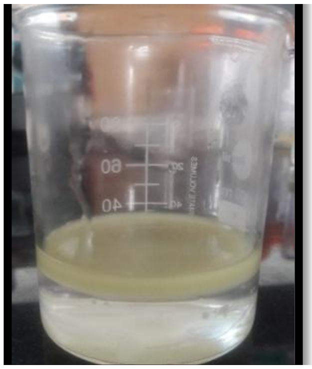


Plate XXVIII

Preparation of oil/water mixture

Plate XXIX

Sonicate oil/water mixture

Plate XXX

Prepared oil/water mixture

3.8.2 Magnetic stirrer method

Magnetic stirrer was carried out for oil absorption test. After the preparation of oil/water mixture, 0.1 g of fibre was added to the oil /water mixture. Again it is placed in magnetic stirrer for 30 minutes at 300-400 rpm with minimum temperature level. The maximum contact time was considered to be 30 min because longer period did not show any improvement in uptake of oil. The mixed oil/water and sorbent mixture was then separated by centrifuging at 600- 800 rpm for 10 min and the mixture has to be filtered. The oil loaded sorbents was scraped from filtrate paper and dried in oven at 70 ºC for 4- 5 hrs till the constant weight is obtained.

The amount of oil absorbed was calculated by, weight of the fibre before sorption - after sorption.

Plate XXXI

Cotton immersed in oil/water mixture

Plate XXXII

Stirring of cotton immersed mixture

Plate XXXIII

Filtration of prepared mixture

Plate XXXIV

Bagasse immersed in oil/water mixture

Plate XXXV

Filtration of prepared mixture

3.9 Oil sorption of developed materials

The oil absorbency test of developed materials was carried out at laboratory condition of RH and room temperature. Absorption was carried out with different time duration of 15 min, 30 min and 1hr time interval.

3.9.1 Oil absorbency test by dipping method

Prepare the oil/water mixture of 30 ml water added with 3 g of oil in 200 ml beaker and make the materials with different combinations of onion, garlic, banana peel, and the blend of onion/cotton, garlic/cotton, banana /cotton and onio,garlic,banana/cotton. Maintaining the bag weight of 3g.The prepared bag was dipped into oil/water solution up to 15 min, immediately the weight of the bags were measured to calculate the extent of absorption. The water content present in the bag was evaporated by keeping the sample in petridish at room temperature for 30 min.Then weight of sample and petridish was taken. The absorbent sample was kept for 1 hr until the water gets evaporate fully. The final dried weight of the bag was noted. Repeat the procedure for reabsorption.

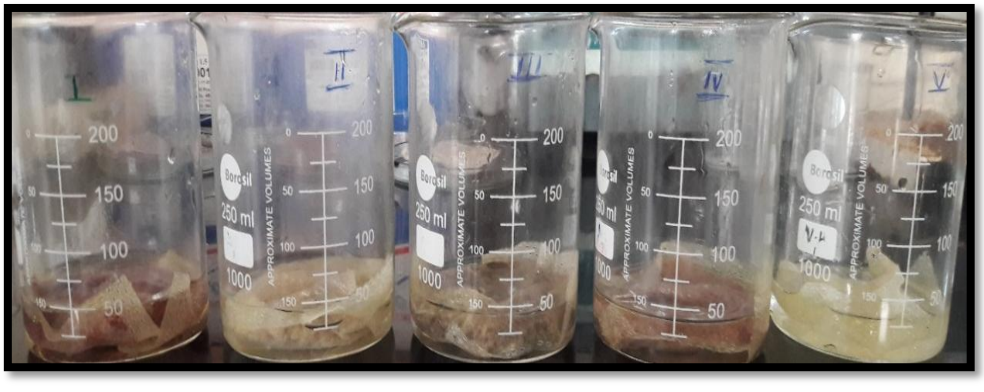
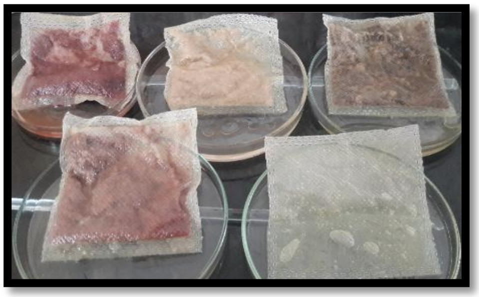


Plate XXXVI

Oil test of developed sample

Plate XXXVII

Drying of tested sample



RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

The results of the study on **“Development of oil absorption fabric coated with vegetable waste”**, presented in results and discussion are as follows**.**

materials

7.3 Sinking test for vegetable waste/cotton blended coated nonwoven PP developed materials

7.4 Sinking test for reused vegetable waste/cotton blended coated nonwoven PP developed materials

From the review of literature table VIII shows FT-IR absorption peaks.

TABLE VIII

FTIR absorbents peaks

S.No	**Literature (cm^{-1})**	**Experimental (cm^{-1})**	**Assignments**	**Reference**
1	3330 , 3600 -3100	3330, 3329,	O-H stretching, intra and intermolecular H bonds	Stancu *et al.*, 2017
2	1160, 1155, 1150	1160 and 1155	C-O-C antisymmetric stretching	
3	1051	1051	C-O-C symmetric stretching	
4	1030 ,1035	1030 and 1035	C-O stretching	
5	1425,1423	1425	H-C-H, O-C-H in plane bending	
6	1317	1317	C-H wagging	
7	1640, 1635	1640	HOH bending of absorbed water	
8	1364	1364	CH_3 symmetric deformation	
9	2900	2900-2800and 2852	C-H stretching	
10	2913	2913,2918	C-H asymmetric stretching of CH_2 groups	Sathasivam et al., 2010
11	2800-3000	2800- 3000	C-H stretching	Liang et al., 2013
12	895	895	C–C, C-6 and CH bending vibrations	Babu *et al.*, 2015
13	3700-3600	3502	O-H stretching vibrations	
14	2910	2910	Asymmetric and symmetric vibrations in CH_2 and CH_3	Wang *et al*, 2013
15	2360	2360	C-O stretching of acetyl (or) carboxylic acids	Mohanta *et al.*, 2015
16	1456	1456	CH_3 deformation	
17	2341	2341	N-H and the asymmetric stretching vibrations of C=O bonds	Arakha *et al.*, 2015

18	1012	1012	C-O-C stretching	Duygu *et al.*, 2012
19	2342	2342	Stretch of CO_2	Berstein *et al.*, 2005
20	2358	2358	CO stretching vibrations	Kannan, 2014
21	2359	2359	Asymmetric stretching, asymmetric deformation and symmetric deformation of – CH_3 groups	Thakur *et al.*, 2015
22	3200-3600	3275	O-H groups	Mothe *et al.*, 2009
23	1020	1021	C-C, C-OH, C-H ring and side group vibrations	Fan *et al*, 2012
24	2892	2848,2867 and 2863	CH stretching	

4. FTIR

4.1 Cotton

4.1.1 Untreated cotton

The absorption spectrum on the infrared region (FTIR) of the untreated cotton, can be observed in the Figure 1 and Table IX.

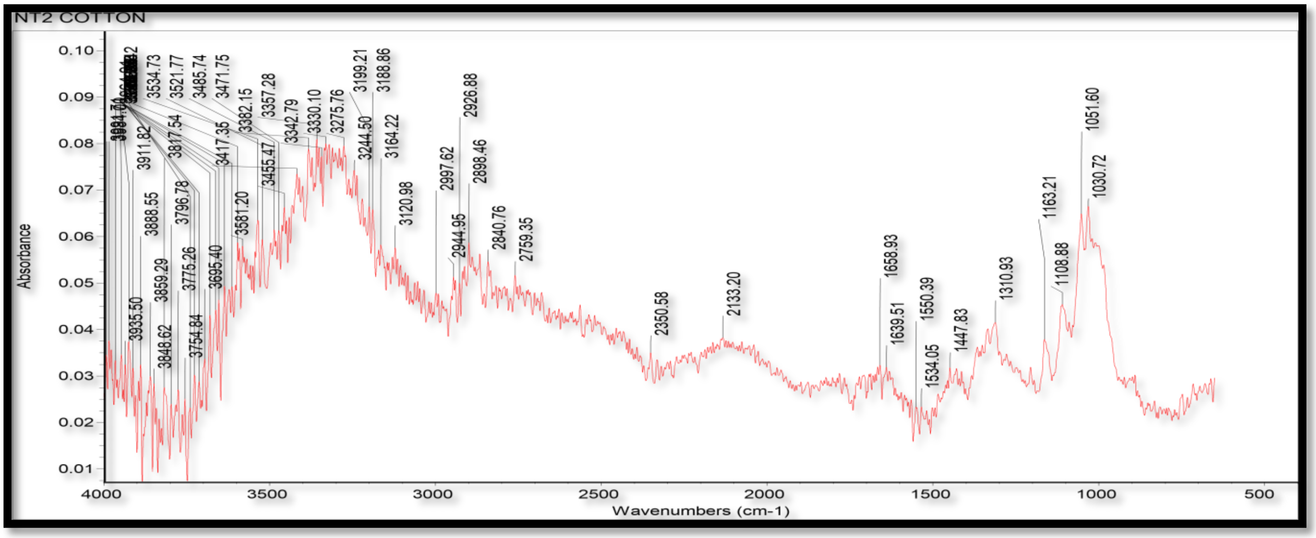


FIGURE 1

FTIR spectrum of untreated cotton

TABLE IX

FTIR value of untreated cotton

S.No	Untreated fibre(cm^{-1})	Assignments

1	3275	O-H stretching intra and inter molecular bond
2	1051	C-O-C symmetric stretching and vibrations
3	1030	C-O stretching vibrations

The FTIR spectrum (Figure 1 and Table IX) of untreated cotton shows strong band at 3275cm^{-1}corresponds to O-H stretching intra and inter molecular H bonds which represents the presence of water adsorbents/hydrophilic groups. The related strong band 3200-3600 cm^{-1}also represent the presence of O-H groups in natural fibres (Mothe *et al*., 2017). The peak 1051cm^{-1}and 1030cm^{-1}appeared in untreated cotton ,showed hydrophilic nature of cotton fibre which may be due to presence of CO functional groups.

4.1.2 Treated cotton

The FTIR results in Figure 2 and Table XI clearly indicate that cotton fibres undergoes modification by means of chemical reaction.

