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MORE ABOUT NONWOVENS OUT OF TEXTILE WASTES FOR VARIOUS END USES

BY

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مزيد من الضوء حول الاقمشة الغير منسوجة المصنعة من العوادم النسيجية والتى تصلح لاغراض متعددة .

الخلاصة :

الغرض من هذا البحث هو حصر شامل لاصناف وكميات العوادم الصلبه فى مصر ثم اقتراح تكنولوجيا مناسبة لتحويلها الى شعيرات نسيجية وأخيرا تصنيع هذه الشعيرات الى أقمشة غير منسوجة عن طريق تسليحها ميكانيكيا (أنوال الابر – تيار من الماء المضغوط) .

ثبت صلاحية الاقمشة الناتجه للاستخدام فى مجال الزراعة (كمرقد للبذور) ومجال الهندسة المدنية (مرشحات للمياه – عوازل للحرارة للمبانى – تقوية الخرسانات المسلحة ضد أحمال الصدم) ومجال صناعة الملابس الجاهزة (حشوات للبدل الرجالى) وفى مجال حماية البيئة من التلوث (مرشحات الهواء – تصنيع المخلفات النسيجية) .

ABSTRACT

The purpose of this paper is to survey first the sources, quantities and types of textile wastes produced in Egypt; secondly to find the suitable technology for recycling these wastes and converting it to fibres, and thirdly to select the suitable technology for producing nonwoven fabric according to the properties of resulted fibres.

The rag waste has been opened using "CGC" processes to be used in the production of shade and soil felts for agriculture; filter felts for dust collector and water for civil engineering; as a building insulation material; a externally reinforced for concrete beams against impact loadings; and producing a shoulder pads and interlining paddings for garment industry.

In this way, we shall help to place nonwoven fabrics out of textile waste on a firm basis of physical engineering design. It is clear that recycling of textile wastes will be help also in the field of environmental protection

1. INTRODUCTION

1.1. Environmental Protection By Recycling Of Textile Wastes:

The problem of the pollution of environmental is caused by the amount textile wastes and other waste materials. Being left without any treatment, those wastes become a source of infection disease. Until now, textile waste materials are disposed of in a rather primitive by burning which causes a pollution of the air, water and soil. Nowadays, recycling of textile wastes can be recognized in most developing countries, and there is no doubt that it will be of great help in solving various problems, like filter felts for dust collector and filter cloth for slow sand filters, shade and soil felts for agriculture, nonwovens for civil engineerings (Geotextiles, Concrete beams externally reinforced with nonwovens,... etc.), and shoulder pads and interlining padding for garments.

Recycling is one of the modern Key-Words of the topic of this paper. The recycling of fibre and textile wates provides an important contribution to world textile output. The textile production represents 30% of the production of the whole industry in Egypt, and the amount of textile waste materials calculates 18585 tons per year. In Misr-Company El-Mehalla El-Kobra for spinning and weaving the woven fabric waste represents about 1029.6 ton/year, in El-Nasr Company El-Mehalla El-Kobra it reaches 52 ton/year, and in El-Nasr Company Kabo Elexandria, the percentage of hard waste reaches 700 - 2000 ton/year. (1)

The recovery process of textile wastes comprises principally three steps:

i) Preparation of the waste for the opening,
ii) Opening of the waste into fibres, and
iii) Final treatments of the opened fibre waste.

Each step includes several operations which need not always be applied unless necessary or desirable technologically, or needed for the sake of quality.

1.2. Recycling Of Textile Fibres In Rags Form:

1.2.1. Preparation of rags for processing:

Dust cleaning of rags is carried out in dusting machines of continuous and intermittent action. Moreover, the rags are classified into new and old and according to their colour into white, black, multicolour, and others. Scouring of rags is necessary if they are badly contaminated and they are not cleaned at dedusting.

1.2.2. Cutting-Garneting-Carding Processes "CGC":

The aim of this process is rag opening, dividing larg rag into smaller ones and removal of dust with intensive cleaning from impurities. After these pretreatment, the rags are oiled to facilitate the grinding or tearing up process.

