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# The Microbial Degradation of Cotton and Silk dyed with Natural Dye: A Laboratory Investigation

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**ABSTRACT: In the present work the microbial degradation of cotton and silk fabrics dyed with natural dyes was studied in laboratory conditions. 100% cotton and tussar silk was used as the fabric material for dyeing with *Carrisa carandas* Linn (leaves) extract as a dye source and alum as a mordant. Under laboratory conditions on the 20$^{th}$ day, growth of microorganisms on dyed cotton and silk fabric was observed. Cultivation of microorganisms on PDA (Potato dextrose medium) showed the presence of fungi belonging to families Mucoraceae, Aspergillaceae, Mycosphaerellaceae. Where as cultivation of microorganisms on nutrient agar medium showed the presence of gram positive bacillus on cotton and well as gram negative bacilli on silk fabric . It was noted that microbial growth played a role in drastic discoloration of fabric, which changed clearly from red brown colour to pink brown colour. Growth of microorganisms were found to deteriorate the tensile and tearing strength of cotton & silk fabric.**

**Keywords:** Silk fabrics, natural dyes, *Carrisa carandas,* Potato dextrose medium, Drastic discoloration of fabric

## I. INTRODUCTION

The advent of synthetic dyes led to the demise of natural dyeing industry. However, in view of the polluting aspects of synthetic dyes and long term non-sustainable nature of these petrochemical derivaties, natural dyes are increasingly favoured all over the world. Natural dyes yield economic and ecological benefit (Deo 2008). Besides natural colorants derived from flora and fauna, being non-toxic and bio-degradable, are ecologically safe. Natural dyes have been used since time immemorial for their long, enduring, soft and lustrous coloring.

Textiles, particularly those composed of natural organic fibres such as cotton, linen, wool etc. are readily attacked by microorganisms ( Kotoma *et.al.* 2003). Since microorganisms require water and warmth to flourish and spread, all of the natural and regenerated hydrophilic vegetable and animal fibers `are susceptible to microbial damage. The terms mildew, rot and decay are variously used to indicate growth upon or damage to textiles by microorganisms such as fungi and bacteria. The major types of fungi affecting textile are the moulds such as penicillium and aspergillum and the soil moulds such as actinomycetes (Adanur 1995). Bacteria which cause textile damage are most frequently the bacilli or rod type. Mildew most often develops when textiles are folded and stored for lengthy periods in a warm moist atmosphere (Adanur 1995). Mildew is often manifested in cotton and other cellulosic textiles by a musty odour and the formation of discolored and black area, fabric tendering, and ultimately complete decay (Adanur 1995). Microbial growth on a textile causes loss of strength and elongation, discoloration and changes in appearance. They follow changes in oxidation state, degree of polymerization and breakdown of molecular structure. (Jadwiga 2003).

There is paucity of data on the deterioration of textiles dyed with natural dyes, due to micro organisms, therefore, in the present study an attempt was made to investigate the deterioration of cotton and silk fabric dyed with natural dyes. An effort was also made to find out the causal microorganisms and the environmental factors responsible for the deterioration of the fabric.

The present work will help us to elucidate role of bacteria and fungi involved in affecting the fabric strength and colour. This study will also prove to be of immense help in finding out the further remedial measures for prevention of bacterial and fungal attack on the fabric under commercial conditions.

## II. MATERIALS AND METHODS

100% cotton and Tussar silk was used as the fabric material for the present study. *Carissa carandas* Linn. (leaves) was used as a dye source and alum as a mordant .Grey Cotton was scoured and silk was degummed and prepared for the dyeing.

Aqueous extraction of *Carissa carandas* leaf extract.

*Carrissa carandas* leaves were collected and washed thoroughly to remove dust if seen. Dye extract was prepared with 50% dye material concentration (owf) keeping M:L (Material to Liquo ratio) as 1:50. Extraction was carried out for 4 hours at $90^0$C, maintaining the level of solution in the container through out the process. The dye extract was allowed to cool at room temperature. Solution was strained and transferred to open bath for exhaust dyeing.