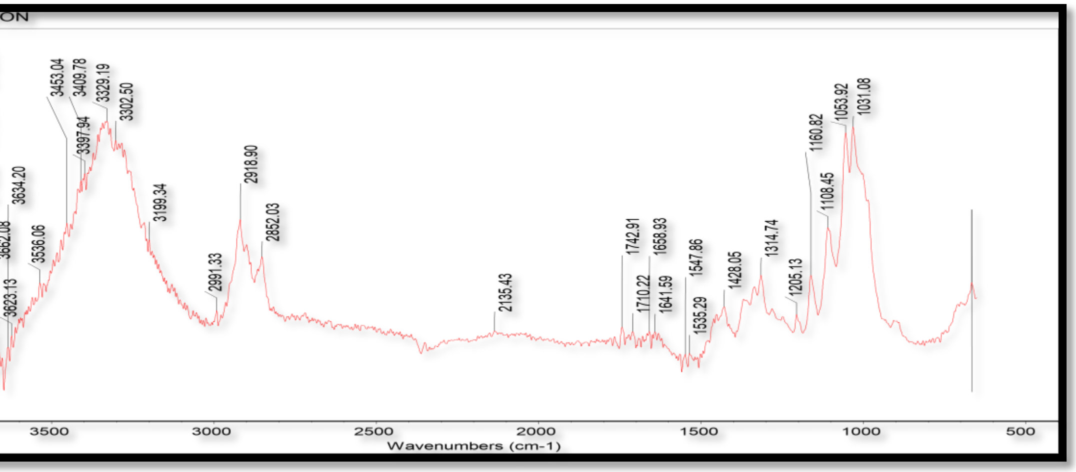


FIGURE 2

FTIR spectrum of treated cotton

TABLE XI

FTIR value of treated cotton

S.No	**Treated fibre (cm^{-1})**	**Assignments**
1	3329	O-H stretching intra and inter molecular bond
2	2918	C-H stretching
3	2852	Aldehyde(C-H)

Figure 2 and Table X showed, FT-IR spectra of treated cotton. The presence of peak 3275$cm^{-1}$is because of OH groups which is otherwise absent in treated cotton. The peak 3329 cm^{-1}shown in stearic acid modified cotton in the presence of thionyl chloride as a catalyst. Treated cotton confirms the presence of OH water absorbent functional groups. The OH group peak intensity range was found to be reduced in treated cotton which may be due to reduction in water absorption.This change in functional groups almost reduced hydrophillicity of fibre. The peak 2918 cm^{-1}, 2852 cm^{-1} showed in treated cotton which corresponds toC-H stretching, Aldehyde (C-H)(Stancu *et al.,* 2017). From the results it is shown that, CH- functional groups is mainly responsible for hydrophobic and affinity towards oil absorption. (Matejkova *et al.*, 2012).

4.2 Wood pulp

4.2.1 Untreated wood pulp

The functional groups that were identified in the untreated wood pulp are showed in Figure 3 and Table XI.

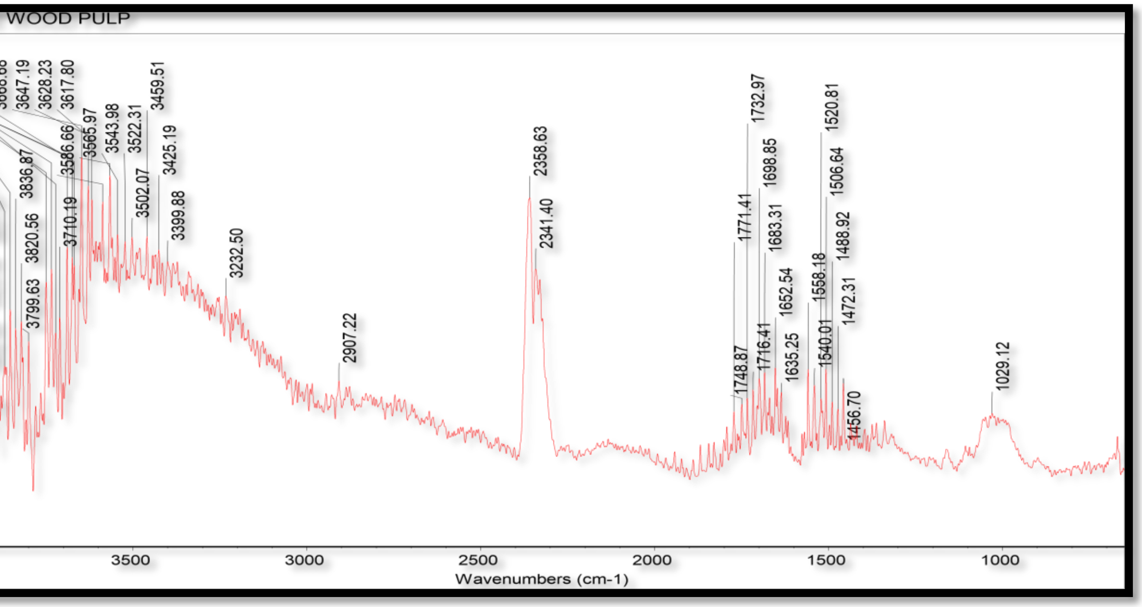


FIGURE 3

FTIR value of untreated wood pulp

TABLE XI

FTIR value of untreated wood pulp

S.No	**Untreated wood pulp (cm^{-1})**	**Assignments**
1	3502	O-H stretching intra and inter molecular bond
2	2341	bending vibrations if N-H and the asymmetric stretching vibrations of C=O bonds
3	2358	CO stretching vibrations

The FTIR spectra of raw wood pulp were showed in Table XI and Figure 3. Hydrophilic/water adsorbents OH functional groups can be found in untreated wood pulp. The strong band at 3502 cm^{-1} due to OH- stretching intra and intermolecular H bonds. The related peak 3700-3000 cm^{-1} showed hydrophilic groups of O-H stretching vibrations. (Babu *et al.*, 2015). The CO functional groups represents the presence of hydrophilic nature of the fibres.

4.2.2 Treated wood pulp

The chemical modification of the wood pulp is confirmed by FTIR analysis were presented in Figure 4 and Table XII.

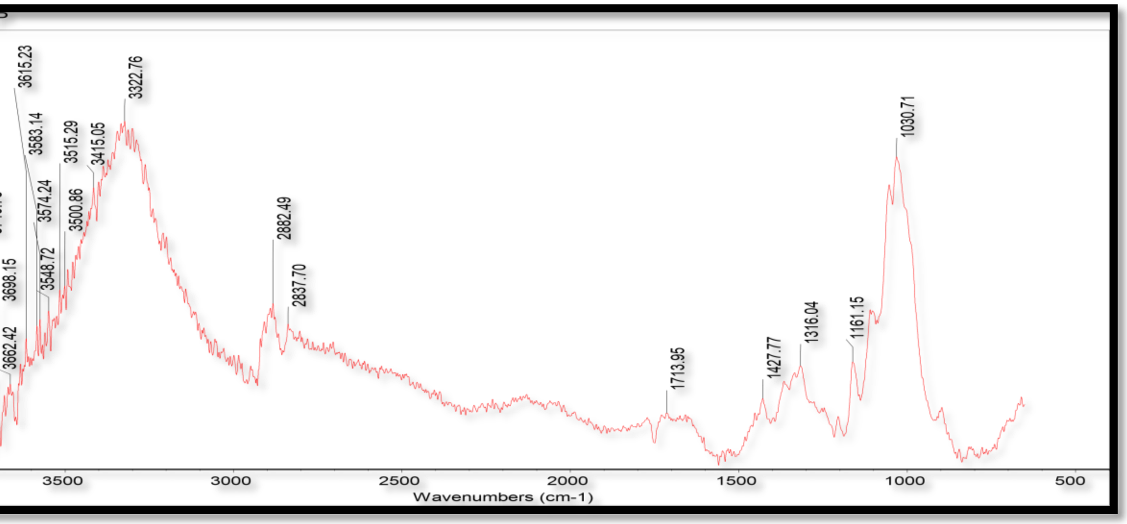


FIGURE 4

FTIR analysis of treated wood pulp

TABLE XII

FTIR value of treated wood pulp

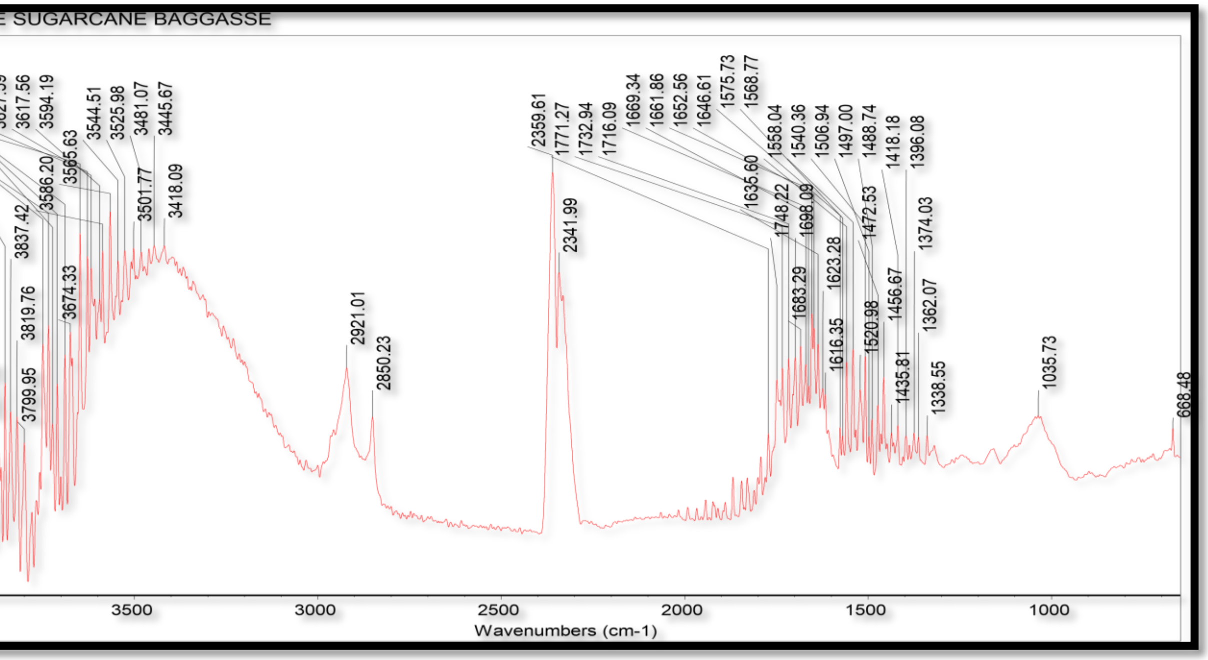
S.No	**Treated wood pulp(cm^{-1})**	**Assignments**
1	3322	O-H stretching intra and inter molecular bond
2	1030	C-O stretching vibrations
3	2882 and 2837	C-H stretching
4	1316	C-H wagging
5	1161	C-O-C antisymmetric stretching

Table XII and Figure 4 showed the FTIR spectra of treated wood pulp. Chemical modification of raw wood pulp in the presence of stearic acid with Thionyl chloride as catalyst showed the absence of water absorbent peak3502 cm^{-1} which present in untreated wood pulp. The related water absorbent peak 3500cm^{-1} present in treated wood pulp indicates the presence of hydrophilic groups and the intensity value of the peak gets reduced. The peak 2882 cm^{-1} and 2837 corresponds to C-H stretching vibrations(Fan *et al*., 2012), 1030 cm^{-1}peak is assigned to C-O stretching vibrations, 1316cm^{-1}corresponds to C-H wagging, peak 1116 cm^{-1}corresponds to C-O-C antisymmetric stretching (Stancu *et al*., 2017). The water absorbency of chemical treated wood pulp is reduced because of presence of (CH) functional groups which is absent in untreated cotton. It is observed that hydrophobic functional group CH arises after the chemical treatment of wood pulp, which is the reason for hydrophobic nature of fibre. This change in functional groups almost reduced hydrophilicity of fibre.

4.3Sugarcane (bagasse)

4.3.1 Untreated bagasse

The infrared absorption wavelengths of each peak and the corresponding functional groups are presented in Figure 5 and Table XIII.



S.NO	**Untreated bagasse(cm^{-1})**	**Assignments**

1	3418	O-H stretching intra and inter molecular bond
2	2921and 2850	Saturated C-H bending and C-H stretching
3	1035	C-O stretching
4	2341	Bending vibrations of N-H and the asymmetric stretching vibrations of C=O bonds
5	2359	Asymmetric stretching, asymmetric deformation and symmetric deformation of –CH_3 groups.