1.2.3.Preneedling-Drawing-Hydroentanglement (2):

The object of preneedling is to:

a) make the web suitable for drawing by reduction and consolidation of its volume,

b) produce pivot points for rotation of the short fibre, and

c) preserve homogeneity of the web and orientation.

The object of drawing may be mentioned at this point:

Controlled reorientation of the fibres, retaining as far as possible the levelness of the web. To attain uniformity of the batt, it is important that preneedling procedes the drafting operation.

Test assemblies were subjected to 10, 20, 30 and 40 passes of the hydroentanglement (spraynozzle). Thus the nominal external pressure level was 4, 8, 12 and 16 bar.

The theory of suggested procedure is given in Fig. 1.

Various Textile Wastes (Rags)

↓

Preparation of the wastes for the opening process. (Dedusting; Sorting; Scouring; Drying and Oiling).

↓

Opening and final product treatment of opened fibres (Cutting; Garnetting; and Carding)

↓

Production of nonwoven fabrics (mechanically reinforced)

↓

Using needled technique (Lapping, needling (400 needle/sq. in.)	Using hydroentanglement technique (See Figure 1_b). (Lapping—Preneedling—Drawing —Hydroentanglement (2—12 bar))
+ Shade and soil felts (550 g/m^2), + Air and water filteration (1180 g/m^2), + Building insulation (650 g/m^2), and + Reinforcement of concrete (1180 g/m^2).	+ Shoulder pade + Interlining fabrics (120 g/m^2).

Fig. 1: Shows the procedure of producing nonwove fabrics out of textile wastes for various end used.

The theory of suggested procedure is given in Figure 1_b.

[C G C] + [Preneedling] (8—12 S.P.C^2) + [Drawing] (draft = doubling) + [Double side—hydroentanglement] (4, 8, 12 and 16 bar) +

[Drying] (90^{o}C) = [Nonwovens] (for various end uses).

Fig. 1_b: Shows the principles of preneedling, drawing, and hydroentanglement procedure.

2. Use Of Nonwoven Fabrics In The Field Of Agriculture (3).

In this part, nonwoven fabrics out of textile wastes will be used as a medium to support the plant, and to maintain the feeding solution and distribute it evenly between plants in the case of dense agriculture, as in the case of corn, barley and lentil.

Shown in Photographs 2 to 4 the photographs of corn, barley and lentil, in various stages of growth, when nonwoven fabric is used and laid on plastic mesh. From these photographs one can observe that the roots were able to penetrate the nonwoven fabric. The thickness is about 2.0 mm. The height of the plant reaches 17.7 cm in 7 days from the time of planting. The degree of germination is above 90%. The results obtained under outerdoor conditions were very close to that obtained under indoor conditions, where the temperature was higher by about $7^oC - 9^oC$.

By calculation it was found that an area of fabric equals to a Fedan ($4200\ m^2$) gives 9.96 tons of green plants (barley) at the end of 9 days of plantation. Generally 1 Kg of barley seeds gives 4 Kg of green barley.

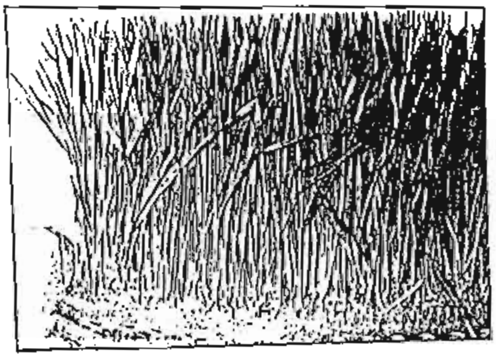


Fig. 2: Corn planted on polyester nonwoven fabric layid on plastic mesh.

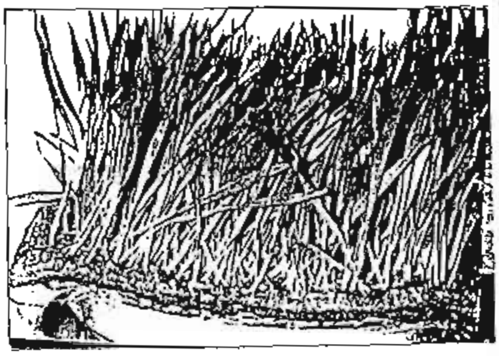


Fig. 3: Barley planted on polyester nonwoven fabric layid on plastic mesh.

