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Comparison of Optimisation Parameters of Raw Cotton and Biodegraded Cotton Fibres

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ABSTRACT

The purpose of this study was to measure and compare the biodegradability of fabrics in laboratory and large scale composting environments. Acid, alkali, thermal resistance and water absorption capacity of raw cotton and biodegraded cotton fibres were tested. Under controlled laboratory conditions, the carbon dioxide produced was monitored and integrated to determine the biodegradation rate by their enzymatic activity, and the weight losses were measured after biodegradation by microbial mass. The raw cotton showed a more alkali, thermal, acid resistance and less water absorption capacity comparatively with the biodegraded cotton under laboratory conditions. In the present study we have used different bacterial strains called *Staphylococcus aureus* and *E.coli*, *B. Subtilis*, *Streptococcus.* The optimum incubation for the maximum degradation is 72 hrs. Biodegradation is an easy, less expensive method to control the toxic effluents of various industries.

INTRODUCTION

Pollution control is the prime concerns of society today. Cotton industrial effluents may effects the environment. They may affect the aquatic life and human system. These fine fibres may cause severe respiratory tract and other chronic infections which leads to the death. These fibres can be treated by a less expensive and highly effective method called biodegradation method. Biodegradation is one of the useful and highly effective methods to protect the global environment. In nature, all the plant, animal and microbial sources show the biosorbant property and hence we may choose any waste material to control this toxic effluents of various industries. At present, the chances of pollution is very much high with the toxic effluents of different chemical industries such as pharmaceutical, chemical, leather, dyes etc. So, we may protect our environment by this biosorption method. [1]Cotton fibres and fabrics, being natural cellulose polymers, are biodegradable under aerobic conditions. Textiles are easily attacked by microorganisms, which means that they quickly become damaged. Microorganisms pose a threat to textile materials at all stages of their production– from the obtaining of raw material (for example on plantations), through to the transportation and storage of the raw material and of the finished product. Microbial degradation of fabrics depends primarily on their chemical composition. Fabrics of natural origin are particularly susceptible to attack by microorganisms. The decomposition of natural plant-based fibres caused by the presence of fungi was known as early as 1926–1928 and was described by Smith and Morris. [ ] Research into the mechanism of the decomposition of such fibres by microorganisms has continued for 80 years. [2] The main component of plant fibres is cellulose. The content of cellulose depends on the type of fibre – in cotton, it reaches 94%, in linen fabric around 80%, and in others from 63% to 77% (jute, sisal, hemp). Cellulose is a polysaccharide composed of molecules of β-glucose linked by 1,4-β-glycoside bonds. The number of glucose molecules in a chain ranges from 7 to 10 thousand. Chains may be arranged in parallel, forming a crystalline structure, tangled to form an amorphous structure. Cellulose is broken down by microorganisms through a process of enzymatic hydrolysis. This mechanism involves a multistage decomposition of cellulose to glucose, brought about successively by the enzymes 1,4-endo-β-D-glucan cellobiohydrolase (EC 3.2.1.91) (also called exoglucanase, cellobiohydrolase),endo-1-4-β-D-glucan glucanohydrolase (EC 3.2.1.4) (endoglucanase, β-glucanase) and glucohydrolase of β-D-glucosides (EC 3.2.1.21) (cellobiose, β-glucosidase) [3].The intensity of cellulose decomposition is indicated by the appearance of differently colored stains on fabrics (carotenes, anthraquinones, excreted by the micro-organisms), reduction in the degree of polymerization, breakage of the fibre structure and reduction in tearing strength. In extreme cases, the cellulose may decompose completely. Plant fibres also contain small quantities (up to 10%) of such compounds as hemicellulose and lignin, which give the fibres rigidity, and pectins, which act as a kind of glue. Many microorganisms are capable of producing enzymes which decompose hemicelluloses and pectins (xylanase, galactosidase, mannosidase, glucuronidase, pectinesterase, glycosidase and others) [4,5]. In spite of this, there are certain species of fungi and bacteria which are capable of decomposing lignin (*Chaetomium, Paeciliomyces, Fusarium, Nocardia, Streptomyces, Pseudomonas, Arthrobacter*and others) [6,7].The rate of decomposition of natural plant-based fibres depends on their chemical composition. Among cellulose-based fibres, the slowest to decompose is jute (35% non www.intechopen.com. Microbial Degradation of Woven Fabrics and Protection Against Biodegradation 269 cellulose substances, including 25% lignin) [8]. The rate also depends on many other factors: apart from environmental factors and the type of microorganisms, there is also an effect from thickness, type of weave, degree of crystallinity (amorphous cellulose is more easily degraded) and degree of orientation (namely the angle made by the fibrils with the long axis of the fibre – highly oriented fibres are less susceptable to biodeterioration) [9,10,11]. In the present study, we have seen the biodegradation capacity of biomass of 4 different bacterial strains such as *B.Subtilis*, *Staphylo.Aureus*, *E.Coli and streptococcus* species in different physical and chemical conditions.