FIGURE 5

FTIR Value of Untreated Bagasse

TABLE XIII

FTIR assignments groups of untreated bagasse

Figure 5 and Table XIII showed FTIR spectrum analysis of sugarcane fibre (bagasse). Water absorbents peaks 3418 cm^{1}were observed whichattribute to presence of OH groups. The related shows water absorbent peak 3200-3600 cm^{-1}which represents the presence of O-H groups, in which O-H group respond to hydrophilic water absorbent character of wood pulp fibres. (Mothe *et al*., 2009).When compared to cotton and wood pulp fibres water absorbency of bagasse has low value of water absorption , which may be due to presence of peak 2921cm^{-1}and 2850cm^{-1}is assigned to CH functional groups represents hydrophobic nature of bagasse fibre. The peak 2341cm^{-1} is assigned to N-H and C=O functional groups, the presence of N-H and C=O groups are not visible in cotton and wood pulp. The change in functional group may be due to reduction in water absorbency of bagasse than cotton and wood pulp fibres.

4.3.2 Treated bagasse

In order to understand the nature of the functional groups present in chemical treated bagasse, FT-IR analysis was carried out and the results were presented in Figure 6 and Table XIV.

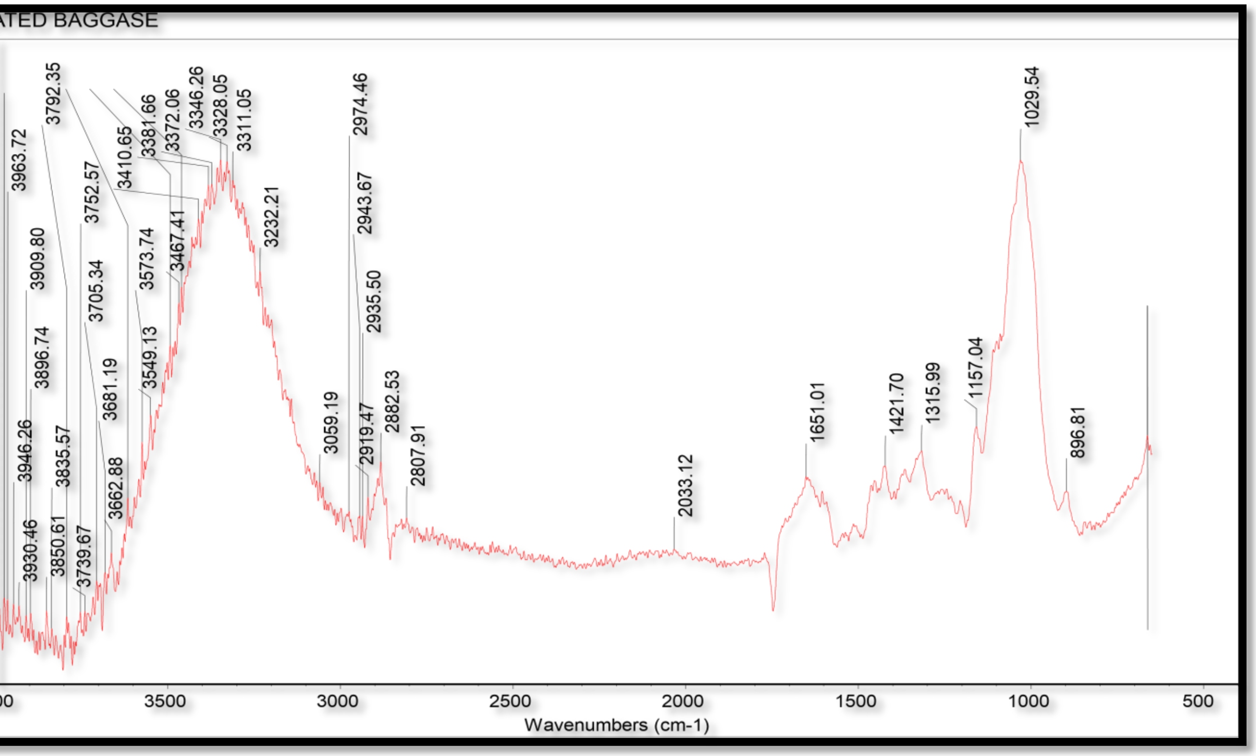


FIGURE 6

FTIR spectra of treated bagasse

TABLE XIV

FTIR value of treated bagasse

S.No	Treated bagasse(cm^{-1})	Assignments
1	3328	O-H stretching intra and inter molecular bond
2	1029	C-O stretching
3	1651	HOH bending of absorbed water
4	1315	C-H wagging
5	896	C-C and CH bending vibrations

Figure 6 and Table XIVshowed FT-IR value of treated bagasse. The fibres are treated in the presence of stearic acid with thionyl chloride as catalyst showed (3481cm^{-1})the absence of water absorbents peak present in untreated bagasse.The related water absorbent peak 3328cm^{-1}intensity was found to be reduced in treated pulp which may be due to reduction in water absorption. The new peaks 1651 cm^{-1}present in treated fibres represents HOH bending of absorbed water, which means that the treated bagasse also has the capacity of absorbing water.The band 1029 $cm^{-1}$and 1315cm^{-1}corresponds to C-O stretch and C-H wagging respectively(Stancu *et al.*, 2017 and Liang *et al.*, 2013). The peak 896 cm^{-1} corresponds to C-C and CH bending vibrations (Babu *et al.*, 2015). The functional groups CH,C-C and C-O represents the presence of hydrophobic and hydrophilic nature of the fibre. The change in functional groups almost reduced the water absorption of bagasse fibre. The majority of non – polar function groups CH and CC represents less water absorption.

4.4 Garlic peel

FTIR spectroscopy was recorded to identify a number of peaks and an organic functional groups on the surface of the garlic peel are shown in Figure 7 and Table XV.

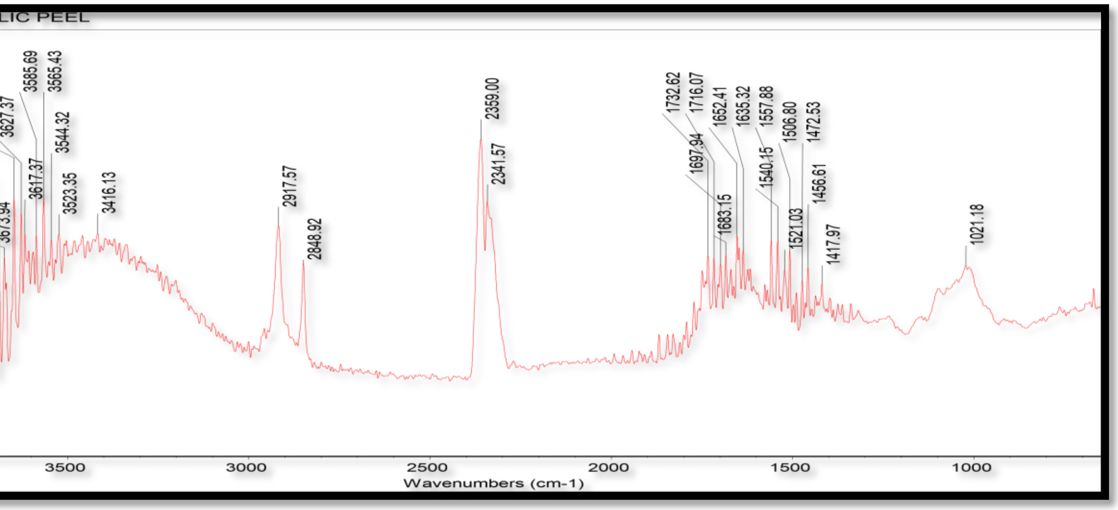


FIGURE 7

FTIR spectra of garlic peel

TABLE XV

FTIR value of garlic peel

S.No	Garlic peel (cm^{-1})	Assignments

1	2913	C-H asymmetric stretching of CH_2 groups
2	2848	C-H stretching
3	2341	Bending vibrations of N-H and the asymmetric stretching vibrations of C=O bonds.
4	1021	C-C,C-OH, C-H ring and side group vibrations
5	2359	asymmetric stretching , asymmetric deformation and symmetric deformation of – CH_3 groups

Figure 7 and Table XV showed the FT-IR spectra of garlic peel, the peak 2913 cm^{-1} is due to C-H asymmetric stretching of CH_2 groups (Sathasivam *et al*,. 2010), 2341 cm^{-1}representN-H and the asymmetric stretching vibrations of C=O bonds (Arakha *et al.*, 2015), 1021 cm^{-1}represents C-C,C-OH, C-H ring and side group vibrations,2848 cm^{-1}attributes to C-H stretching (Fan *et al.*, 2012). The garlic peel has C-H, C=O structure and CH_2 groups by nature, the presence of this functional groups may be leads to absorb oil.

4.5 Onion peel

In order to understand the nature of the functional groups present in onion peel, FTIR analysis was carried out and the results were presented in Figure 8 and Table XVI.

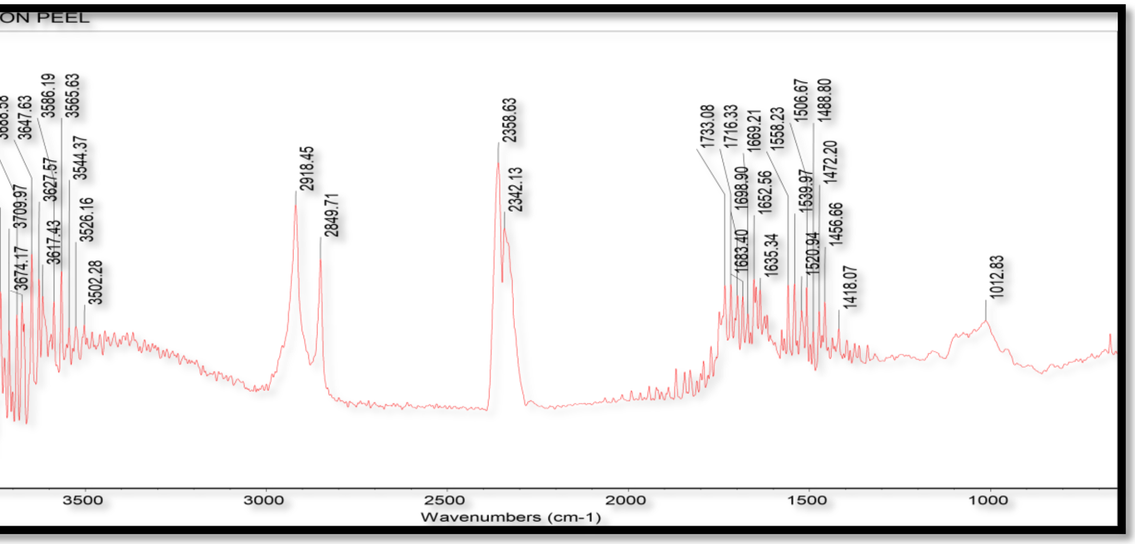


FIGURE 8

FTIR analysis of onion peel

Table XVI

FTIR value of onion peel

S.No	Onion peel (cm^{-1})	Assignments

1	2918	C-H asymmetric stretching of CH_2 groups
2	2849	C-H stretching
3	2358	CO stretching vibrations
4	2342	Stretch of CO_2
5	1012	C-O-C stretching

Figure 8 and Table XVI, showed FT-IR spectroscopy of onion peel, strong peak 2358cm^{-1}represents CO stretching vibrations (Kannan, 2014). The 2919 cm^{-1} peak value represents CH stretching of vibrations, 2849 cm^{-1} corresponds C-H stretching (Stancu *et al.*, 2017), 2342 cm^{-1}attributes to stretch of CO_2 (Berstein *et al.*, 2005) . May be the presence of CH_2 functional groups gets affinity towards oil absorption.