* Mordanting : 10% alum (owf) as a mordant was taken to prepare the mordanting bath. Keeping M:L ratio as 1:50. Separate mordanting bath were prepared for silk and cotton at 90°C. Mordanting was carried out for 50 min. with premordanting method.

**Dyeing :** Mordanted silk and cotton fabric were then inserted into previously prepared dye baths at 40°C; and slowly the temperature was raised upto 90°C. Dyeing was carried out for one hour with adequate movement of dye liquor. The dye bath was allowed to cool for 15 minutes. The dyed samples were then removed, sqeezed qently, washed thoroughly and shade dried.

**Cultivation of Microorganisms on Dyed cotton and Silk.**

The shade dried samples were then kept for 20 days in an enamel tray covered with aluminum foil. During this period the temperature and humidity within the covered tray was recorded daily. The fungal growth on the cloth was also monitored intermittently. On the $20^{th}$ day fungal growth on the cloth was clearly visible as black spots.

Cultivation of this fungal growth was done on Potato Dextrose Agar (PDA) medium. Permanent slides of the fungi grown on PDA were then prepared and stained with cotton blue and lacto phenol. Similarly bacterial growth on the sample cloth was confirmed by cultivation on Nutrient Agar medium. Later permanent slides of bacterial strains were prepared and subjected to gram staining.

Photography of the cultivated fungal and bacterial growth as well as of the permanent slides was done.

**Visual Analysis of affected Cotton and Silk**

The visual analysis of dyed cotton and silk fabric samples which were affected due to the growth of microorganisms was done by a panel of judges.

**Assessment of colour fastness tests**

Dyed and affected cotton and silk samples were subjected to wash fastness by ISO2 method and sunlight fastness by IS : 686-1985.

**Assessment of Tensile and Tearing Strength of Cotton and Silk**

Undyed grey cotton and silk fabric were tested for tearing and tensile strength, similiarly dyed fabrics and fabrics affected due to microbial growth were also assessed for tensile and tearing strength by ASTM standard.

## III. RESULT AND OBSERVATIONS

**Effect of Dyeing :** Cotton dyed with carrissa carandas leaf extract imparted red brown colour. Almost similar colour was produced on silk.

**Identification of Fungal growth on Cotton and Silk fabric :** At temp 26-27°C and humidity 66-60°C, five fungal species were recorded from both cotton and silk which belong to the families, Mucoraceae, Aspergillaceae,& Mycosphaerellaceae.

In the present investigation the Rhizopus species was found to be predominant whereas *Mucer o, Aspergillus niger, Aspergillus nidulans* and *Colosporium herbarum* species showed restricted distribution.

**Identification of Bacterial growth on dyed fabric :** Bacterial growth was found to exist on the dyed cotton and silk fabric. A few bacterial species were found to attack and grow on silk as well as cotton. The bacteria isolated were mostly gram positive rods of the genus Bacillus from cotton fabric and gram positive as well as gram negative rods of the genus Bacillus from the silk fabric.

Banik *et.al*. (2007) evaluated microorganisms associated with piling of jute and isolated gram positive rods of the genus bacillus and fungi mainly of the genera Aspergillus and occasionally Penicillum.

**Effect of Microbial growth on Colour**

Dyed cotton and silk affected due to growth of microorganisms were observed for change in colour. It was noted that microbial growth played a role in drastic discoloration of fabric, which changed clearly from red brown colour to pink brown colour.

Kotowa *et.al.* (2003) demonstrated that the microorganisms can affect all stages of textile processing and storage with fungi being the most important microorganisms in textile biodeterioration process and the growth of these microorganisms causes loss of strength and elongation, discoloration and changes in appearance of textiles.

