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Grafting of Medical Textile using Neem Leaf Extract for Production of Antimicrobial Textile

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Abstract

The existence of microorganisms and their damaging effects such as deterioration and odour formation are the challenging situation for woven, nonwoven and composite fabrics industry. For human beings to work with maximum efficiency health and hygiene are the basal things. So, effective antimicrobial finish has become essential to safeguard the human beings from harmful microorganisms to prevent from cross infection. Chemical based antimicrobial agents are mostly used for fabric finishing which have harmful and environmental issues. Therefore, finishing of fabrics using plant natural dyes and bioactive plant extract as antimicrobial agent is an emergent technology in the making of medical textiles. Based on antimicrobial activity and availability Neem (Azadirachta indica) was selected for present research work. In these work investigations emphasizes on screening of herbs with potent antimicrobial activity, treatment of woven and nonwoven fabrics with herbal leaf extracts, assessment of their antimicrobial efficacy.

Keywords: SMS Nonwoven fabric, Silver nitrate, quaternary ammonium compound and Neem (Azadirachta indica) leaf extract, Antimicrobial activity.

Introduction

Recently, different products like wrinkle resistance, water repelling, fade resistance and resistance to microbial invasion in textile technology has been much demanded in world. Among these, development of antimicrobial textile finish is extremely essential because clothes are in direct contact with human body[1]. Cotton fabrics offer ideal environment for microbial growth. Increasing global competition in textiles has created many challenges for textile researchers and industries. Therefore, medical textile finishes with antimicrobial finish is highly demanded in global. So it is necessary for human beings to wear antimicrobial finished textile products for healthy life style. A wide range of commercial textile products based on synthetic antimicrobial agents such as triclosan, metal and their salts, phenols and quaternary ammonium compounds have been developed by researchers. Some of them are also commercially available[2]. Antimicrobial textiles based on eco-friendly agents have great demand against synthetic antimicrobial agents. In case of synthetic antimicrobial agents they are costly in synthetic in nature which creates environmental troubles. Textile technology using natural colorants on account of their compatibility with deodorizing properties as become a great interest[3].

India is famed for its rich biodiversity and there are more than 450 plants which yields different dyes and pigments. Many of these plants are classified as medicinal plants and exhibit excellent antimicrobial activity[4]. All of the naturally available dyes are eco-friendly[5]. Therefore, antimicrobial agents extracted from plants have been more demanding for apparel technology. Effect of various antimicrobial plant extract on microorganisms have been studied by number of researchers[6-8].

Many therapeutic agents are present in neem so in Indian culture neem is used as a traditional medicine. Neem expresses the potential role of antidiabetic activity[9]. Airborne bacterial contamination in the residential premise could be controlled by neem leaves due to its antimicrobial activity[10,11]. Neem aqueous extract has a great potential and used as a powerful chemotherapeutic and antiviral agent[12].

In the present investigation effect of synthetic antimicrobial agents such as quaternary ammonium compound and silver nitrate were compared with eco-friendly neem leaf extract. Both synthetic antimicrobial agents and eco-friendly agent were grafted on woven and nonwoven fabrics and check its effect on human pathogenic bacteria such as *Escherichia coli*, *Pseudomonas aeruginosa, Staphylococcus aureus, Candida albicans* and *Bacillus subtilis*.

Material and Methods

Selection of medicinal plant and preparation of the extract: Plant neem (Azadirachta indica) was selected for present investigation. Neem leaves were acquired from Botanical garden of SRKI College in Surat. Aqueous plant extract has been synthesized from green neem leaves. 5g of Fresh leaves were collected and properly washed with distilled water. Fresh leaves were cut into fine pieces and boiled with 100 ml distilled water and filtration was done by using whatmann No.1 filter paper. The extract was used for further studies.

Commercial chemical antimicrobial agents: Silver nitrate ($AgNO_3$) and quaternary ammonium compound (QAC) were used. Quaternary ammonium compound was purchased from Sigma-Aldrich and silver nitrate was procured by Qualigens.