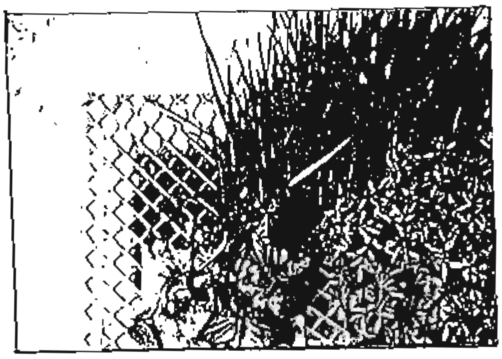


Fig. 4: Lentil planted on polyester nonwoven fabric layid on plastic mesh.

We would like to mention here that no feeding elements were added to the plant during the experiment and nothing more than tap water had been added. In addition to this the retention of the nonwovens to water for long periods reduces the consumption of water and hence no need to continuous irrigation.

It is now easy to plant on portable medium, i.e. the nonwoven fabric, any where and at any time.

By using this type of fabrics, there is no need to use chemicals or toxic solutions against green grass in between the plants, i.e. decreasing the number of plants, animals, and people who become diseased and disabled.

3. Use Of Nonwoven Fabrics In The Field Of Civil Engineering:

3.1. Filter bags out of Textile Wastes (4)

Air pollution, which has become a world problem, may be sappressed to a minimum when nonwoven filter clothes are used. The importance of studying the structure of nonwoven fabric appears when testing it's performance when used for the purpose of filteration. For this purpose three types of fabrics have been designed and the best of it is tested in the time being as air filter in the production line in Talkha Mill (No. 1) for fertilizers. The results of this experiment including a comparison between woven fabrics (local and imported) and nonwoven fabrics (virgin and recycled fibres) are given in Table 1.

Table (1): Comparison of Some Properties of Needled Punched and Woven Filter Fabrics.

Fabrics / Properties	Mass/ area (g/m^2)	Thick- ness at 24.2 g/cm^2 (mm)	Packing density Ø	Porosity % (1-Ø) x 100 %	Hairness (g/cm^2. mm)	Cost* ($L.E/m^2$)	Service life (month)
1- Needled Felt	550	2.0	0.199	80.1	10.14	4	5
2- Batt on Base	650	2.8	0.168	83.2	28.30	6	8
3- Needled Rein- forced from textile wastes	1180	13.4	0.064	93.6	195.2	11	15
4- Woven 50/50 wool/nylon	340	2.4	0.119	88.0	9.6	70	12

*The prices given here are those of 1990.

The economical analysis which assumed that the weaving surface layer is constant before and after filteration proved that a reduction of filter bag cost, when using nonwoven out of waste, is in the range of 91 – 94% of the total initial woven filter bag cost.

3.2. Utilization Of Nonwoven Fabrics Out Of Textile Wastes As A Building Insulation Material (5).

An effective way of saving energy is to improve the thermal insulation of buildings. In addition to the need for energy conservation, high insulation standards are justified by improved comfort levels and increased building life.

An experiments were carried out to examine the application of the nonwoven insulation material on walls. The nonwoven fabric was fixed direct to the concrete blocks using steel nails Figs. 5 and 6. The plaster mortar was applied on the nonwoven in two ways. The first was by applying the mortar directly to the insulation material using the traditional method. The sand cement mortar stiked to the nonwoven with no problems appeared such as falling or cracking. The second way of applying was by preparing the nonwoven surface by ordinary plaster base coat.

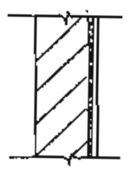


Fig. 5: Steel neits plaster layer.

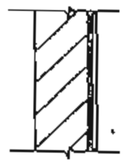


Fig. 6: Plaster layer.
Plaster base coat.
The nonwoven concrete block wall.