MATERIALS AND METHODS

In this experiment, we have used Raw Cotton, which was collected from the cotton plants (Gossypium herbaceum, Family- Malvaceae), located at our college -Nirmala college of pharmacy. Atmakuru. All the chemicals were purchased from universal laboratories from Mumbai. Microorganisms were collected from NCIM (National Collection of Industrial Microorganisms, Pune)

Equipments: Autoclave, Incubator, Hot air oven, Bunsen burner.

Chemicals: Sulphuric Acid (98%), Potassium Hydroxide Solution(30ml), Methanol(15ml) Distilled water (500ml).

Procedure:

Weigh the specified quantity 100gm of raw cotton and distribute 25gms of raw cotton into four conical flasks and add 15 gm of peptone, 5 gm of sodium chloride make up the volume up to 500 ml with distilled water. Now inoculate the biomass of test cultures *B.Subtilis, Staphylo.Aureus, E.Coli and Streptococcus* and incubate for 72 hrs. Biodegradation capacity of the biomass and raw cotton was determined by studying the various parameters such as weight (mass) of the raw cotton, thermal resistance, resistance to acid treatment, alkali treatment and alcohol treatment on comparison with the standard cotton. The raw cotton was mercerized and acid hydrolyzed treatment. Water absorption capacity was also tested.

a) Weight of the raw cotton: Take the initial weight of raw cotton and weigh the degraded cotton weight for successive three days incubation period.

b) Thermal resistance:

1. Direct Heating Method: Raw cotton was directly heated on flame.

2. Mechanical Heating Method: Raw cotton was kept in the hot air oven and it was heated at 150°c for about1hr.

c) Acid resistance: 1 gm of raw cotton was treated with 15ml of sulphuric acid (98%) for about 3 hours.

d) Alkali resistance: 1 gm of raw cotton was treated with 5 ml of potassium hydroxide solution.

e) Alcohol treatment: 1 gm of raw cotton was treated with 15ml of methanol for about 3 hours.

f) Mercerization: 5 gm of raw cotton was soaked in 25ml of potassium hydroxide solution for about 2 days.

g) Acid hydrolysis**:** The cotton fibers were soaked in 98% sulfuric acid for about 2 days.

h) Water Absorption Capacity**:** The raw cotton fibers (absorbent and non-absorbent) were soaked in 240ml of distilled water for about 1½ hours.

RESULTS AND DISCUSSION

Mass of the raw cotton: Mass of the raw cotton decreased with increased incubation period from 24 to 72 hrs. This is due to utilization of cellulose cotton fibers by inoculated cultures (Tab:1, Graph 1.a)

Thermal resistance: Indirect heating method the raw cotton had burnt completely in 3hrs, whereas biodegraded cotton takes 30 minutes to burn completely. And in mechanical heating method, the raw cotton had completely decomposed and turned to black color but the biodegrade cotton has taken short time with slight color change due to hydrolysis of cellulose by biomass and because of exhaustion of fibers by biomass. Citation" button to add citations to this document.

Acid resistance: On treatment by acid the raw cotton had decomposed partially by acid whereas biodegraded fibers are completely decomposed due to its less tensile strength and its utilization by biomass.

Alkali resistance: The raw cotton fibres were swelled and shrinked when treated with alkali. Whereas the biodegraded fibers are not affected.