Microorganism: Pathogenic strains of *E.coli*, *P.aeruginosa*, *S.aureus*, *C.albicans* and *B.subtilis* were purchased from MTCC (Microbial Type Culture Collection) and used for present study.

Substrate: A 100% cotton woven fabric (medium weight, plain weave, 75×30 g/m^2, ends 75/inch, picks 60/inch) and a polypropylene spunbonded/melt blown/spunbonded (SMS) nonwoven were used for the application purpose.

Methods: Grafting of substrate with neem leaf extract, silver nitrate and quaternary ammonium compound. Neem leaf extract, silver nitrate and Quaternary ammonium compound were enforced on 100% cotton and SMS fabrics using pad-dry-cure method. Test fabrics were cut in to the size of 30 X 30 cm and soaked up in the solution containing neem leaf extract (5%), 0.01M AgNO3 solution (2%) and quaternary ammonium compound (2%) in three separate conical flasks. Then add citric acid binder (1%) in all three flasks and kept for 40 second. Then test fabrics were moved on a padding mangle to remove excess solution. Padding mangle was running at a speed of 15 m/min with a pressure of 2 kgf/cm^2. A 100% wet transfer was asserted for all of the treatments. Then fabrics were air-dried. Curing was done at 140°C for 3 mins. Fabric without any treatment was used as control.

Evaluation of antimicrobial Efficacy: Pathogenic strains of *S.aureus* (gram positive bacteria), *E.coli* (gram negative bacteria), *P.aeruginosa* (gram negative bacteria), *B.subtilis* (gram positive bacteria) and *C.albicans* (fungi) were used for present study. The qualitative antibacterial assessment was done using Agar diffusion method (AATCC test method 147).

Agar Diffusion Test (AATCC 147): Agar diffusion test is used for qualitative analysis. It is simply carried out and suitable for a large number of samples are to be screened for the presence of antimicrobial activity. In this test, first test organisms were inoculated on nutrient agar plates. Textile samples were placed above inoculated nutrient agar plates for close contact. The plates were then incubated at 37°C for 18–24 h and analyzed for zone of inhibition. No bacterial growth directly below the fabric sample indicates the presence of antimicrobial activity. A zone of inhibition becomes obvious when the antimicrobial agent can diffuse into the agar. Effectiveness of the antimicrobial activity or the release rate of the active agent can be checked by size of zone of inhibition.

Results and Discussion

Agar Diffusion Test (AATCC 147): Antimicrobial activity of the treated SMS Nonwoven and 100% Cotton woven fabrics were assessed by Agar diffusion method. Figures 1 to 4 indicate the result of qualitative analysis for coated 100% cotton woven fabric. In case of 100% cotton woven fabric, all the coated woven fabric exhibit antimicrobial activity for *E.coli*, *P.aeruginosa, S.aureus, C.albicans* and *B.subtilis* based on their zone of inhibition. Data of antimicrobial assessment of 100% Cotton woven fabric using–AATCC 147 method is presented in table-1.

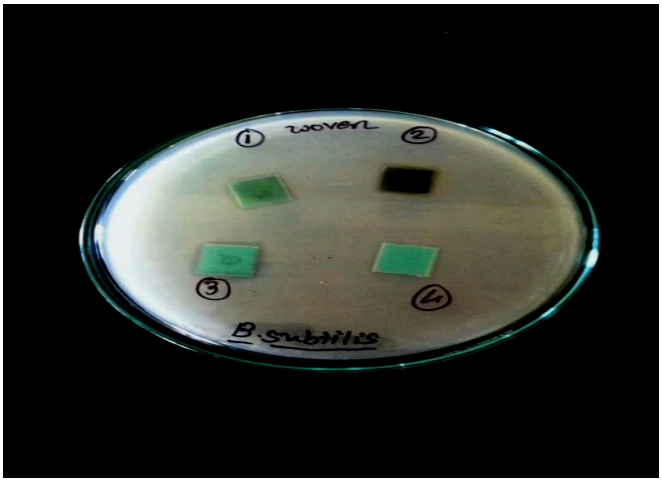

Figure-1
Zone of inhibition (*Bacillus subtilis)* of 100% Cotton woven coated fabric