Sixteen tests and measurements were undertaken to study the characteristics of the nonwoven insulation material (5). The results obtained from the mensioned tests and measurements were encauraging to use the fabric as a thermal insulation layer in building. The thermal conductivity of the tested nonwoven out of textile wastes was 0.029 w/m°C which represent acceptable in comparison with the other insulation material, as shown in Fig. 7. Other characteristics such as flammability, capillary, service temperature, water absorption and tensile strength were studing (5).

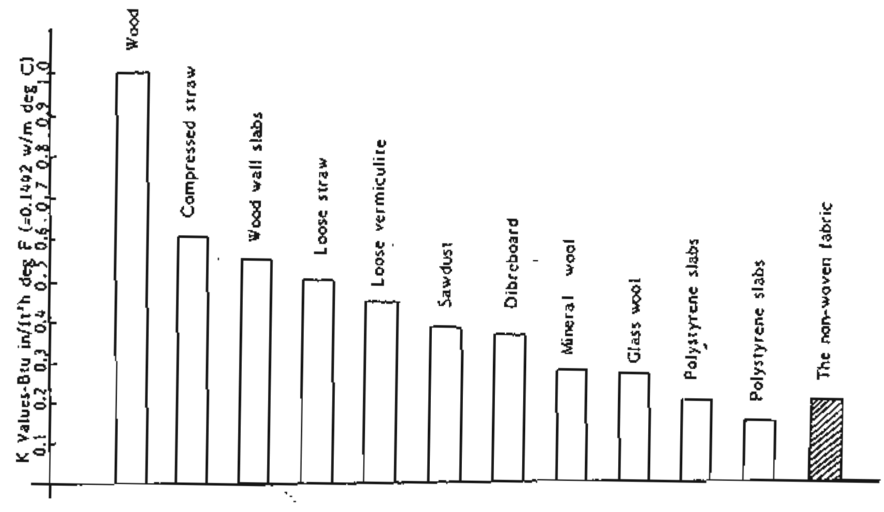


Fig. 7: Thermal conductivity values of materials commonly used for thermal insulation and the tested nonwoven out of textile wastes.

3.3. Use Of Nonwovens In Slow Sand Filters (6, 7 and 8):

The use of textile fabrics is a good contribution in slow sand filters, and useful to civil engineering, and truley an addition to the technology of water filteration by this method.

The nonwoven fabrics used in this part showed no resistance to water flow rate in the filter, and it's properties are suitable for the filteration process ($4.35 \sim 6.52\ m^3/m^2/day$), which considered normal discharge in slow sand filters.

The following water properties were measured and evaluated:

1. Turbidity removal (%),
2. Algae removal (%),
3. Bacterial removal (%),
4. Values of Alk. and pH,
5. Coliform removal (%),
6. Run length (days) and Head losses (Cm).

Figure 8 shows the filtered water properties before and after using nonwoven fabric out of textile waste as a filtering component in the slow sand filter, to carry the contaminant layer and prevent it from precipitation on the sand filter without blocking of it's pores, and reduces the cost of removed sand after each cleaning process for the filter, also to keep a part from the contamination layer inside the internal structure of the fabric.