**Table 1: Wash and Sunlight fastness ratings of Cotton and Silk fabric.**

| Fabric | Dyed Fabric | | Affected Dyed Fabric | |
|---|---|---|---|---|
| | Wash fastness colour change | Sunlight fast colour change | Wash fastness colour change | Sunlight fast colour change |
| Cotton | 4 | 4 | 2 | 2 |
| Silk | 4.5 | 4 | 2 | 2 |

**(Rating Class)**

1- Extremely poor 2/3 – Fair 4 – Good
1/2 – Very Poor 3 – Moderate 4/5 – Very good
2 – Poor 3/4 – Fairly good 5 – Excellent)

Table 1 shows the ratings towards colour change of cotton and silk dyed with *Carissa carandas* leaf extract . It reveals the fastness ratings of affected dyed fabric, which rated 2 in terms of colour change as poor wash and sunlight fastness as compared to unaffected dyed fabric which showed good to very good wash and sunlight fastness ratings of 4 to 4.5.

**Tensile Strength of Cotton and Silk**

Cotton and Silk fabrics dyed with *Carissa carandas* leaf extract were kept for the microbial growth under favorable laboratary conditions during the study. Over the period of 20 days microbial growth was observed on both cotton and silk. The affected fabric samples were then subjected for Tensile Strength.

**Table 2: Tensile and Tearing Strength of Cotton and Silk fabric as mean ± S.E.**

| | **Tensile Strength** | | | | | | **Tearing strength** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Undyed (n=4) | | Dyed (n=5) | | Affected dyed(n=5) | | Undyed(n=5) | | Dyed (n=5) | | Affected Dyed(n=5) | |
| | Wp | Wf | Wf | Wp | Wf | Wp | Wp | Wf | Wp | Wf | Wp | Wf |
| Cotton | 43.2± 0.86 | 22.4± 1.04 | 44.09± 1.94 | 23.2± 1.07 | 26.00± 0.78 | 16.00± 0.44 | 37.2± 2.82 | 27.4± 1.29 | 37.8± 0.22 | 28.4± 2.11 | 33.4± 1.50 | 22.0± 0.44 |
| Silk | 15.6± 1.71 | 13.4± 0.40 | 16.8± 2.05 | 14.0± 0.31 | 11.4± 0.51 | 13.0± 0.44 | 17.2± 1.39 | 19.4± 1.57 | 17.4± 1.03 | 19.6± 2.30 | 15.4± 0.51 | 18.4± 2.16 |

Wp = Warp Wf = Weft

Table 2 indicates the mean values of Tensile strength in terms of Undyed, Dyed and affected dyed cotton, in both warpwise and weftwise direction. Tensile strength of Undyed cotton in Warp direction was noted 43.2± 0.86gmf. and 22.4 ± 1.04 gmf. in sample cut from weft direction. There is an increase in strength when cotton was dyed with *Carrisa carandas* leaf extract for both the samples ; where it was noted 44 ± 1.94 gmf. in warp direction and 23.2 ± 1.07gmf. in weft direction. Growth of microorganisms degrade the cotton where tensile strength in warp direction was calculated as 26± 0.78 gmf and 16 ± 0.44gmf in weft direction.

Tensile strength with mean value of undyed silk was noted 15.6 ± 1.71gmf (warp) and 13.4± 0.40 gmf (weft). Carrisa carandas dyed silk showed increased strength in both direction noted as 16.8± 2.05 gmf and 14 ± 0.31gmf. While the growth of microorganisms on dyed silk also deteriorated the strength noted as 11.4 ± 0.51gmf and 13± 0.44 gmf in warp and weft direction.

**Tearing Strength of Cotton and Silk:** Table 2 represents the mean values of tearing strength for undyed, dyed and affected cotton and silk. Slight increase in strength can be seen in terms of dyed cotton compared to undyed grey cotton ; noted as 37.8 ± 0.22 gmf in warp and 28.4± 2.11gmf in weft direction, where as it was found 37.2 ± 2.82 gmf and 27.4 ± 1.29 gmf in warp and weft direction respectively. Mean of tearing strength for affected dyed cotton is noted 33.4 ± 1.50 gmf (warp) and 22 ± 0.44 gmf (weft).

Micro increase in strength has been noted with a mean value 17.4± 1.03 gmf (warp) and 19.6 ± 2.30 gmf. (weft) which was noted 17.2 ± 1.39 gmf (warp) and 19.4 ± 1.57gmf (weft) before dyeing of silk with leaf extract of Carissa carandas as a source of nature dye. Deterioration of silk due to the attack of microorganisms in terms of tearing strength has been noted as 15.4± 0.51 gmf ( warp) and 18.4 ± 2.16 gmf (weft).