4.6 Banana peel

Figure 9 and Table XVII shows, FT-IR spectra of banana peel were obtained in order to understand the nature of the functional groups present in banana peel.

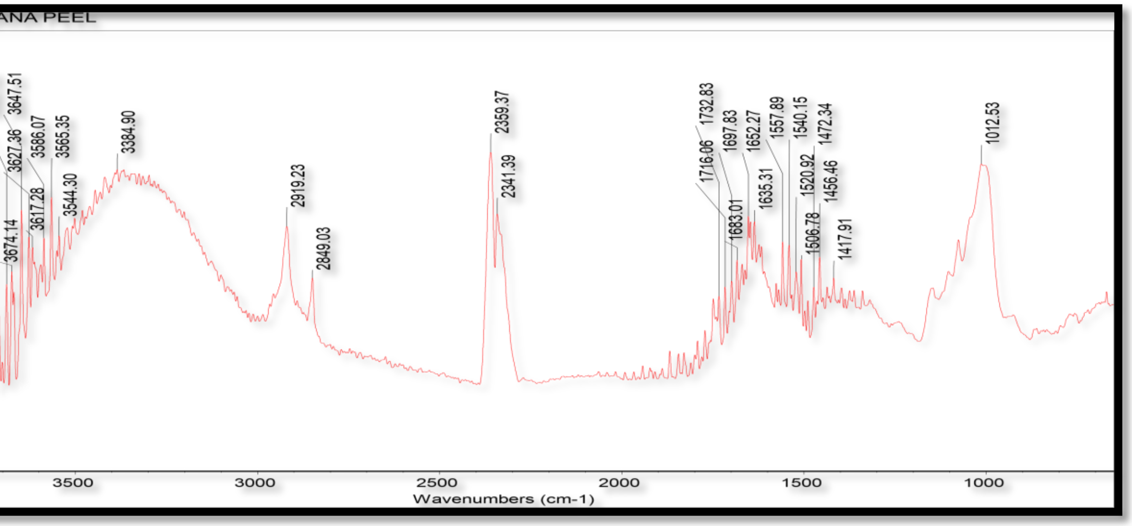


FIGURE 9

FTIR spectrum of banana peel

TABLE XVII

FTIR value of banana peel

S.No	Banana peel (cm^{-1})	Assignments

1	2919	C-H asymmetric stretching of CH_2 groups
2	2341	Bending vibrations of N-H and the asymmetric stretching vibrations of C=O bonds
3	1012	C-O-C stretching
4	2359	asymmetric stretching , asymmetric deformation and symmetric deformation of – CH_3 groups

Figure 9 and Table XVII shows, FTIR spectra of banana peel. The strong band 2341 cm^{-1} which represents N-H and the asymmetric stretching vibrations of C=O bonds (Arakha *et al.*, 2015). The peaks 2919 cm^{-1}corresponds to C-H asymmetric stretching of CH_2 groups (Sathasivam *et al*, 2010), 1012 cm^{-1} C-O-C stretching vibrations (Duygu *et al.,* 2012), 2359 representsasymmetric stretching , asymmetric deformation and symmetric deformation of – CH_3 groups (Thakur *et al.,* 2015). The presence of methyl functional groups creates oleophilic surfaces. (Toyada *et al.,* 2006).

4.7 Polypropylene

Figure 10 and Table XVIII showed FTIR spectroscopy was recorded to identify a number of peaks and on organic functional groups present of the surface of the polypropylene sheet.

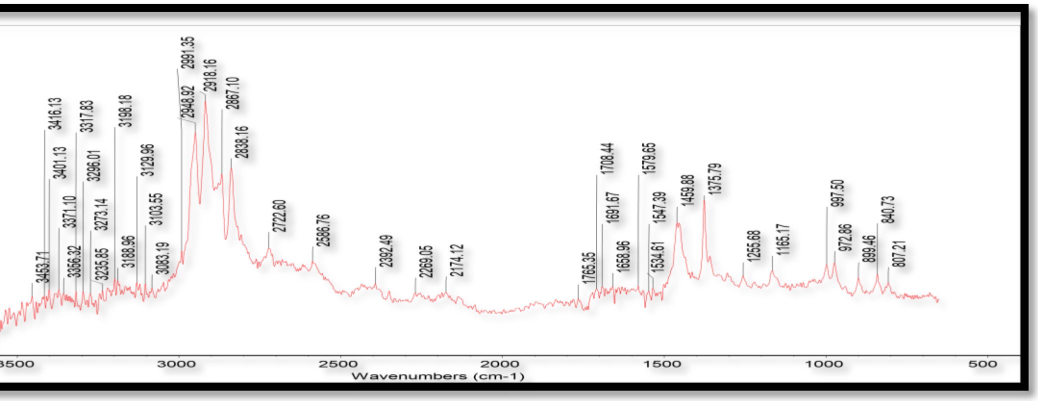


FIGURE 10

FTIR spectrum of polypropylene

Table XVIII

FTIR value of polypropylene

S.No	Polypropylene (cm^{-1})	Assignments
1	2918	C-H asymmetric stretching of CH_2 groups
2	2867and 2838	C-H stretching
3	1459	CH_3 deformation
4	1357	Symmetric CH_3 deformation

Table XVIII and Figure 10, showed the FI-TR spectra of polypropylene sheet. The peak 2918cm^{-1}represents C-H asymmetric stretching of CH_2 groups (Sathasivam et al,. 2010), peak 1459cm^{-1}correspond to CH_3 deformation (Mohanta et al., 2015), 1375cm^{-1} represents symmetric CH_3 deformation,2867 and 2838cm^{-1}represents CH stretching (Fan *et al.*, 2012). (CH_3) methyl functional groups present in material get affinity towards oil absorption (Brewis *et al.*, 2006) and CH groups showed reduction in water absorption (Matejkova *et al.*, 2012).

5. Water Absorbency Test

5.1.1 Free Swell Method

5.1.1.1 Water absorbency of treated and untreated cotton

Table XIXand Figure 11 showed the comparison water absorbency value of untreated and treated cotton.

TABLE XIX

Water absorbency of treated and untreated cotton

Water absorbency		
S.No	**Untreated cotton (g)**	**Treated cotton (g)**
1	23.76	14.04
2	30.48	11.92
3	26.92	11.61
Average	27.046	12.52333

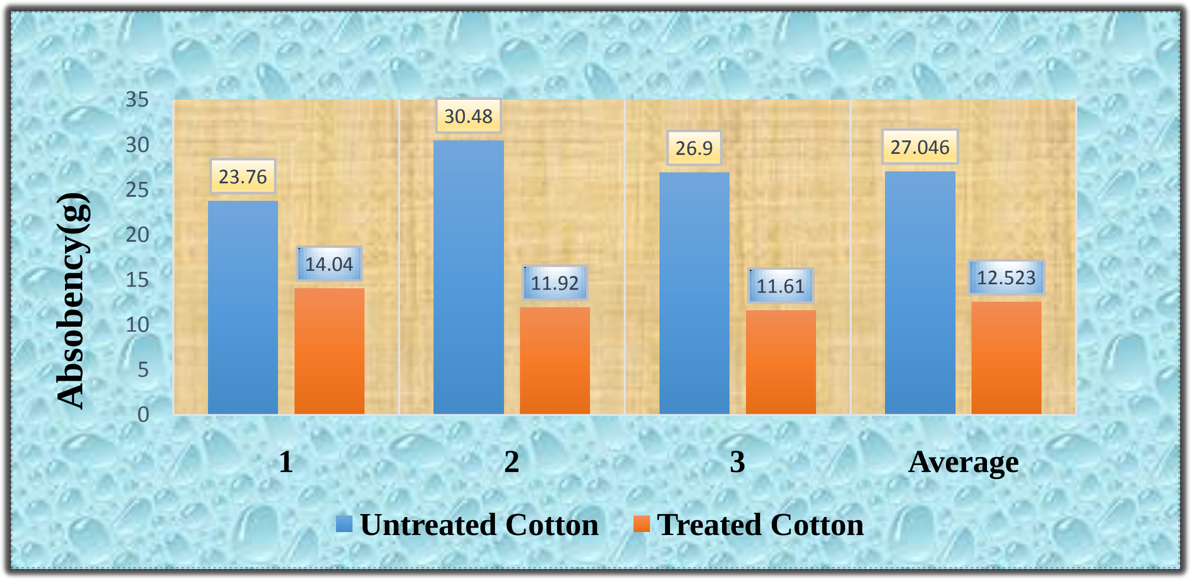


FIGURE 11

Water absorbency of treated and untreated cotton

The above Table XIX and Figure 11 showed that, the water absorbency of treated and untreated cotton. On comparing the average of water absorbency of treated and untreated cotton, treated cotton shows less water absorbency than untreated cotton. Reduction in water absorption may be chemical treatment of natural fibres.

5.1.1.2Water absorbency of treated and untreated wood pulp

The water and oil absorbency test values of untreated and treated cotton were shown in Table XX and Figure 12.

TABLE XX

Water absorbency of treated and untreated wood pulp

Water Absorbency		
S.No	**Untreated pulp (g)**	**Treated pulp (g)**
1	25.678	16.13
2	24.15	17.46
3	23.51	19.78
Average	24.446	1.5082

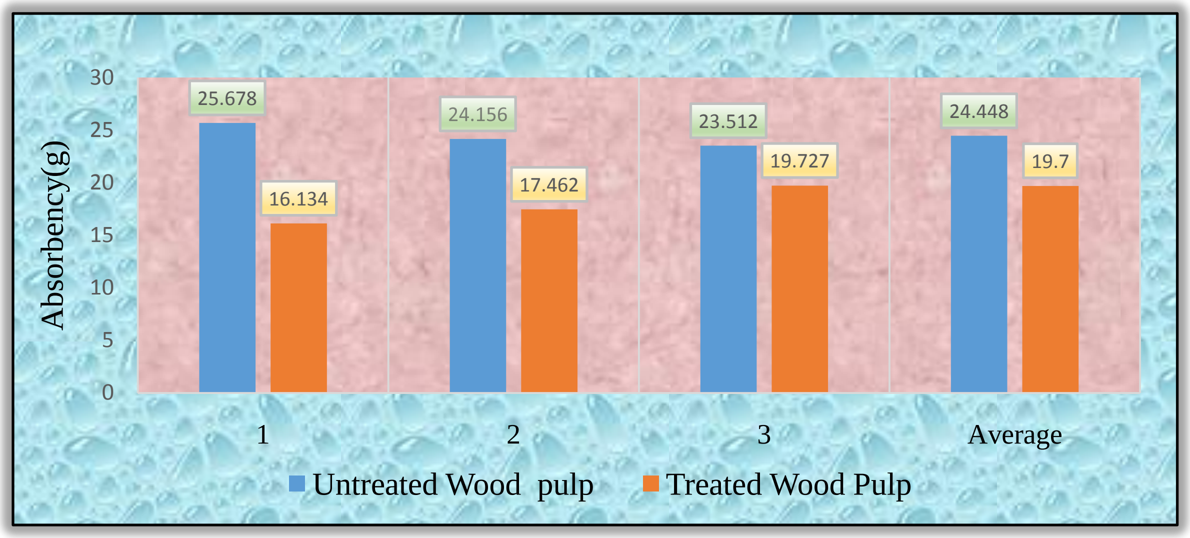


FIGURE 12

Water absorbency of treated and untreated wood pulp

The above Table XX andFigure 12 showed the water absorbency of treated and untreated wood pulp. On comparing the average of water absorbency of treated and untreated pulp, chemical treated pulp shows less water absorbency than untreated pulp.

