COMPARATIVE STUDY OF WOVEN AND NONWOVEN FITER FABRIC FOR WATER FILTRTATION

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ABSTRACT

Water filtration is the process of removing undesirable chemicals, biological contaminants, suspended solids and gases from contaminated water. The goal is to produce safe and clean water for a specific purpose. In this paper we reported on the water filtration behaviour of nonwoven fabrics produced from polypropylene fibers and compared the filtration efficiency of nonwoven fabric with polyester woven filter fabric. Four different types of needle punched nonwoven fabrics were produced by varying the needle punching density. The filtration was carried out by varying the flow rates. Properties and fabric efficiency for nonwoven fabric were evaluated by measuring total suspended solids after effluent filtration and air permeability of fabrics. Time required for filtration and GSM of fabric after filtration, bursting strength of fabric were also measured. The result showed that as needle punching density increases the filtration efficiency increases and air permeability decreases. It is also observed that nonwoven fabric having better filtration efficiency than woven fabric.

Keywords: *Filtration Efficiency, Suspended Solids, Textile Effluent, Water Filtration*

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1. INTRODUCTION

Water filtration is the process of removing undesirable chemicals, biological contaminants, suspended solids and gases from contaminated water. The goal is to produce safe and clean water for a specific purpose. The filtration process of water may reduce the concentration of particulate matter including suspended particles, parasites, bacteria, algae, viruses, fungi and a range of dissolved and particulate material derived from the surfaces that water may have made contact with after falling as rain[1, 2].

Filtration is defined as "it is the mechanical or physical operation which is used for the separation of solids from fluids (liquids or gases) by interposing a medium through which only the fluid can pass."

Nonwoven filter media is a generic term that includes a wide variety of filtration and separation media. Needle punching is mechanical bonding method for producing nonwoven web structure. The water flow through the nonwoven fabrics plays important role in determining the characteristics of fabrics and efficiency of fabrics [3-5].Efficiency is the most critical performance data to consider when comparing two different filter media. Data of efficiency which identifies the capability of the medium to remove and retain particulate under specified test conditions. It is a common practice to compare filter media based on micron ratings instead of removal efficiency. However, such practice is flawed as it does not indicate the degree of efficiency for the rating and allows for wide variance in filter performance of different filters having the same micron rating [6].

Ideally, filter media should be compared according to their removal rating and the test conditions (single pass vs. multiple pass), as well as the retention efficiency at various percentages. The removal rating is directly related not only to the end quality of the fluid being filtered, but also to how the medium interacts with the catalysts and various additives.

The permeability characteristics in nonwoven fabrics vary from region to region, due to variation in orientation of fibers and processing parameters. Through a porous medium fluid will pass which indicates permeability of the fabric. The pressure drop is inversely proportional to the permeability of the filter medium. Therefore, a medium with high permeability is desirable[7-16].

The objective of this study is to investigate efficiency of nonwoven fabric for textile effluent filtration. Also to evaluate and compare the performance of woven and nonwoven fabric for filtration efficiency.

2. EXPERIMENTAL

2.1 Materials

PP based nonwoven fabric having 200, 400, 600 and 800 needle punch ddensity is used for study and its results were compared with polyester woven fabric which is most commonly used for filtration.

Textile effluent used for study. It is collected from equalization tank of Common Effluent Treatment Plant, Ichalkaranji.

2.1.1. Details of Raw Material

Table 2.1 - Properties of woven fabric

Sr.no	Parameters	values
1.	Type	100% Polyester
2.	Weave	Plain
3.	Warp Count	33.70 Ne
4.	Weft Count	31.58 Ne
5.	EPI XPPI	58 X 38
6.	GSM (gm/m^2)	87.60
7.	Thickness (mm)	0.24
8.	Tensile Strength (kgf)	84.00 (warp way) 77.00 (weft way)
9.	Breaking Elongation (%)	23.75 (warp way) 22.50 (weft way)
10.	Bursting Strength (bar)	1.05
11.	Airpermeability ($cm^3/cm^2/sec$)	32.95
12.	Waterpermeability (lit./min./ cm^2)	2.67