Similiar studies demonstrated that heavy infestation of microorganisms on fabric results in rotting and breakdown of the fibres and subsequent physical changes such as a loss of strength or flexibility may cause the fabric to fail in service. (Hamlyn 1998)

## CONCLUSION

It can be concluded from the results of the investigation that tensile and bearing strength of the cotton and silk has been increased when *Carissa carandas* leaf extract was used as a source of nature dye.

Microorganisms most often develop when natural fibers are folded and stored for lengthy periods in a warm, moist atmosphere. The present investigation has showed that there is a loss in strength and discoloration of dyed cotton and silk due to the growth of microorganisms such as fungi and bacteria. Cotton was found more susceptible to microbial attack compared to silk fabric.

Photograph:-1

**Plate showing growth on PDA of fungal colony isolated from cotton fabric.**

Photograph:- 2

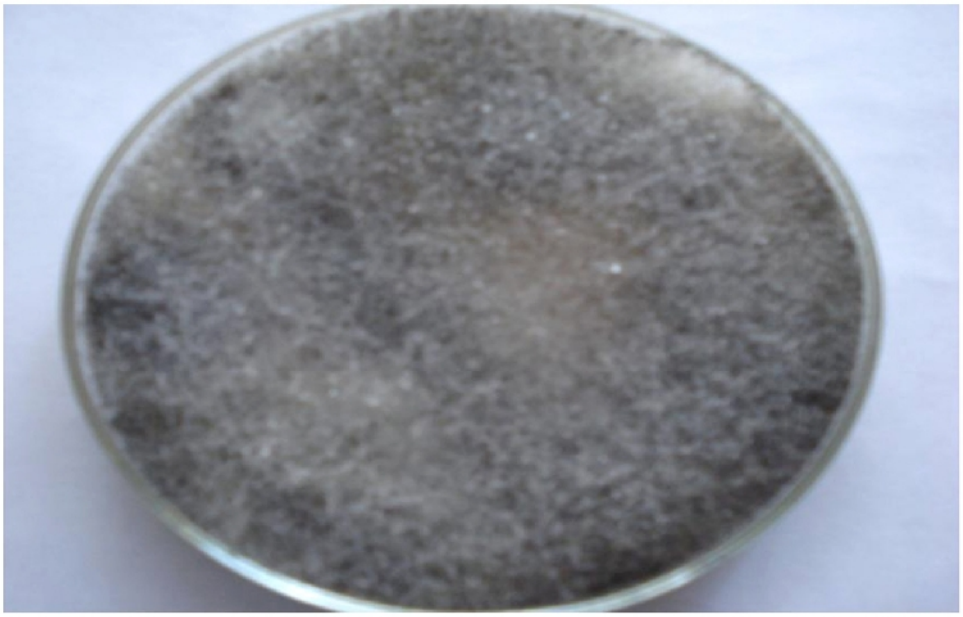

**Plate showing growth on PDA of fungal colony isolated from silk fabric.**

Photograph:-3

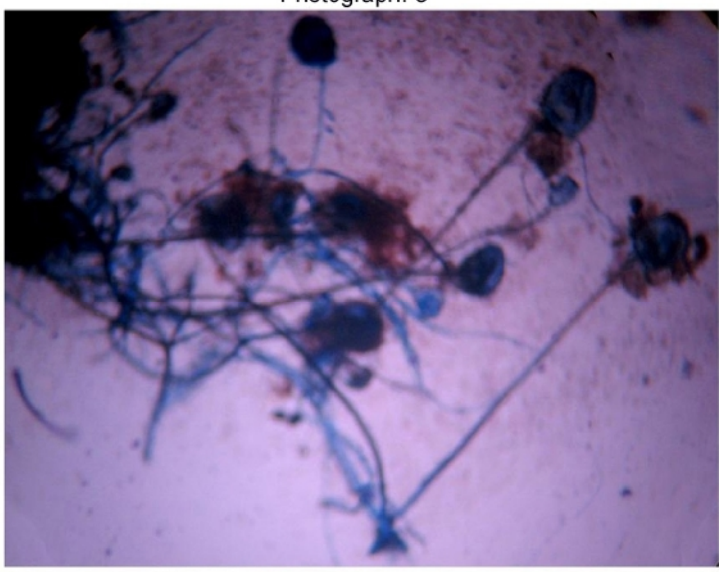

**Plate showing Rhizopus species and Aspergilles species on cotton fabric. (x 400)**

Photograph:-4

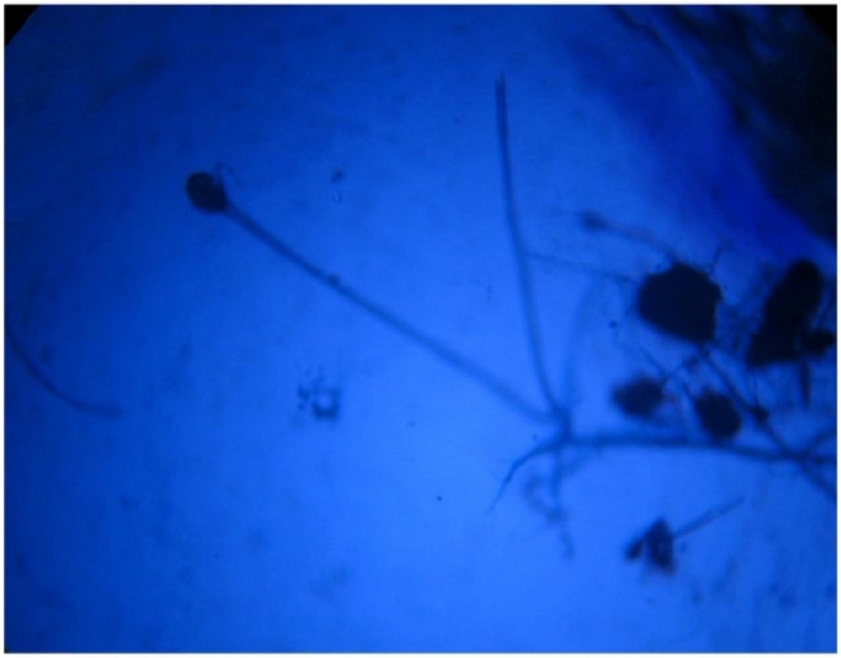