In figure. 1). Neem extract treated fabric, 2). Silver nitrate treated fabric, 3). QAC treated fabric showing antimicrobial property respectively, 4). Untreated control fabric dose not showing antimicrobial activity

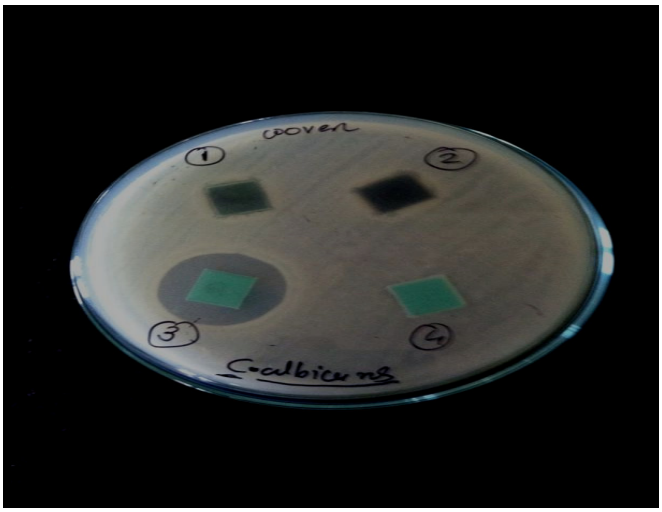

Figure-2
Zone of inhibition (*Candida albicans)* of 100% Cotton woven coated fabric

In figure, 1). Neem extract treated fabric, 2). Silver nitrate treated fabric, 3). QAC treated fabric showing antimicrobial property respectively, 4). Untreated control fabric dose not showing antimicrobial activity

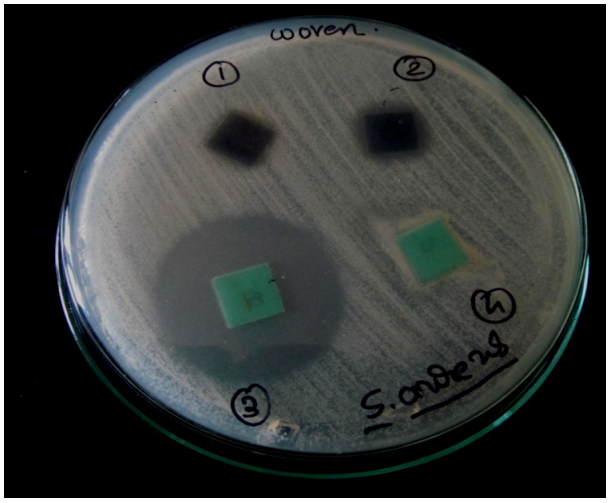

Figure-3
Zone of inhibition (*Staphylococcus aureus)* of 100% cotton woven coated fabric

In figure, 1). Neem extract treated fabric, 2). Silver nitrate treated fabric, 3). QAC treated fabric showing antimicrobial property respectively, 4). Untreated control fabric dose not showing antimicrobial activity

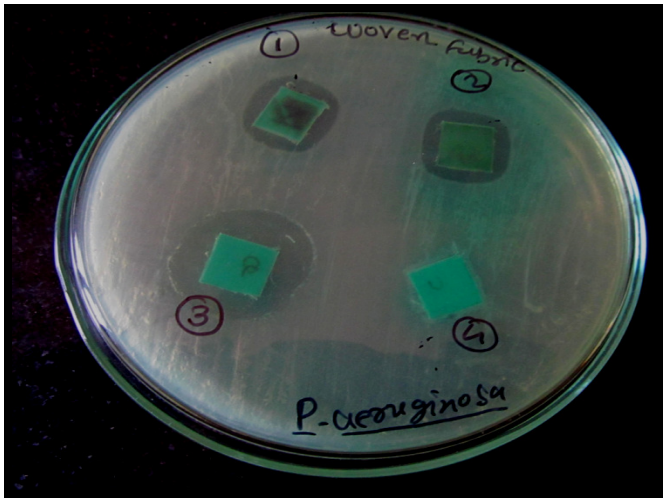

Figure-4
Zone of inhibition (*Pseudomonas aeruginosa)* of 100% cotton woven coated fabric.