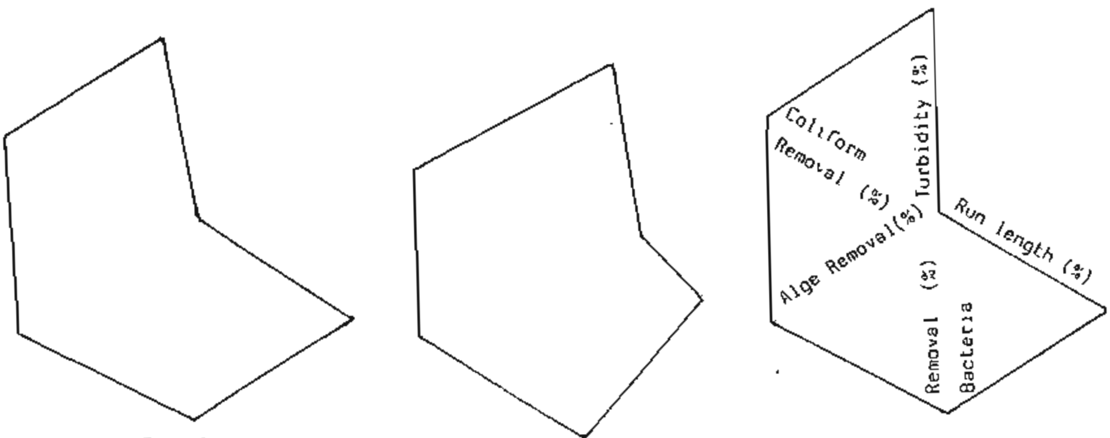


Fig. 8a — Slow Sand Filter with nonwoven out of textile waste (1180 g/m^2). %P = 100%

Fig. 8b — Slow Sand Filter without using nonwoven. %P = 91%

Fig. 8c — Slow sand Filter in Ideal working conditions. %P = 100%

Fig. 8: Shows filtered water properties using slow sand filters with and without using nonwoven fabrics.

where $\%P = \frac{A_i}{A} \times 100$, ...(1)

A = area of polygon in ideal working conditions.

A_i = area of polygon in normal working conditions.

It has been proved that the quality (or the properties) of the raw water when using packed filter cloth improved remarkably in slow sand filter when compared with other filters which does not contain theses fabrics.

3.4. The Impact Resistance of Concrete Beams Externally Reinforced With Nonwovens Out of Textile Wastes (9).

Among the most wide applications of nonwoven fabrics in the building industry are as protective layers for under ground structure subjected to ground water, lining of canals and water passes and in general as reinforcement for bituminous materials used as insulation materials. Nonwovens proved to be excellent material to reinforce cement and concrete.

This part concerns mainly with the effect of using nonwoven fabrics out of textile wastes commercially available in the Egyptian market on the impact resistance of concrete beams. The fabric used in this research is reinforced needle punched nonwoven fabric group (1180 g/m^2) as shown in Table 1.

Two sets of beams were cast and tested in this investigation as shown in Table 2. The first set of beams was coast of plain concrete. The second set of beams was cast of plain concrete with nonwoven fabrics glued to the hardened concrete beams at different positions. All the tested beams were of 100 x 100 x 500 mm. dimensions.

The nonwoven fabrics from textile wastes reinforced concrete set consisted of three group of beams, one was glued at the bottom of the concrete beams, the second were glued to the bottom side and the top side of the hardened concrete beams, while the third were glued to the bottom and to the sides of the concrete beams as shown in Table 2.

Table 2: Schedule of Investigated Beams.

Set No.	No. of Spec.	Type of concrete	Tested Property	Beam Cross-Section
1	3	Plain concrete	Impact resistance	 100 100
2	3	Nonwovens reinforced concrete	Impact resistance	 100  100 100

To carry out the impact test, the beam were laid on two support with an effective span of 400 mm, under the simple laboratory apparatus (9).

The falling weight (16 N) was left to fall free from different heights starting from 85 mm with 50 mm intervals which increased continously up till beam failure. Impact reistance was calculated as the multiplication of the falling weight with thesum of the different hights till faliure i.e.:

$$\text{Impact resistance} = P\,(h_1 + h_2 + \ldots.\ h_n) \qquad \text{N.mm.} \qquad \ldots..(2)$$

Out of the three beams externally reinforced with nonwoven fabrics were tested under impact loading.

Using nonwoven fabrics as external reinforcement at the bottom of the concrete beams at the tension side caused significant retardation in the crack initiation which was increased when an additional layer of the nonwoven fabric was used at the top of the beam. The nonwoven fabric layer used at the top of the concrete beam has mainly absorbed the impact energy of the falling load while the bottom layer helped in resisting the tensile stresses created at the bottom of the beam. Gluing nonwoven fabric to the sides of the concrete beams beside the bottom layer has shown the highest resistance among all the tested beams to crack initiation which was observed in this case as a sign on the fabrics surface but could not be measured in width.