**Plate showing Rhizopus species on cotton fabric. (x 400)**

Photograph:- 5

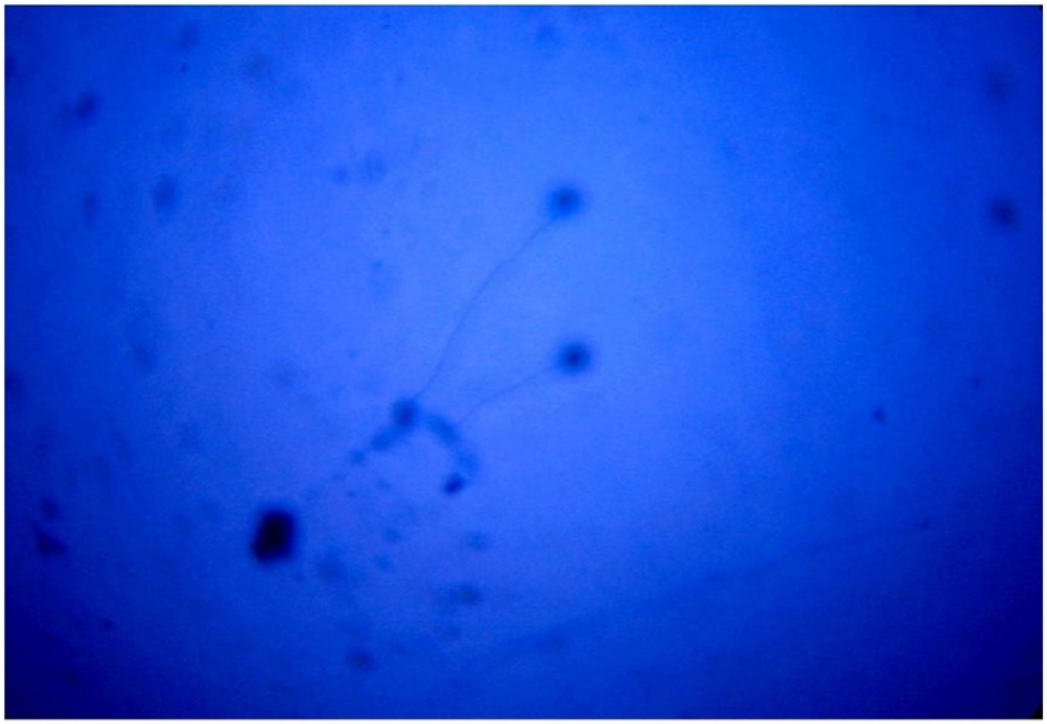

**Plate showing Mucar species on cotton fabric. (x 400)**

Photograph:- 6

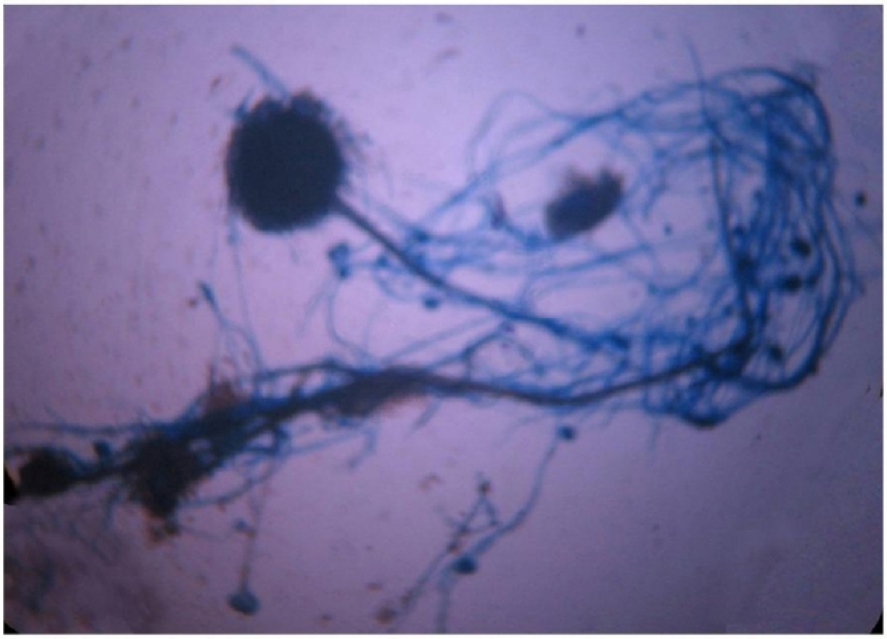

**Plate showing Conidial head of aspergillus species on silk fabric. (x 400)**

Photograph:- 7

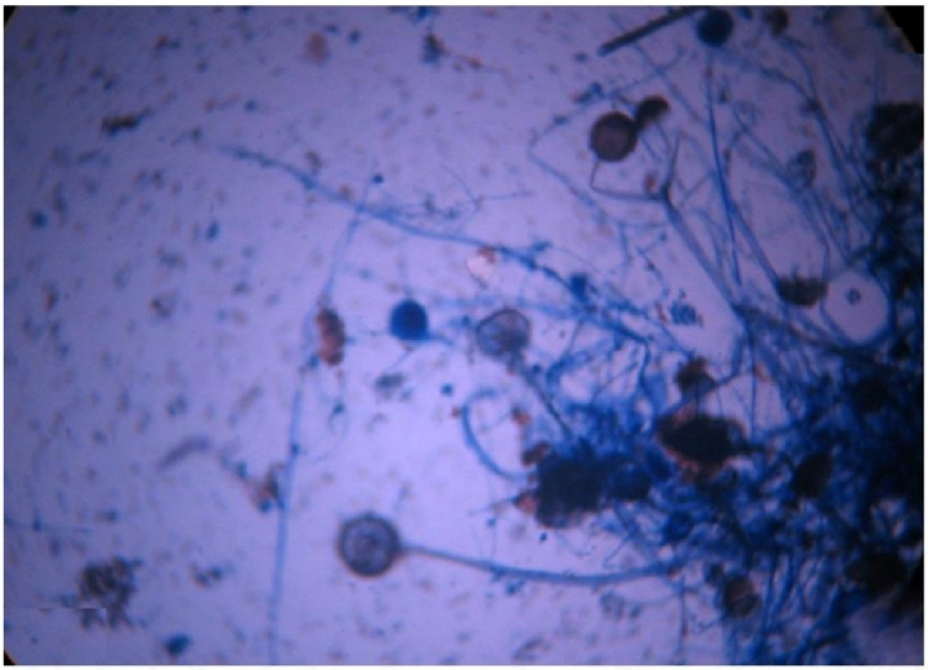

**Plate showing fungal colony of mucar and aspergillus species on silk fabric. (x 400)**

Photograph:-8

**Plate showing growth on nutrient agar of bacterial colony isolated form cotton fabric.**

Photograph:- 9

Plate showing growth on nutrient agar of bacterial colony isolated from silk fabric