Table 2.2 - Properties of nonwoven fabric

Sr.no	Parameters	200 needle punching density	400 needle punching density	600 needle punching density	800 needle punching density
1.	GSM (gm/m^2)	264.52	384.20	537.40	724
2.	Thickness (mm)	3.16	4.53	4.83	6.24
3.	Tensile Strength (kgf)	40.27(MD) 63.05(CD)	120.06(MD) 70.18(CD)	140.10(MD) 99.86 (CD)	219(MD) 136.18(CD)
4.	Breaking Elongation (%)	113.95(MD) 115.05(CD)	99.85(MD) 113.55(CD)	71.60(MD) 98.5(CD)	66.60(MD) 71.00(CD)
5.	Bursting Strength (bar)	17.32	24.08	36.68	41.87
6.	Air permeability ($cm^3/cm^2/sec$)	67.46	28.03	10.33	6.93
7.	Water permeability (lit./min./ cm^2)	10.50	6.20	4.63	3.57

Table 2.3 - Characteristics of effluent

Sr. no.	Parameters	values
1.	pH	8.5
2.	TSS	600 mg/lit
3.	COD	1105 mg/lit
4.	BOD	480 mg/lit

2.2 Methods

2.2.1. Nonwoven Filter Fabric

Here, single layer of nonwoven fabric (having needle punch density 200, 400, 600, 800) was placed in the filtration device. Textile Effluent was passed through that filterfabric at flow rate 0.5, 1.0, 1.5 lit/min. at atmospheric pressure. And all filter fabrics were evaluated for filtration efficiency by measuring the amount of total suspended solids and time required for filtering the textile effluent through the filter fabric. Change in GSM of nonwoven filter fabric also measured after filtration. Bursting strength was also observed.

Same method was followed for woven fabric and results were compared with nonwoven fabric.

3. TESTING

The results obtained were evaluated using standard test methods. Filtration efficiency, air permeability, GSM, bursting strength of the fabric is measured according to ASTM D- 5141, ASTM D- 737, ASTM D-6242-98, ASTM D 6797-02 respectively.

4. RESULTS AND DISCUSSION

4.1 Woven fabric

Table 4.1 –Woven Fabric

Parameter	Flow rate (lit/min)	0.5	1.0	1.5
GSM (gm/m^2)	Before Filtration	87.60	87.60	87.60
	After Filtration	87.76	87.73	87.65
TSS (mg/lit)	Before Filtration	600	600	600
	After Filtration	574	592	595
Air Permeability (cm^3/cm^2/s)	Before Filtration	32.95	32.95	32.95
	After Filtration	28.87	30.16	31.67
Bursting Strength (bar)	Before Filtration	1.05	1.05	1.05
	After Filtration	1.08	1.07	1.06
Time (sec)		85.16	47.95	12.64
Filtration Efficiency (%)		4.00	1.33	0.83

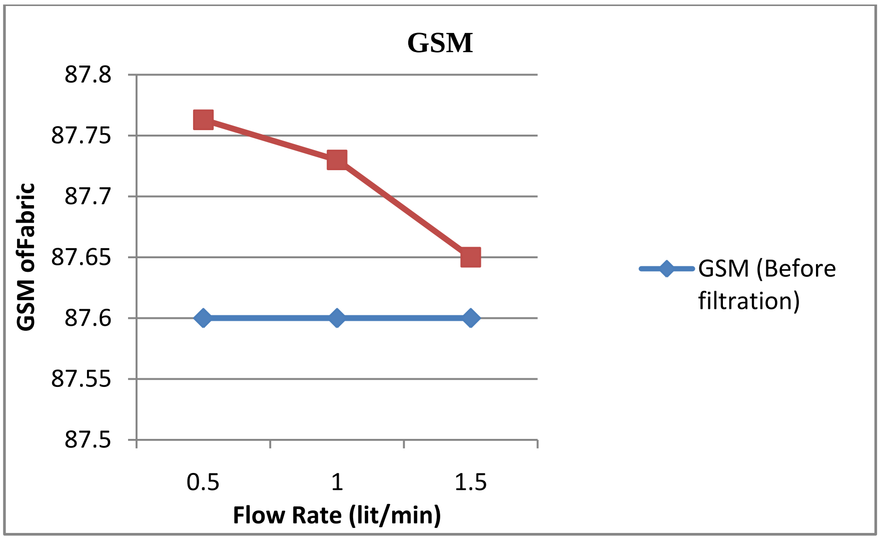

Figure 4.1 - Effect of flow rate on GSM of fabric

The above Table 4.1 and Figure 4.1 it is observed that increase in GSM at after filtration. Before filtration fabric shows GSM 87.600. After filtration, at flow rate 0.5 lit/min. the fabric shows GSM 87.763 and at flow rate 1.5 the fabric shows GSM 87.650. This may be due to the density of fabric and increasing flow rate of filtration.