In figure, 1). Neem extract treated fabric, 2). Silver nitrate treated fabric, 3). QAC treated fabric showing antimicrobial property respectively, 4). Untreated control fabric dose not showing antimicrobial activity

Table-1
Antimicrobial Assessment of 100% Cotton woven fabric–AATCC 147

Fabric Treatment	Zone of Inhibition in mm				
	Test Organisms				
	E.coli	***P.aeruginosa***	***S.aureus***	***C.albicans***	***B.subtilis***
Untreated control	0	0	0	0	0
Neem extract treated	14	14	13	11	11
AgNo3 treated	13	19	16	12	11
QAC treated	13	20	22	23	13

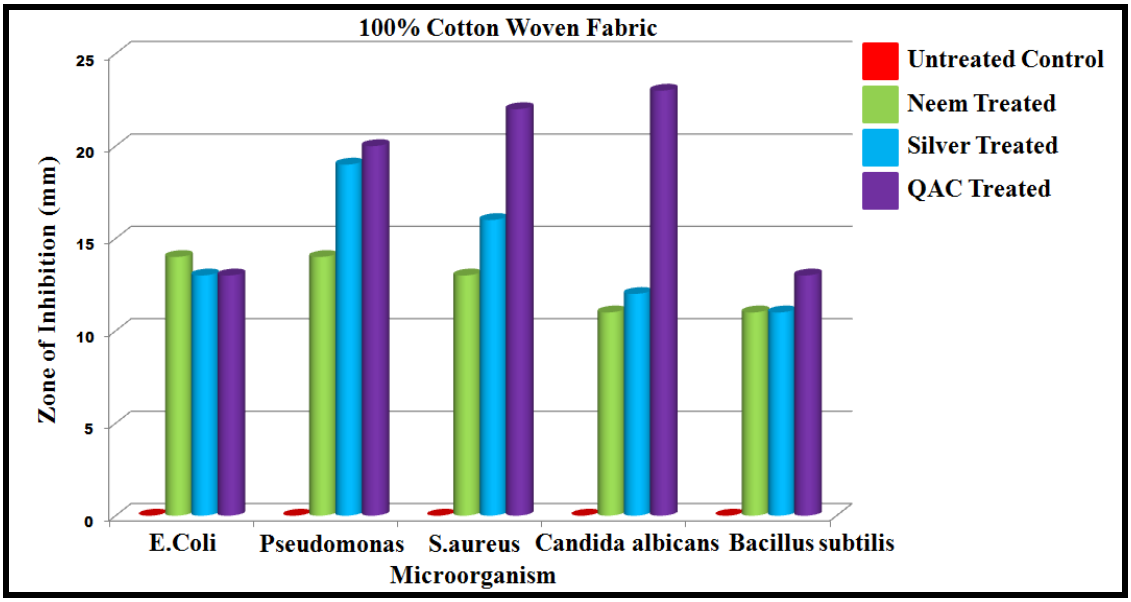

Figure-5
Antimicrobial Assessment of 100% Cotton woven fabric -AATCC 147

Figure 5 indicate the graphical result of 100% Cotton woven treated fabric against the test microorganisms. In that neem treated woven fabric has highest antimicrobial activity against *E.coli* and *P.aeruginosa*. Silver treated woven fabric has highest antimicrobial activity against *P.aeruginosa* and in case of QAC treated woven fabric which has highest antimicrobial activity against *C.albicans*.

Figure 6 to 9 indicate the result of qualitative analysis for coated SMS Nonwoven fabric. In case of SMS Nonwoven fabric which was coated with QAC show its antimicrobial activity against all test microorganisms except against *E.coli.* SMS Nonwoven fabric which was coated with Neem leaf extract also shows its antimicrobial activity against all test microorganisms except against *S.aureus*. Data of Antimicrobial Assessment of SMS Nonwoven fabric using– AATCC 147 method is presented in table-2.