5.1.1.3Water Absorbency of Treated and Untreated bagasse

The water absorbency level of untreated and treated bagasse and analysis of average are shown in Table XXI and Figure 13.

TABLE XXI

Water absorbency of untreated and treated bagasse

Water absorbency		
S.No	**Untreated bagasse (g)**	**Treated bagasse**
1	8.497	5.322
2	5.532	61818
3	7.1488	5.876
Average	7.0559	6.005

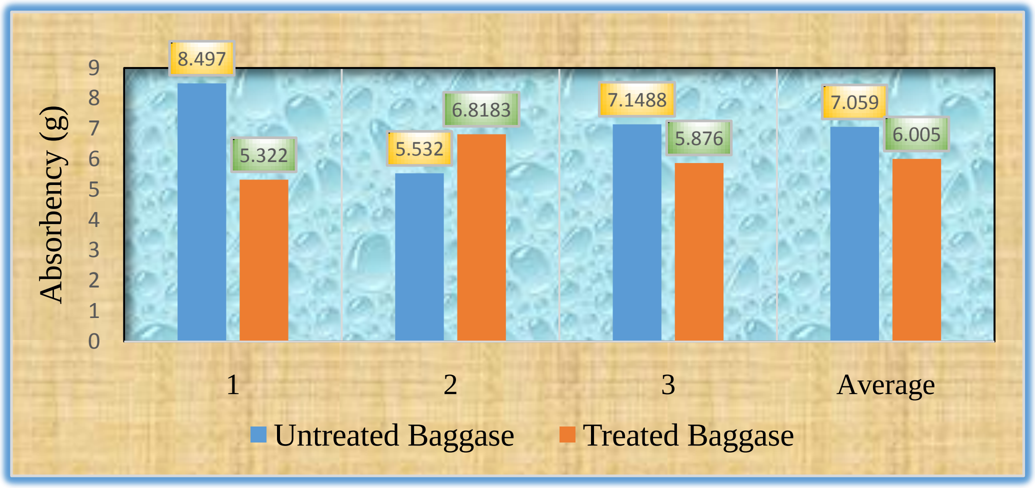


FIGURE 13

Water absorbency of untreated and treated bagasse

The above Table XXI andFigure 13 showed the water absorbency of treated and untreated bagasse. On comparing the average of water absorbency of treated and untreated bagasse, treated bagasse showed less water absorbency than untreated. The bagasse treated fibres has less water absorption than cotton and wood pulp fibres.

6. Oil Absorbency Test

6.1 Magnetic Stirrer Method

6.1.1 Oil absorbency treated and untreated cotton

The oil absorbency test values of Treated and Untreated Cotton are shown in Table XXII and Figure 14.

Table XXII

Oil absorbency of treated and untreated cotton

Oil Absorbency			
S.No	**Test samples(g)**	**Untreated cotton(g)**	**Treated cotton(g)**
1	Before wgt	0.1057	0.1090
2	After wgt	1.332	0.7697

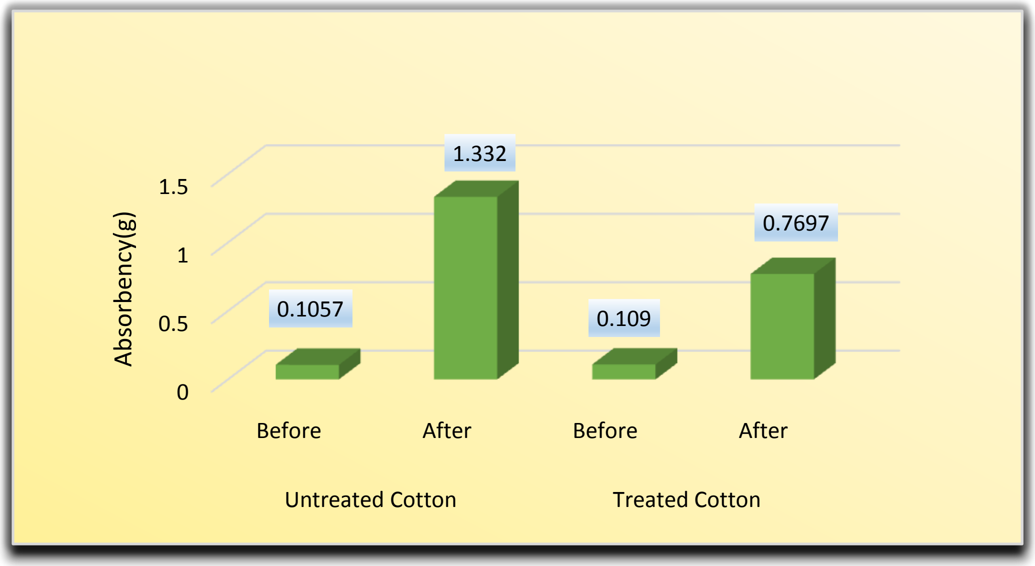


Figure 14

Oil absorbency of treated and untreated cotton

From Table XXIIand Figure 14, it is evident that untreated cotton has high oil absorption of 1.332 g when compared to stearic acid treated cotton.

6.1.2Oil absorbency treated and untreated wood pulp

Table XXIII and Figure 15 showed the oil absorbency level of Treated and Untreated Wood Pulp fibre.

Table XXIII

Oil absorbency of treated and untreated wood pulp

Oil Absorbency			
S.No	**Test samples(g)**	**Untreated Wood pulp (g)**	**Treated Wood pulp (g)**
1	Before wgt	0.1025	0.7697
2	After wgt	0.5253	0.5444

FIGURE 15

Oil absorbency of treated and untreated wood pulp

From Table XXIIIand Figure 15, it is clear that the stearic acid treated wood pulp has high oil absorption value of 0.5444 g when compared to untreated wood pulp.

6.1.3Oil absorbency treated and untreated bagasse

The oil absorbency level of Treated and Untreated bagasse are shown in Table XXIV and Figure 16.

TABLE XXIV

Oil absorbencytreated and untreated bagasse

Oil Absorbency			
S.No	**Test samples(g)**	**Untreated Bagasse(g)**	**Treated Bagasse(g)**
1	Before wgt	0.1081	0.1081
2	After wgt	0.5127	0.3816

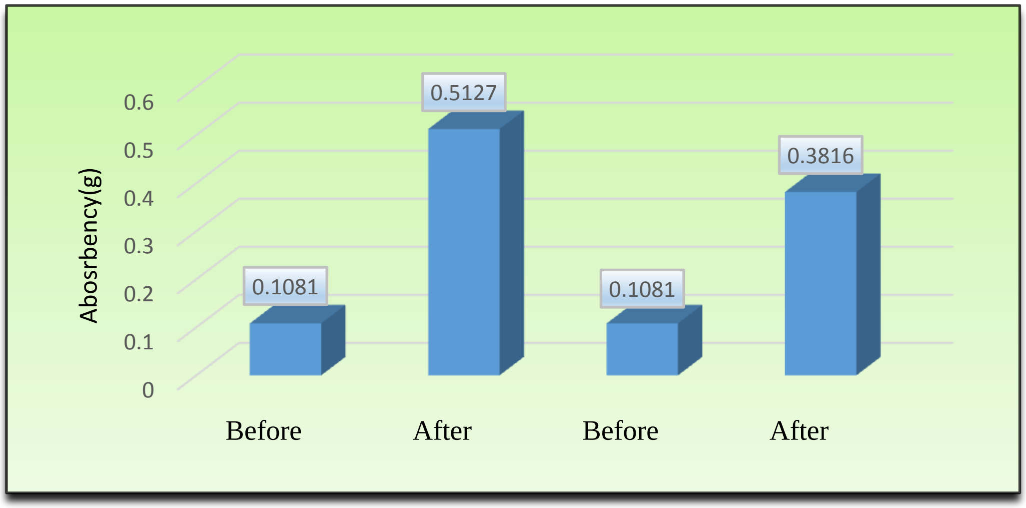


FIGURE 16

Oil absorbency of treated and untreated bagasse

From Table XXIV and Figure 16, it is observed that the oil absorbency of untreated bagasse has high absorption of 0.5127 g when compared to chemical treated bagasse.

6.1.4 Oil absorbency of garlic, onion and banana peel

The oil absorbency test values of onion, garlic, banana peel are shown in Table XXV and Figure 17.

Table XXV

Oil absorbency of garlic, onion and banana peel

Oil absorbency			
S.No	**Source**	**Before (g)**	**After(g)**
1	Garlic	0.1679	0.6804
2	Onion	0.1679	0.6804
3	Banana	0.1896	0.4008

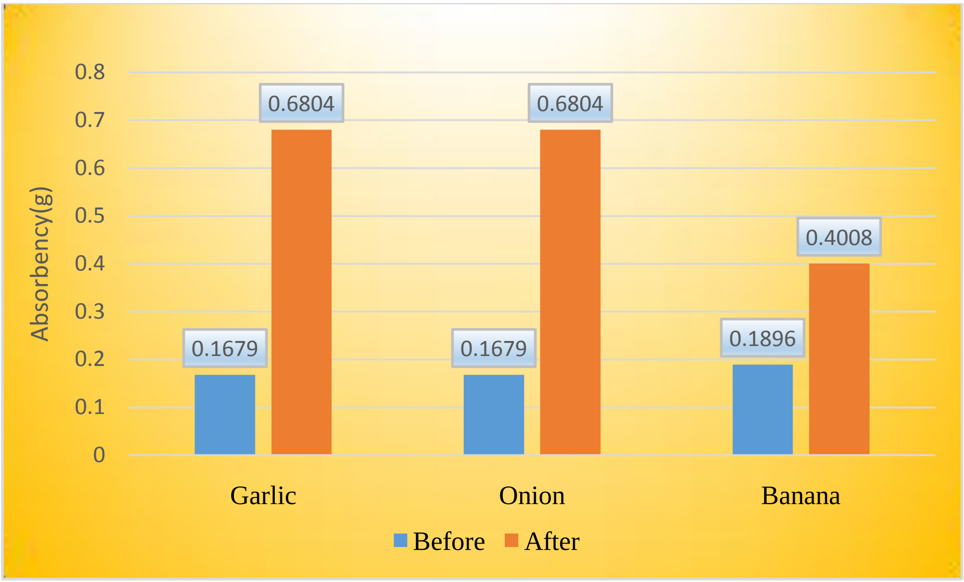


FIGURE 17

Oil absorbency of garlic, onion and banana peel

From the above Table XXV and Figure 17 showed the oil absorbency different vegetable wastes. It is observed that garlic and onion peel has high absorption of 0.6804g when compared to banana.

6.1.5 Oil absorption of polypropylene

The oil absorbency test values of nonwoven polypropylenewere shown in Table XXVI and Figure 18.

TABLE XXVI

Oil absorption of polypropylene

Source	**Before (g)**	**After (g)**
Polypropylene	0.2073	2.2194
	0.3560	3.4887

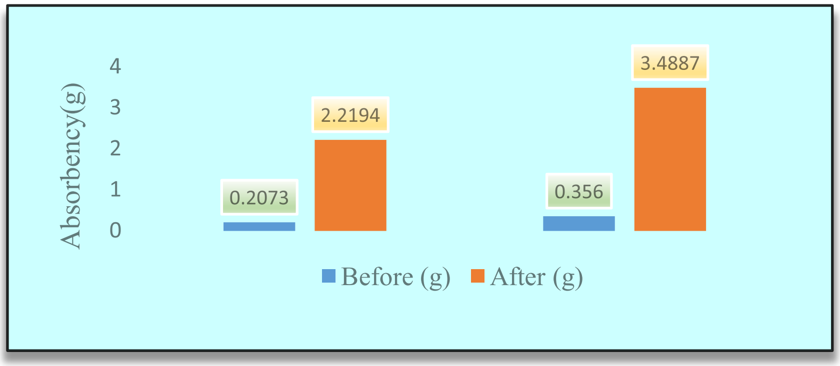


FIGURE 18

Oil absorbency of polypropylene

The Table XXVI andFigure 18 shows the oil absorbency polypropylene sheet. It is also observed the oil absorbency of polypropylene is high this may be due to presence of spin finish present on the surface of the sheet.