Alcohol treatment: By alcohol treatment, the raw cotton color turned to white whereas biodegraded cotton shrinked and formed an entangled mass due to decrease in mass of cotton and utilization by biomass.

Mercerization: On mercerizing, the raw cotton fibres swelled and shrinked whereas biodegraded cotton disintegrated at a fast rate due to less friability and tensile strength.

Water absorption capacity: Water absorption capacity of raw cotton is based purity and it is also affected by impurities and other inorganic matter. In the present research work, water absorption capacity of raw cotton was decreased in comparison with biodegraded cotton due to its degradation and less weight. Raw cotton fibres had good absorption properties and on water absorption, the weight increased from 10 to 130.25gm.The weight of the biodegraded cotton had increased to 10.8gm from 50gm. Independent lab results have also shown that cotton is compostable. In the case shown below, 100% cotton wet wipe hydroentangled fabrics were tested for compostability using astm method 6400. The test procedure calls for at least 90% weight loss to constitute complete biodegradability.

Average biodegradability (percent weight lost)

Sample	After 2 weeks	After 4 weeks
Cotton Wet Wipe	40	90

Tables and Graphs:

Table 1:

S. No.	Raw cotton. wt (gm)	Incubation period	Biomass	Biodegraded cotton wt (gm)
1.	25 gms	24 hrs	2.5 inoculums	23 gms
2.	25 gms	48 hrs	2.5 inoculums	20 gms
3.	25 gms	72hrs	2.5 inoculums	16 gms
4.	25 gms	96hrs	2.5 inoculums	14 gms

Table 2: Thermal resistance of raw cotton and biodegraded cotton

Time (hrs)	Raw Cotton (gm)	Biodegraded Cotton (%)
0	0	0
0.5	15	100
1	37	93
1.5	55	80
2	78	75
2.5	90	70
3	99.9	60

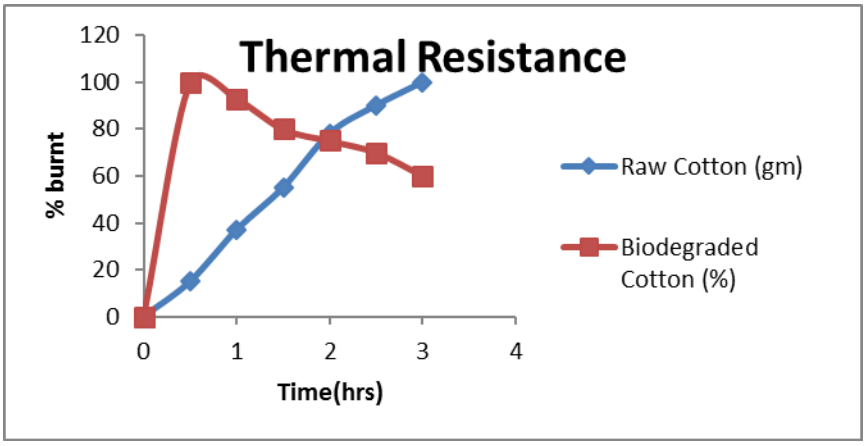
Table no. 3: Acid Resistance of Raw cotton and Biodegraded cotton

Time(mins)	raw cotton	biodegraded cotton
0	0	0
30	8	25
60	15	35
90	22	42
120	26.5	62
150	37.8	78
180	58	100