Photograph:- 10

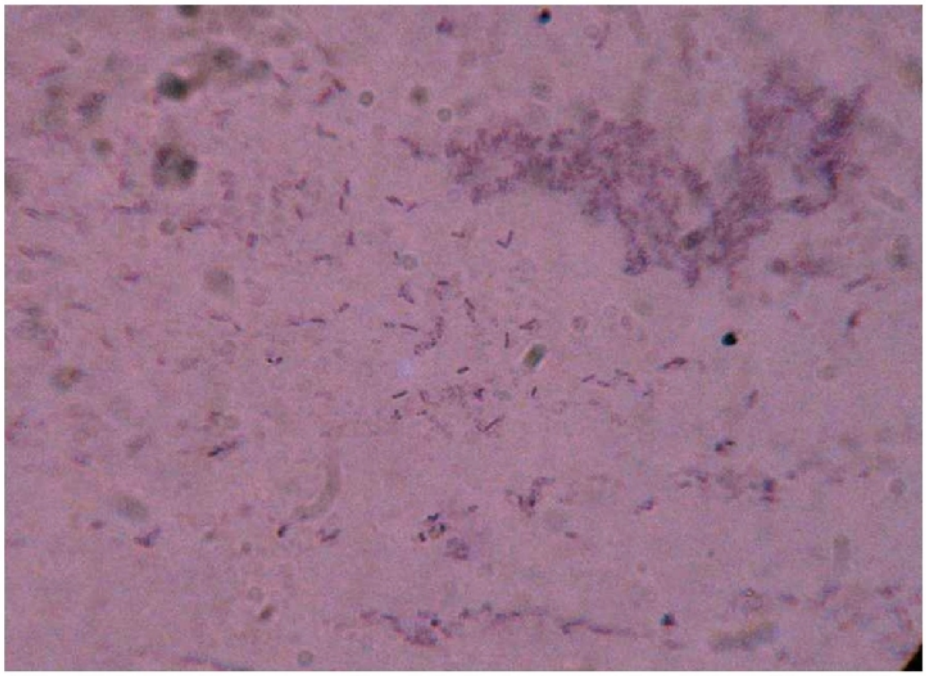

**Plate showing gram positive Bacilli cultivation from cotton fabric. (x 1000)**

Photograph:-11

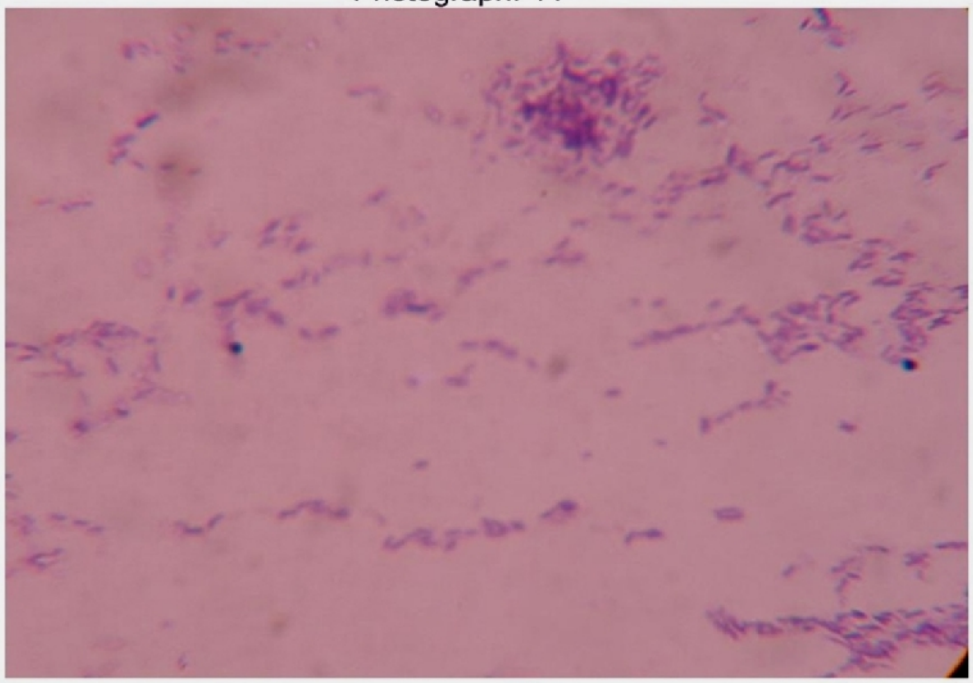