6.1.6 Oil absorption of vegetable waste coated developed materials

To evaluate the oil absorption of plain polypropylene fabric and different vegetable waste (onion, garlic, banana, and onion/garlic/banana) PVC coated polypropylene developed materials. Different absorption time results are presented in Table XXVII and Figure 19.

TABLE XXVII

Oil absorption of vegetable waste coated developed materials

S.No	Source	Absorption after 15 min (In %)	30 min after absorption (In %)	1 hr after absorption (In %)	Oil retained in petridish (g)	Oil retention after 1 hr (g)	Oil retained under pressure (g)
1	Onion	611.9163	533.8765	493.9803	2.4111	0.8113	9.8398
2	Garlic	594.0038	560.7902	543.8487	0.8762	0.8538	10.5403
3	Banana	303.1242	240.7707	204.966	1.0139	0.2794	7.1563
4	Onion/Garlic/Banana	593.2132	512.1077	477.4339	7.3768	0.9625	8.8311
5	Polypropylene	970.6233	660.1061	621.60	0.2491	9.3574	0.1603

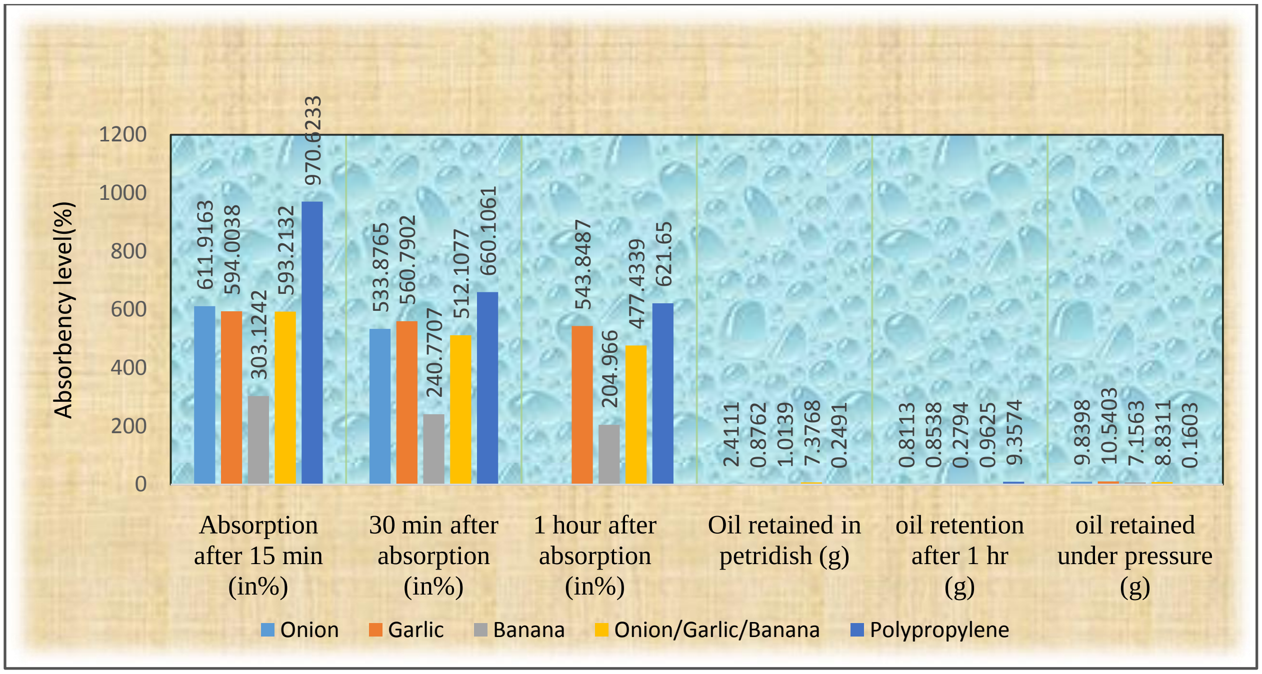


FIGURE 19

Oil absorption of vegetable waste coated materials

The above Table XXVII and Figure 19 showed, oil absorption of plain polypropylene fabric and different vegetable waste (onion, garlic, banana, and onion/garlic/banana) PVC coated polypropylene developed materials.Different absorption time takes place with time duration of 15 min, 30 min and 1 hour. It was observed that after absorption time of 15 min, the polypropylene showed high oil uptake of 970.6% this may be due to presence of spin finish on the surface of the sheet. Among all the natural source onion coated PP showed 611.91% highest absorption. The material to be dried for 30 min after absorption it is observed that, the polypropylene sheet retained higher absorption level of 660.10%, but the absorption values changed in vegetable waste coated PP materials. Garlic coated PP materials has higher absorption 560.79% value than onion, banana and onion/ garlic/banana coated PP materials, with extend to time duration of 1 hour after absorption polypropylene sheet retained high level in oil absorption of 621.91%. Among all the natural source garlic coated PP material showed high level in oil absorption 543.84 %.

6.1.7 Oil absorption of reusable vegetable waste coated developed materials

To evaluate the oil absorption of reused plain polypropylene fabric and different vegetable waste (onion, garlic, banana, and onion/garlic/banana) PVC coated polypropylene developed materials. Different absorption time results are presented in Table XXVIII and Figure 20.

TABLE XXVIII

Oil absorption of reusable vegetable waste coated developed materials

S.No	Source	Absorption after15 min (In %)	30 min after absorption (In %)	1 hr after absorption (In %)	Oil retained in petridish (g)	Difference in oil retaining after sample reuse (g)
1	Onion	159.7651	128.3346	118.4026	1.6776	0.7335
2	Garlic	134.8628	121.8925	113.7439	1.2877	-0.4115
3	Banana	125.8527	85.67652	72.07083	2.6946	-1.6807
4	Onion/Garlic/Banana	143.1853	126.9726	118.1824	2.4256	-9.8024
5	Polypropylene	261.9381	131.1064	130.6943	0.8363	-0.5872

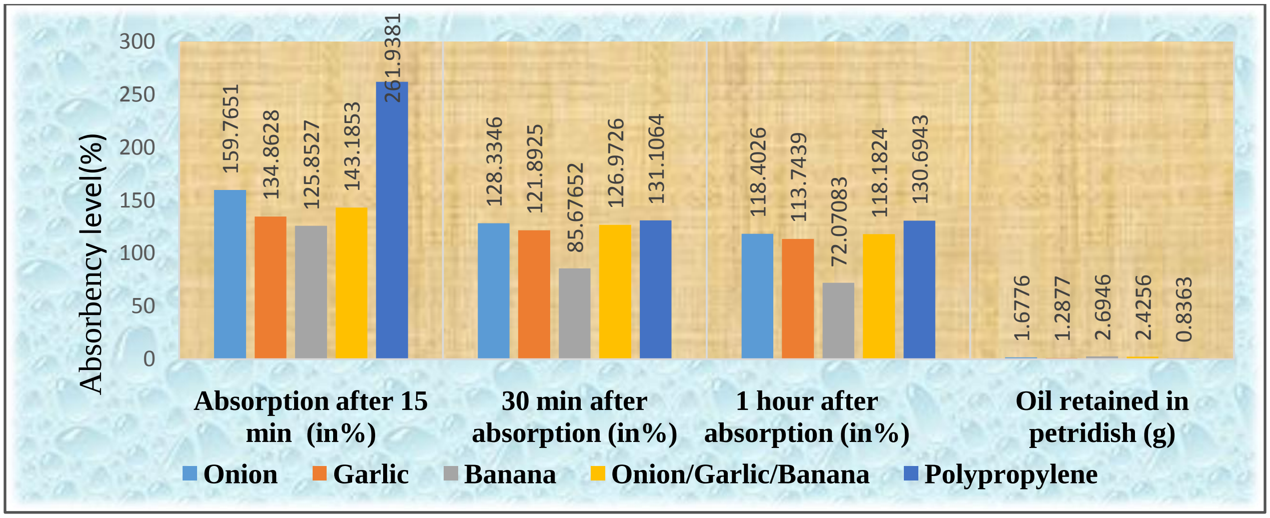


Figure 20

Oil absorption of reusable vegetable waste coated material

The above Table XXVIII and Figure 20showed the oil absorption of reused plain polypropylene fabric and different vegetable waste (onion, garlic, banana, and onion/garlic/banana) PVC coated polypropylene developed materials. Absorption time takes place with different time duration of 15 min, 30 min and 1 hour. It was observed that after absorption time of 15 min, the synthetic (polypropylene) sheet showed high oil uptake of 261.93%,this may be due to presence of spin finish on the surface of the sheet. Among all the natural source onion coated PP materials showed highest absorption of 159.76%. The material to be dried for 30 min after absorption it is observed that, the polypropylene sheet absorbed 131.10% and onion coated PP absorbed 128.33%, with extend to time duration of 1 hour after absorption polypropylene sheet retained high level in oil absorption of 130.69%. Among all the natural source onion coated PP showed 118.40% and the mixture of garlic/onion/banana coated PP fabric showed 118.18% high level of oil absorption.

6.1.8 Oil absorption of vegetable waste/cotton coated developed materials

To evaluate the oil absorption of plain polypropylene materials and different vegetable waste was blended with treated cotton fibre such as onion/cotton, garlic/cotton, banana/cotton, and onion/garlic/banana/cotton PVC coated polypropylene developed materials. Different absorption time results are presented in Table XXIX and Figure 21.