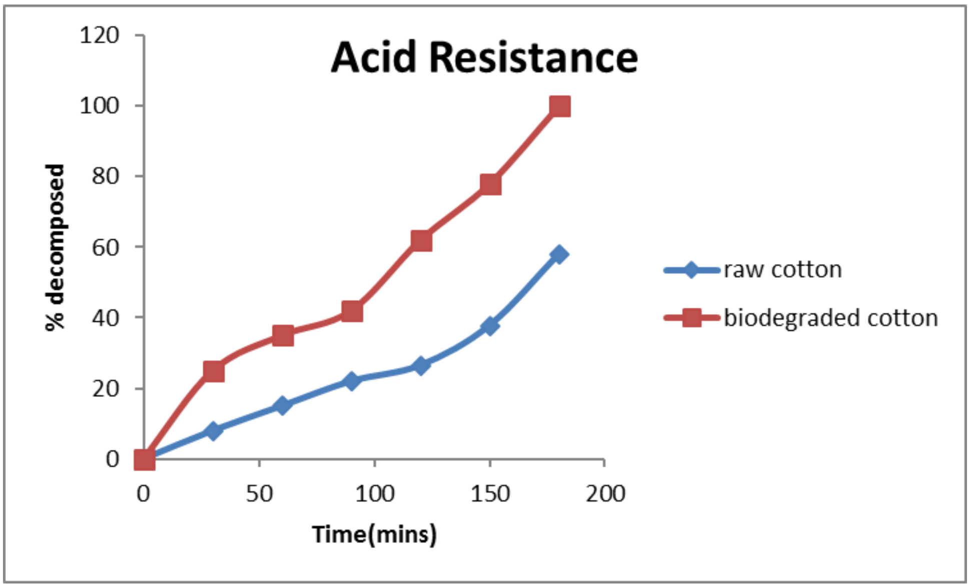
Table no: 4 Water Absorption Capacity of Raw cotton and Biodegraded cotton

Time(mins)	Raw cotton	Biodegraded cotton
0	10	10
15	25.8	15.8
30	44.8	20.4
45	78.5	28.6
60	105.9	38.4
75	115.8	45.3
90	130.25	50.8

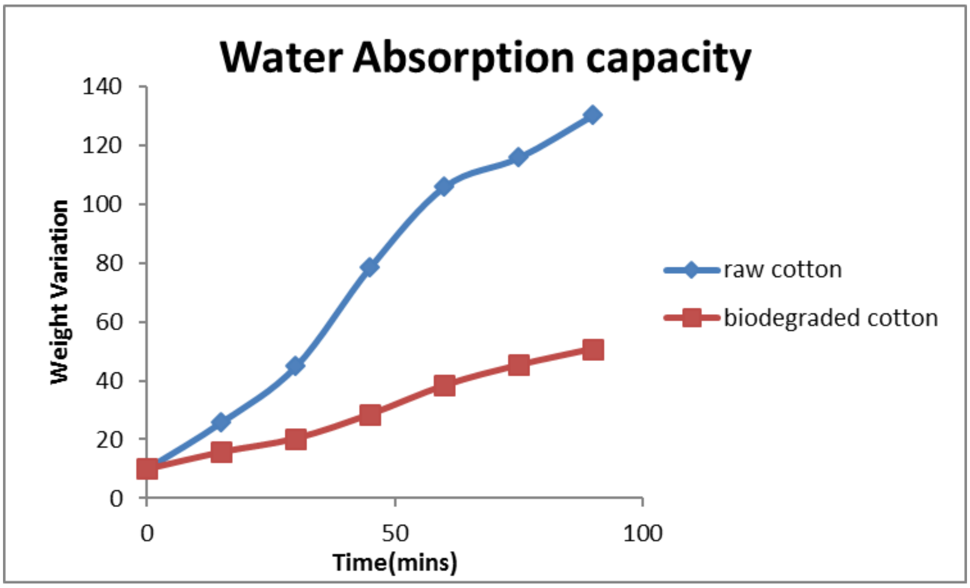
Graph no: 2a: Thermal resistance Capacity of Raw cotton and Biodegraded cotton



Graph no: 3a: Acid Resistance capacity of Raw cotton and Biodegraded cotton



Graph no.4a: Water Absorption Capacity of Raw cotton and Biodegraded cotton



CONCLUSION

In the present study we have used two different microbial biomass for the absorption of different cotton fibre effluents and to control the pollution effects of various textile industries. And we studied about different physico-chemical parameters for the rapid degradation of toxic cotton effluent fibres.

We found that the optimum time for the maximum biodegradation is 72 hours.

We found that the biodegraded cotton has less thermal resistance than the raw cotton.

By treating with the acid, we have observed that the biodegraded cotton is less tensile and so it has degraded completely.

From the treatment with alkali, we studied that the raw cotton is less resistant to alkali while the biodegraded cotton is resistant.

When treated with alcohol the biodegraded cotton has formed and entangled mass due to its less tensile strength.

On mercerisation, the biodegraded mass has completely burned.

The water absorption capacity of the raw cotton is more when compared to the biodegraded cotton.

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