However, reinforcing the concrete beams with three nonwoven fabric layers one at the bottom and one at each side of the beam increased the initial cracking reistance and the ultimate impact reistance twelve times and fifty times, respectively, as shown Fig. 9.

The above mentioned results show that existing of nonwoven fabric layer in the tension side of the beam resists the tensile stresses, while the top layer absorbs and minimise the impact energy transfered to the concrete beam. The nonwoven fabrics glued to the sides of the concrete beams helped in resisting the shear stresses.

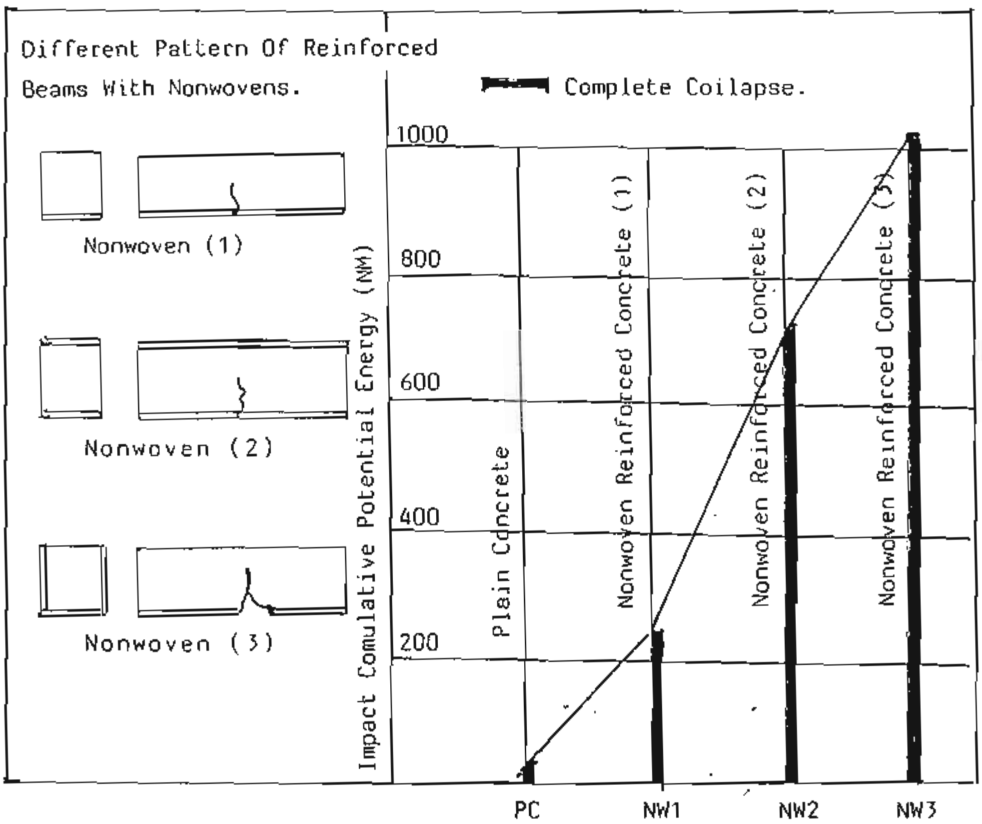


Fig. 9: Effect of the Reinforcement of Concrete Beans with Nonwoven Fabrics From Textile Wastes on their Impact Resistance.