Figure 10 indicate the graphical result of SMS Nonwoven treated fabric against the test microorganisms. In that neem treated nonwoven fabric has maximum antimicrobial activity against *B.subtilis*. In case of silver and QAC treated Nonwoven fabric which have highest antimicrobial activity for *P.aeruginosa* and *S.aureus* respectively.

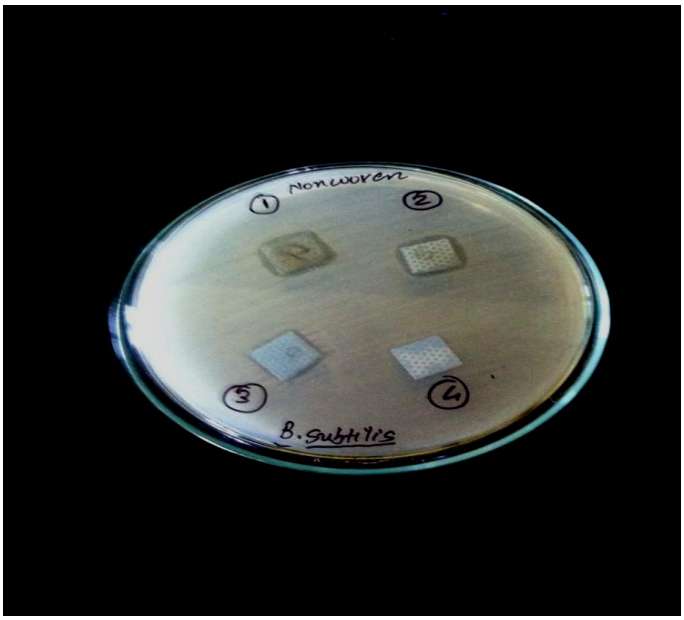

Figure-6
Zone of inhibition (*Bacillus subtilis)* of SMS Nonwoven coated fabric

In figure, 1). Neem extract treated fabric, 2). Silver nitrate treated fabric, 3). QAC treated fabric showing antimicrobial property respectively, 4). Untreated control fabric dose not showing antimicrobial activi

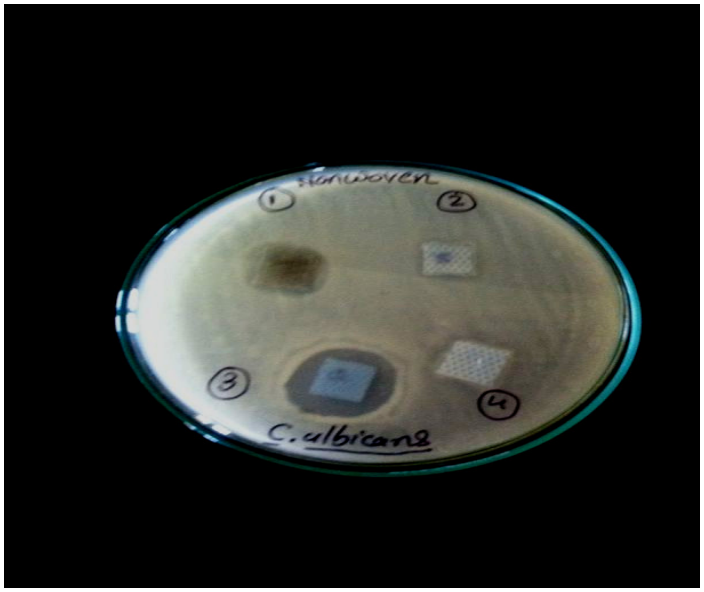

Figure-7
Zone of inhibition (*Candida albicans)* of SMS Nonwoven coated fabric

In this figure, 1). Neem extract treated fabric, 2). Silver nitrate treated fabric, 3). QAC treated fabric showing antimicrobial property respectively, 4). Untreated control fabric dose not showing antimicrobial activity