TABLE XXIX

Oil absorption of vegetable waste / cotton blended coated developed materials

S.No	**Source**	**Absorption after 15 min (In %)**	**30 min after absorption (In %)**	**1 hr after absorption (In %)**	**Oil retained in petridish (g)**	**Oil retention after 1 hr (g)**	**Oil retained under pressure (g)**
1	Cotton/onion	470.39	370.033	343.53	1.5363	0.5773	8.66
2	Cotton/garlic	474.9	406.45	401.38	2.6012	0.4903	10.197
3	Cotton/banana	414.23	247.1	230.95	2.6933	0.3877	7.221
4	Cotton/onion/ Garlic/banana	559.22	412.21	392.6	3.0655	0.683	8.784
5	Polypropylene	879.98	584.52	525.28	0.881	2.0661	0.726

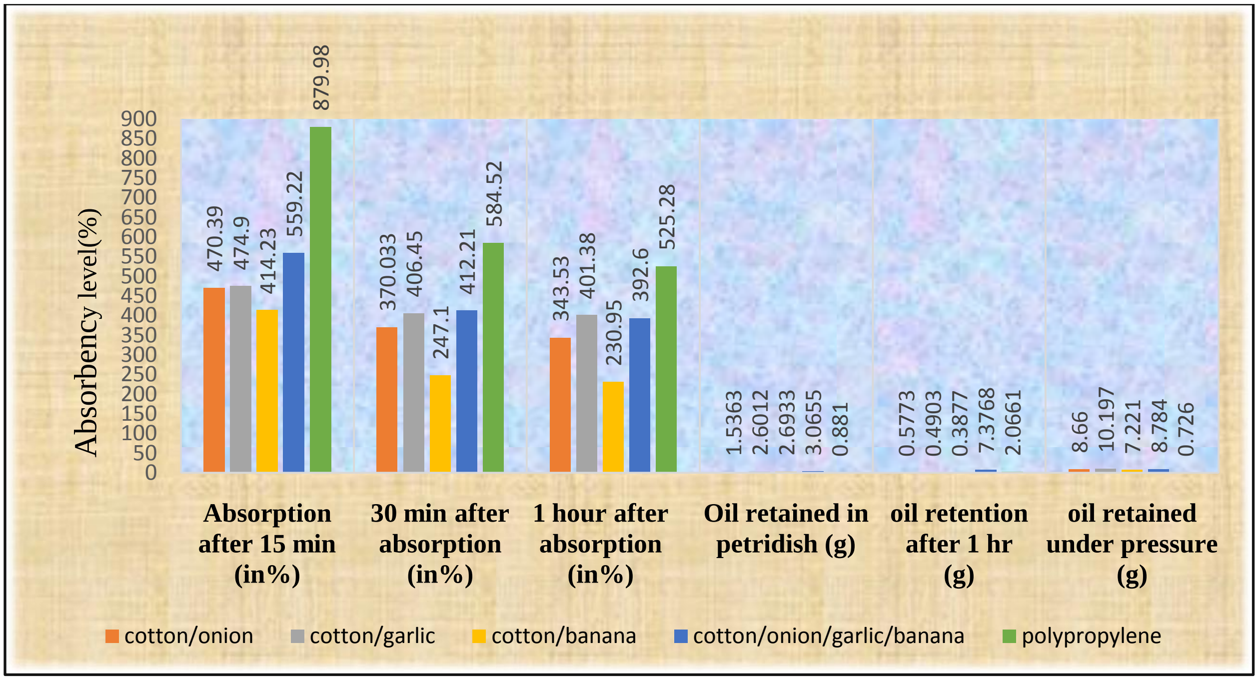


FIGURE 21

Oil absorption of vegetable waste/ cotton blendedcoated material

The above Table XXIX and Figure 21 revealed oil absorption of plain polypropylene materials and different vegetable waste was blended with treated cotton fibre such as onion/cotton, garlic/cotton, banana/cotton, and onion/garlic/banana/cotton PVC coated polypropylene developed materials. Absorption time takes place with different time duration of 15 min, 30 min and 1 hour. It was observed that after absorption of 15 min, polypropylene sheet showed 879.98% high oil uptake, this may be due to presence of spin finish on the surface of the sheet. Among all the natural source the mixture of onion/garlic/banana coated PP materials showed 559.22% highest oil absorption. The material to be dried for 30 min after absorption it is observed that, polypropylene sheet showed 584.52 %and onion/garlic/banana coated PP materials showed 412.21 % higher absorption, with extend to time duration of 1 hour after absorption,polypropylene sheet retained high level in oil absorption of 525.28%. Among all the natural source blend of garlic/cotton mixed coated PP bags showed 401.38% high oil absorption.

6.1.9Oil absorption of reusable vegetable waste/cotton blended coated developed materials

To evaluate the oil absorption of reused plain polypropylene and different vegetable waste blended with treated cotton fibres such as onion/cotton, garlic/cotton, banana/cotton, onion/garlic/banana/cotton, PVC coated polypropylene developed materials. Different absorption time results are presented in Table XXX and Figure 22.

Table XXX

Oil absorption of reusable vegetable waste cotton blended coated developed materials

S.No	Source	Absorption after 15 min (in %)	30 min after absorption (In %)	1 hr after absorption (In %)	Oil retained in petridish (g)	Difference in oil retaining after sample reuse (g)
1	cotton/onion	122.8113	68.10545	62.06118	1.5363	-2.2864
2	cotton/garlic	178.6949	96.08831	90.00723	2.6012	-4.3166
3	cotton/banana	194.5799	81.57175	73.16282	2.6933	-2.981
4	cotton/onion/ garlic/banana	169.3745	91.43485	79.22534	3.0655	-1.3517
5	Polypropylene	201.2887	133.0914	130.2284	0.881	-0.1313

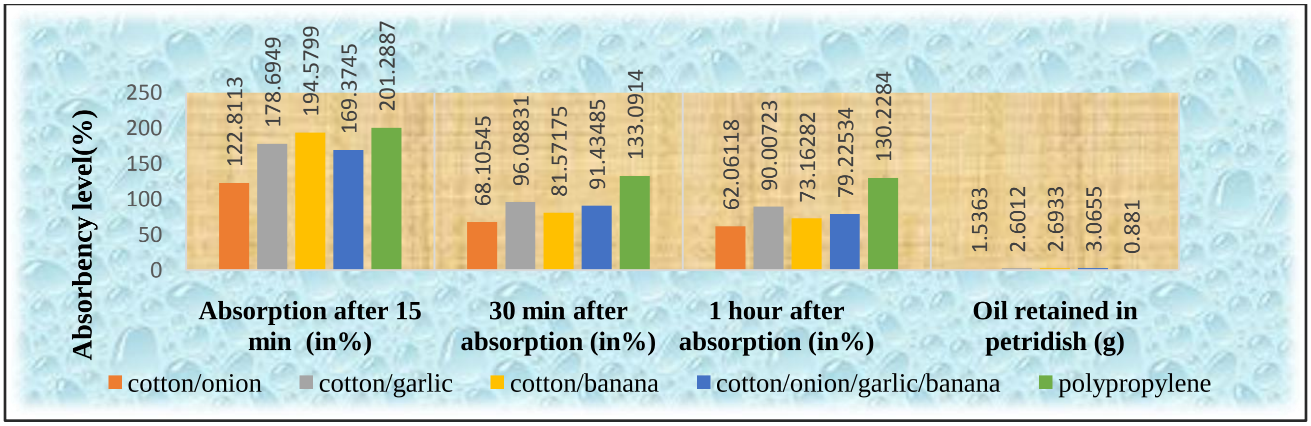


FIGURE 22

Oil absorption of vegetable waste /cotton blended coated reusable materials

The above Table XXX and Figure 22 showed, oil absorption of reused plain polypropylene and different vegetable waste blended with treated cotton fibres such as onion/cotton, garlic/cotton, banana/cotton, onion/garlic/banana/cotton, PVC coated polypropylene developed materials. Absorption time takes place with different time duration of 15 min, 30 min and 1 hour. It was observed that after absorption of 15 min, the synthetic (polypropylene) sheet absorbed 201.288% high oil uptake, this may be due to presence of spin finish on the surface of the sheet. Among all the natural source cotton/banana coated PP showed highoil absorption of 194.57%. The material to be dried for 30 min after absorption it is observed that, the polypropylene sheet retained higher absorption of 133.09 % and the natural cotton/garlic coated PP showed 96.088% highest oil absorption next to polypropylene sheet, with extend to time duration of 1 hour after absorption polypropylene sheet absorbed 130.22 % and natural cotton/garlic blended coated PP absorbed 90% in oil absorption.

7. Sinking Test for developed sample

7.1 Sinking test forvegetable waste coated PP developed materials

The sinking level of onion/coated PP, Garlic coated PP, Banana coated PP, Onion/garlic/banana mixed coated developed material and plain PP fabric and sinking time are shown in Table XXXI and Figure 23.

Table XXXI

Sinking test forvegetable waste coated PP materials

S.No	**Materials**	**Sinking time (min)**
1	Onion Coated PP	2
2	Garlic Coated PP	3
3	Banana Coated PP	2
4	Onion/garlic/banana mixed Coated PP	3
5	Plain PP	1

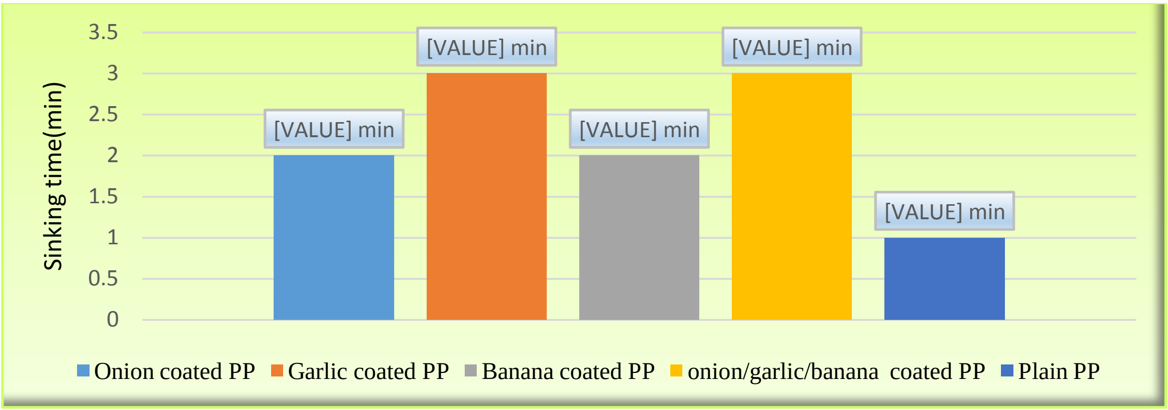


Figure 23

Sinking test for vegetable waste coated PP materials

Table XXXI and Figure 23 showed sinking level of developed materials during oil absorption test. From the results it is observed that plain polypropylene absorbed first with the time duration of 1min. Among all the vegetable waste coated materials, garlic coated and the mixture of onion/garlic/banana coated materials absorbed second with the time duration of 2.5min.

7.2 Sinking test forreused vegetable waste coated PP developed materials

To evaluate the oil absorption sinking level of reused plain polypropylene fabric and different vegetable waste (onion, garlic, banana, and onion/garlic/banana) coated polypropylene developed materials. Different sinking time results are presented in Table XXXII and Figure 24.

Table XXXII

Sinking test forreused vegetable waste coated PP materials

S.No	Materials	Sinking time (min)
1	Onion Coated PP	3.5
2	Garlic Coated PP	2.15
3	Banana Coated PP	2.33
4	Onion/garlic/banana mixed Coated PP	3.18
5	Plain PP	2.26

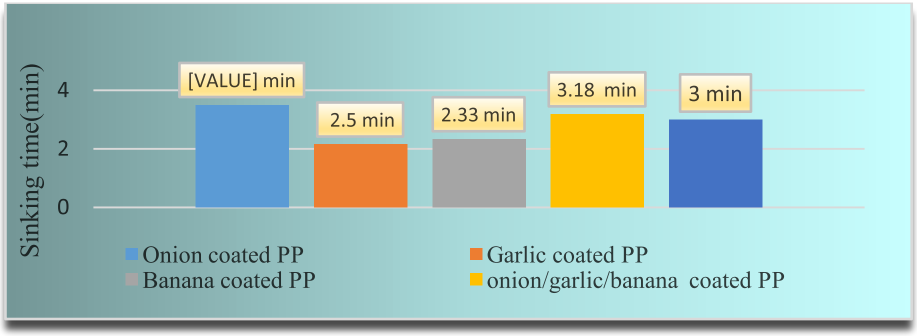


Figure 24

Sinking test for reused vegetable waste coated PP materials

From the Table XXXII and Figure 24, it is evident that the sinking level of reused developed materials during oil absorption test. From the results it is observed that reused garlic coated polypropylene absorbed first with the time duration of 2.15min which represents garlic coated PP has good oil absorption uptake after reabsorption.

7.3 Sinking test forvegetable waste/cotton blended coated nonwoven PP materials

The sinking level of plain polypropylene materials and different vegetable waste/cotton coated materials such as onion/cotton, garlic/cotton, banana/cotton, and onion/garlic/banana/cotton coated polypropylene developed materials. Different sinking time results are presented in Table XXXIII and Figure 25.