4. Nonwoven Out Of Textile Wastes For Garment Industry:

4.1. The Morphology of Layered Nonwoven Fabrics:

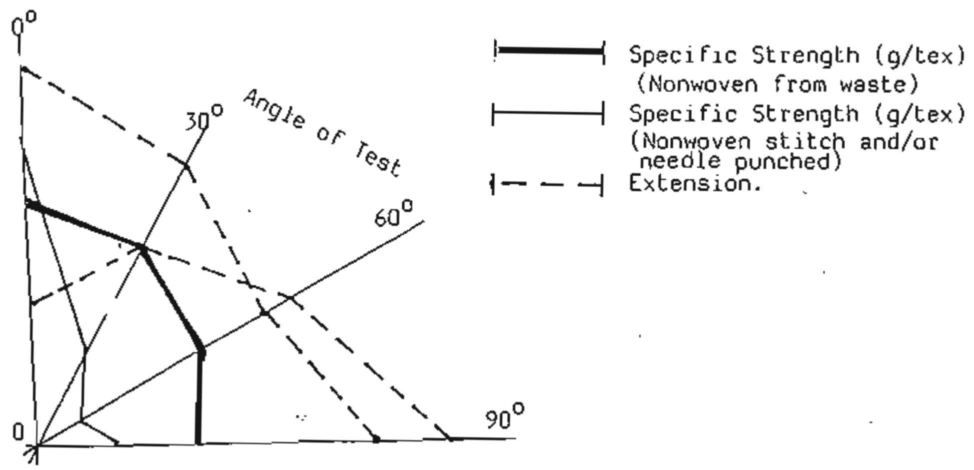
Since the nonwoven interlining fabric in the apparel industry is used in the form of layers, sandwitched or quilted, it is important to understand the nature of the structure of the nonwoven of the new composite. The need to information about the morphology of layered nonwoven have been known from early times of nonwoven research, and the following parameters have been known for this study: thickness, mass per unit area, and packing density coefficient.

Given in Table 3 the values of a and m (slope of the line) for tested nonwoven fabrics.

Properties	Best fit equation (N 1)	
Thickness of multi-layered NW.	$t_L = 10.23\ N + 1.2$	.....(3)
Mass per unit are of multi-layered NW.	$Q_{SL} = 0.698N - 0.006$	.....(4)
Packing density coefficient multi-layered NW.	$\emptyset_s = \emptyset_L$	.....(5)
Hardness of multi-layered NW.	$H_L = \dfrac{\bar{H}}{N}$ ($\bar{H}$ = average fabric hardness)	.....(6)

4.2. Tensile Strength of Different Interlining Fabrics:

The stitch bonded interlining as a known interlining textile was compared with needle punched and/or using hydroentanglement technique. The tensile strength and extension at break for two tested fabrics are illustrated in Fig. 10. Regarding the given values in Fig. 10, it is apparently seen that the anisotropy of tested fabrics is better using needle punched nonwoven fabric (120 g/m^2) in both strength and extension values (9).



$S_s = 0.7$, $S_n = 0.19$, $S_{waste} = 0.21$

Where:

$$S = \frac{\sigma_{max} - \sigma_{min}}{\sigma_{max} + \sigma_{min}} \quad (7)$$ (σ = specific strength).

Fig. 10: Specific strength (g/tex) versus angle of test.

5. DISCUSSION AND CONCLUSIONS

Nonwoven fabrics out of textile wastes, with low punching density (400 needle/squ. in., or 12 bar) and of high surface hairness (10.14 – 195.2 g/cm^2. mm), high mass per unit area (550 – 1180 g/m^2), were found to be suitable for use in the following areas:

i) In the field of agriculture,
ii) In producing filter bags,
iii) In building as insulation material, and
iv) In slow sand filters, for the following reansons:

1- The fabric is considered as multi-layer filter, since each layer forming the batt of fibres acts as a seperate filter. This would increase the efficiency of the filter in filtering the water and/or air, i.e. less chance to pollution of environmental.

2- The high mass per unit area of the packed filter fabric, give a chance to bacteria growth in the pores of the fabric and on the fibres protruding on fabric surface, which inturn reducing the maturity period of the contaminant layer, and helps in maintaining it partially after the washing process of filter, this enables in the filteration process. It is clear also that as fabric hairness increseas the insulation characteristic increased also, i.e. good comfort.

3- In the case of existance of cercaria in the raw water, thick fabrics (2-13.4 mm) limited the capabilities of the cercaria from penetration through the fabric, and the propability of its death during penetration trails is high, because of the random pathes inside the fabric, and if moved horizontally the fabric will be a grave.

4- The use of nonwoven fabrics out of textile wastes is highly recommended as: Shade and soil felts for agriculture; filter felts for dust collector or water; insulation material for buildings; and others.

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