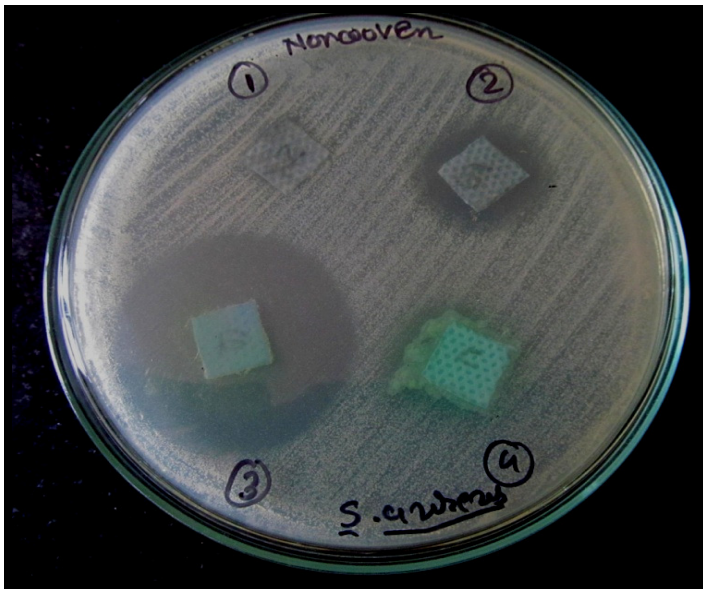

Figure-8
Zone of inhibition (*Staphylococcus aureus)* of SMS Nonwoven coated fabric

In this figure, 2). Silver nitrate treated fabric, 3). QAC treated fabric showing antimicrobial property respectively, 1). Neem extract treated fabric and 4). Untreated control fabric dose not showing antimicrobial activity

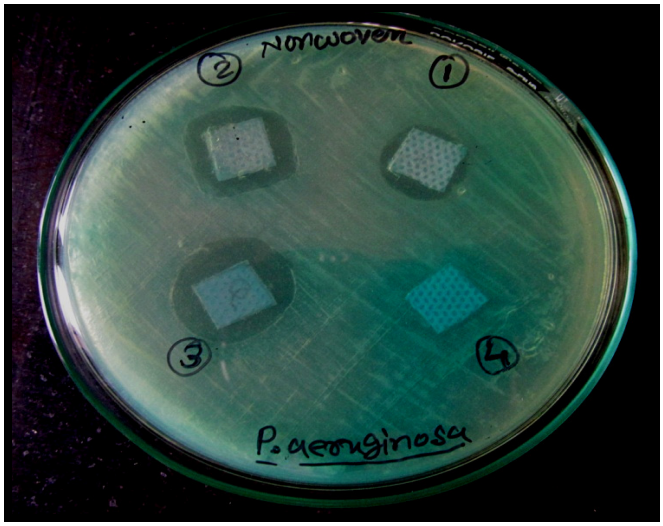

Figure-9
Zone of inhibition (*Pseudomonas aeruginosa)* of SMS Nonwoven coated fabric.

In this figure, 1). Neem extract treated fabric, 2). Silver nitrate treated fabric, 3). QAC treated fabric showing antimicrobial property respectively, 4). Untreated control fabric dose not showing antimicrobial activity

The antimicrobial activity of Neem leaf extract coated 100% Cotton woven and SMS nonwoven fabrics against test microorganisms were revealed in present research work. Different parts of neem tree such as bark, leaf, stem and flower have been reported to contain more than 300 different types of compounds but, the most important liminoids are azadirachtin, salanin and nimbin[13]. Few patents based on the use of neem oil using microencapsulation technique have been recently reported[14]. A well-conducted study on incorporating neem seed and bark extracts to cotton[15] and cotton/polyester blend[16] textiles have been reported in the last few years. Bark extract of neem has also been used for wool dyeing under the optimum conditions[17]. Bacteria colony forming unit of *B.subtilis* before and after the finishing treatment of cotton/polyester blend fabric with neem seed extracts have been documented[18].