**Plate showing gram positive Bacilli cultivation from silk fabric. (x 1000)**

Photograph:- 12

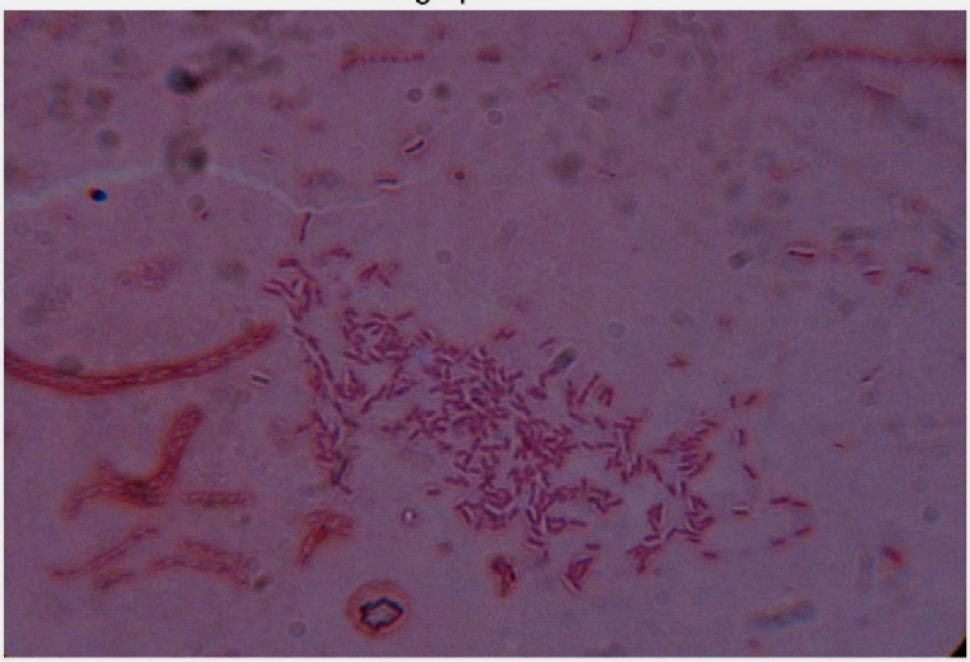

**Plate showing gram negative Bacilli cultivation from silk fabric.**

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