Table XXXIII

Sinking test forvegetable waste/cottonblended coated nonwoven PP materials

S.No	Materials	Sinking time (min)
1	Onion/cotton Coated PP	4
2	Garlic/cotton Coated PP	3
3	Banana/cotton Coated PP	3
4	Onion/garlic/banana/cotton mixed Coated PP	4
5	Plain PP	1

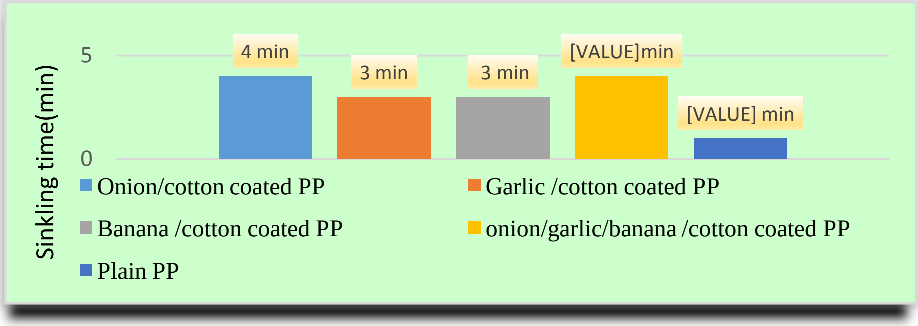


Figure 25

Sinking test for vegetable waste/cotton blended coated nonwoven PP materials

The above Table XXXIII and Figure 25 Showed, the oil absorption test sinking level. Nonwoven polypropylene absorbed first with the time of 1 min. Natural onion peel waste /cotton coated materials fully sinks with the time of 4 min.

7.4 Sinking test forreused vegetable waste/cotton blended coated nonwoven PP materials

Table XXXIV and Figure 26 showed the sinking level of plain polypropylene materials and different vegetable waste/cotton coated materials such as onion/cotton, garlic/cotton, banana/cotton, and onion/garlic/banana/cotton coated polypropylene developed materials. Different sinking time results are noted in oil absorption test of materials.

Table XXXIV

Sinking test forreused vegetable waste/cottonblended and coated nonwoven PP materials

S.No	Materials	Sinking time (min)
1	Onion/cotton Coated PP	2
2	Garlic/cotton Coated PP	1
3	Banana/cotton Coated PP	2
4	Onion/garlic/banana/cotton mixed Coated PP	2
5	Plain PP	1

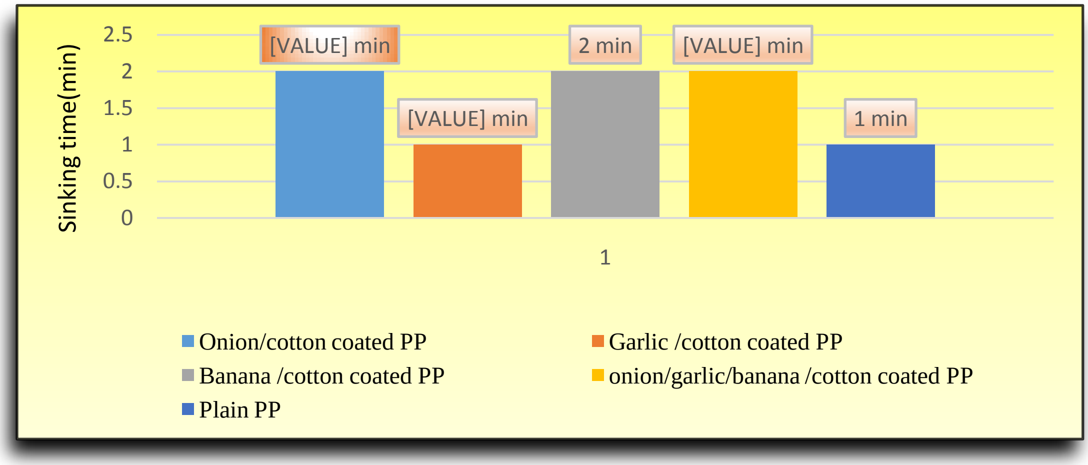


Figure 26

Sinking test for reused vegetable waste/cotton blended coated nonwovenPP materials

From the Table XXXIV and Figure 26, it is evident that the sinking level of reused vegetable waste/cotton coated developed materials during oil absorption test. It is observed that after reabsorption plain polypropylene absorbed first with the time of 1 min. Onion/coated, banana/coated, onion/garlic/banana mixed coated materials absorbed next to polypropylene with the sinking time of 2 min.

SUMMARY AND CONCLUSION

5. SUMMARY AND CONCLUSION

Oil spills are causing enormous damage to environment by the way of water pollution and it releases toxic chemicals .The consumption of oil and petroleum products has been estimated to be million barrels per day. Oil spills caused major threat to environment and economy .It is considerable interest to find a simple, effective, and inexpensive method to treat this calamity.

The globalization of markets and increasing demand for oil spill cleanup products has created a deep interest in the use of raw materials form natural resources. Oil pollution causes toxications to water, land and many other natural resources. Hence, prevention of oil pollution is utmost important. We are adopting many methods to recover oil spills and wastage which sometimes even pollutes the environment. In order to save the environment, biodegradable and recyclable agro waste can be used to remove oil pollution which in turn friendly to the environment.

Hence the present study **"Development of oil absorption fabric coated with vegetable waste**" was carried out with the following objectives to:

- To reduce utilization of synthetic materials and develop biodegradable sorbents materials.
- To develop sorbent product using utilized vegetable waste for oil absorbency.
- To study oil absorbency characteristics of the developed product.

Methodology Adopted

- To make the fibre into hydrophobic, chemical treatment method are to be carried out to treat the natural fibres such as cotton, wood pulp, sugarcane (bagasse).
- Bagasse are treated with NaOH to remove the impurities in the fibres.
- Preparation of agro waste sorbents into granules for oil absorption application.
- Free swell method was carried out to identify the water absorbency of treated and untreated fibres.
- Probe sonicator method was carried out to prepare oil/water mixture for oil absorption test.
- Magnetic stirrer method was carried out to evaluate the oil absorption of treated and untreated cotton, wood pulp and bagasse fibres.

Findings of the study

Evaluation of the vegetable waste coated developed oil absorbent fabric

- After the absorption time of 15 min synthetic absorbent polypropylene sheet has high oil absorption of 970.62% this may be due to presence of spin finish on the surface of the polypropylene materials. Among all the natural sorbents onion coated polypropylene has high absorption of 611.91 %.
- The material to be dried for 30 min after absorption it is observed that, polypropylene top sheet retained high sorption of 660.10% and garlic coated polypropylene showed high absorption of 560.79%.
- Nonwoven polypropylene and coated garlic polypropylene sheet retained high absorption of 621.60% and 543.84% respectively with extend to time duration of 1 hour after absorption.
- Reusable of vegetable waste coated PP and plain nonwoven polypropylenewas taken for study, onion coated polypropylene and nonwoven polypropylene sheet showed high sorption of 159.76 % and 261.93% respectively. Absorbed material to be dried for 30 min after absorption, showed polypropylene sheet and onion coated polypropylene materials retained high sorption level of 131.10% and 128.33 % respectively.
- With the extend to time duration of 1 hour after absorption reused polypropylene sheet , onion coated polypropylene and onion/ garlic/banana/mixed coated polypropylene absorbent materials showed high absorbency of 130.69 %, 118.40% and 118.18% respectively.
- On second reusable of material it is observed that difference in oil retaining materials is 2 to 3 times more than that of plain nonwoven polypropylene. The developed materials may be more suitable due to its cost effectiveness, reabsorbency and recyclability.
- After the absorption time of 15 min blend of cotton/ onion/ garlic/banana mixed coated polypropylene and plain polypropylene sheet showed high oil absorption of 559.22 % and 879.98 % respectively. With the time duration of 30 min after absorption polypropylene sheet and cotton/onion/garlic/banana blended coated mixed polypropylene retained high absorption of 584.52% and 412.21% respectively. With the extent to time duration of 1 hour after absorption, garlic/cotton/polypropylene coated materials and polypropylene plain sheet showed high level oil absorption of 401.38% and 525.28% respectively.

- Reusable of vegetable waste and treated fibres blended coated PP materials and polypropylene nonwoven taken for the study, polypropylene sheet and cotton/banana blended coated polypropylene showed high oil absorption of 201.288% and 194.57%. With the time duration of 30 min after absorption cotton/garlic coated polypropylene materials and polypropylene nonwoven absorbed 96.088% and 133.09 % respectively. After the time of 1 hourafter absorption polypropylene sheet and cotton/garlic coated polypropylene showed high oil absorption of 130.22% and 90 % respectively.
- It was observed that, on second reuse of vegetable waste and cotton blended material, the difference in oil retaining materials after sample reuse is higher for vegetable and fibre coated materials than that of plain nonwoven materials.

Conclusion

From this experimental study shows the sorption behavior of cotton, wood pulp, sugarcane (bagasse) fibres and agro waste sorbents such as onion, garlic and banana peel. It is also observed the sorption efficiency of developed vegetable waste coated and blend of fibre mixed vegetable waste coated materials. Onion, garlic and banana peel are generally disposed as waste in municipal sites and local markets. Instead of treating them as waste it can used for making into oil absorbent fabric by recycling. Although natural fibres have advantages of being low cost and easily available in nature. Therefore, it is also recommended for the development of oil absorbent materials. Because of the strong polar hydrophilic character and chemical treatments can be considered in modifying the properties of natural fibres. In this present study FTIR spectra peaks shows water absorbency of natural fibres are reduced. This may be due to chemical treatment of natural fibres by using stearic acid as chemical. From the test results of developed materials it is showed that nonwoven polypropylene has high oil absorption this may be due to presence of spin finish on the surface of the polypropylene sheet. It is also observed that natural biodegradable, recyclable garlic peel coated polypropyleneand cotton/garlic blended coated polypropylene materials showed high oil absorption. Furthermore, the reusability of individual onion, garlic, banana, onion/garlic/banana vegetable waste coated polypropylene and the blend of cotton/vegetable waste coated materials was impressive at reabsorption than its original oil absorption efficiency of the materials. Being a god absorbents and hydrocarbon by its nature, onion, garlic, and banana peel are utilized for oil absorption materials. Overall it can be seen that sorption capacity of garlic, onion, blend of onion/garlic/banana coated polypropylene and cotton /garlic blended coated polypropylene materials has good oil absorption. Subsequently, garlic, onion, banana peel agro waste not only helps in the minimizing of environmental toxications and contaminations, but also helps in the reduction of agricultural waste form pollutes sites.

FURTHER STUDY

- There are many natural sorbents such as coconut shells, gorse, silkworm cocoon, rice husk, raw ruffa, corn hubs etc. are present in nature which could be used for development of oil absorption materials. Within this stipulated time work was done on cotton, sugarcane (bagasse), wood pulp, garlic, onion and banana peel. So the same work could be carried on other natural sorbents.
- This study could be done to check the extent of bio- degradability of natural sorbents.
- The chemicals used in the study for making natural fibres into hydrophobic. Different concentration with various parameters can be used to differentiate the water absorption in the fibres.
- Other chemicals like acetic anhydride can be used to increase the hydrophobicity and oleophilicity content in place of stearic acid.
- Particle size of the materials used garlic, onion and banana granules can also place an important role in determining the physical behavior of the substrate, variations in particle size can also be studied to get the change in results.

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