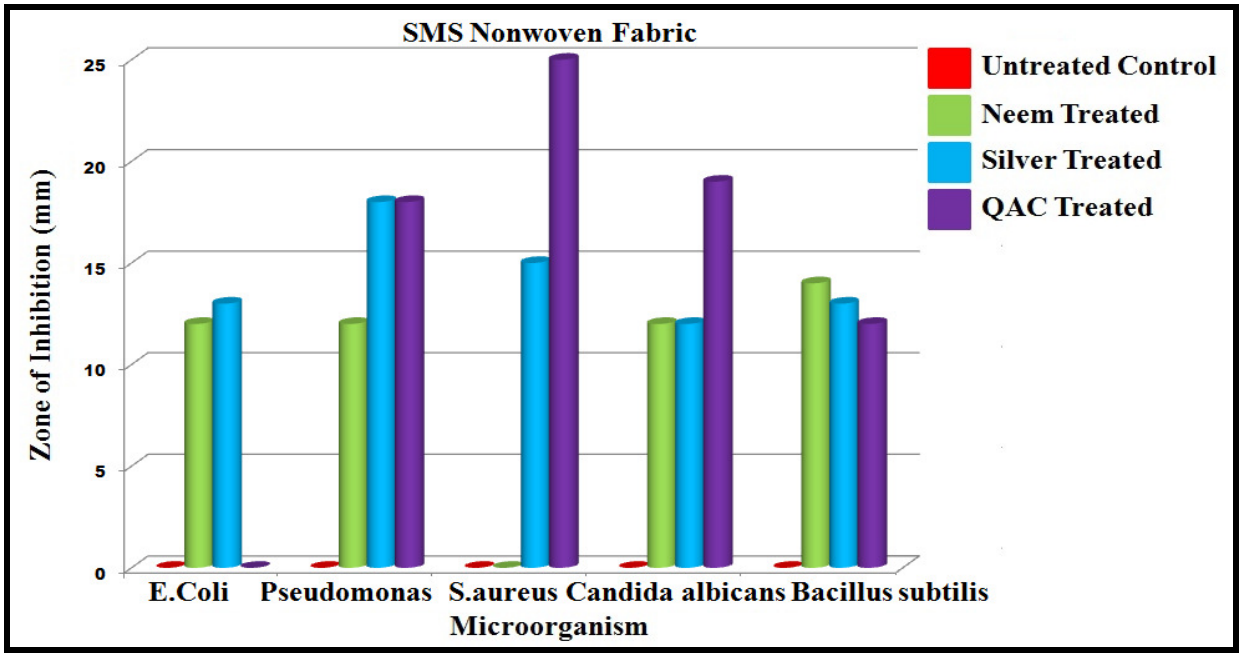

Figure-10
Antimicrobial Assessment of SMS Nonwoven fabric -AATCC 147

Table-2
Antimicrobial Assessment of SMS Nonwoven fabric–AATCC 147

Fabric Treatment	Zone of Inhibition in mm				
	Test Organisms				
	E.coli	*P.aeruginosa*	*S.aureus*	*C.albicans*	*B.subtilis*
Untreated control	0	0	0	0	0
Neem extract treated	12	12	0	12	14
$AgNO_3$ treated	13	18	15	12	13
QAC treated	0	18	25	19	12

Conclusion

The Disposable Medical Textiles are quite new to Indian market. The high profile doctors, whose number is increasing day by day, prefer safety of themselves and the patients. The blood, sweat, alcohol and other liquids used in clinical operations get quickly absorbed and held by the woven fabric. The absorbency will increase with each laundering operation and reuse of woven fabrics, hence, lead to serious threat in their applications. And the cost of laundering, sterilizing and reusing would increase rapidly in the near future. So, many such factors would lead to the higher consumption of disposable nonwoven medical textiles. Hence disposable nonwovens have become very popular in medical textiles.

Acknowledgement

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Abbreviation

E.coli - Escherichia coli, P.aeruginosa - Pseudomonas aeruginosa, S.aureus - Staphylococcus aureus, B.subtilis - Bacillus subtilis, C.albicans – Candida albicans, SMS - Spunbonded/Melt blown/Spunbonded, QAC – Quaternary ammonium compound

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