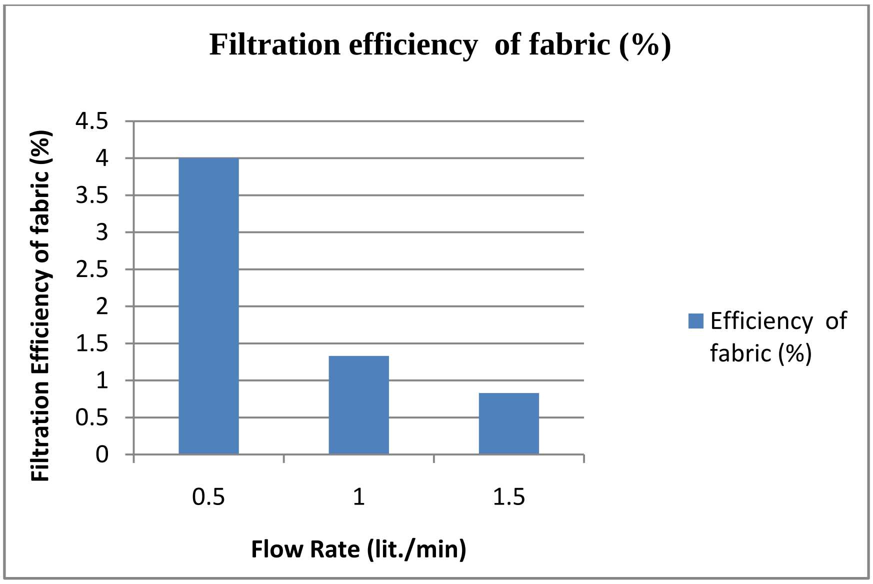

Figure 4.2 - Effect of flow rate on filtration efficiency of fabric (%)

The above Table 4.1 and Figure 4.2 it is observed that increase in filtration efficiency of fabric with decreasing flow rate of filtration. From the Table, it is observed thatat 0.5 lit/min flow rate the value of raw effluent was 600 mg/lit and after passing through the woven fabric the TSS shown was reduced 574 mg/lit. and this gives 4.0% efficiency in TSS reduction. At flow rate 1.5 lit/min., the value of raw effluent was 600 mg/lit and after passing through the woven fabric the TSS shown was reduced 595 mg/lit. and this gives 0.83% efficiency in TSS reduction. The reason for the decrease in filtration efficiency with increase in flow rate of filtration is due to decrease in air permeability of woven fabric.

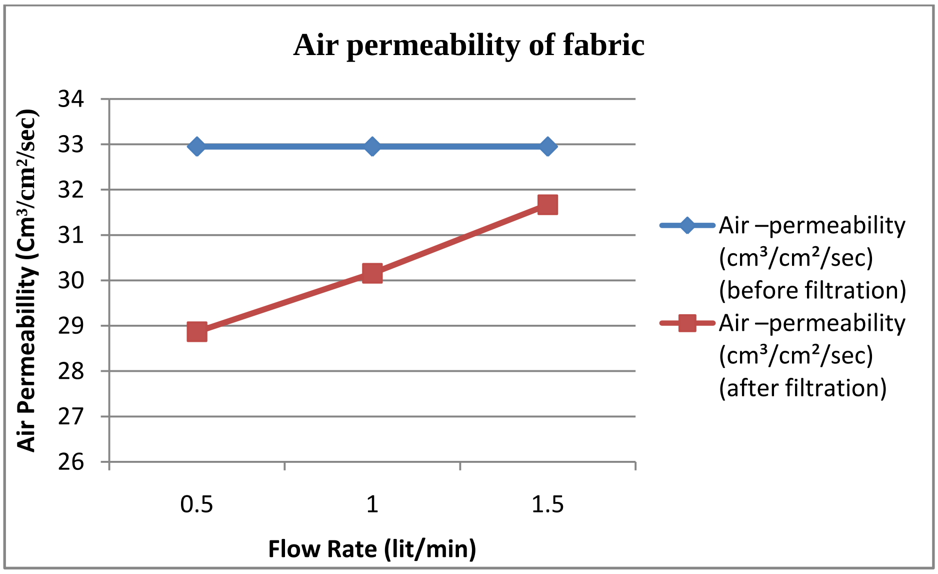

Figure 4.3 - Effect of flow rate on air permeability of fabric

The above Table 4.1 and Figure 4.3 it is observed that after filtration, decrease in air permeability. Before filtration, fabric shows air permeability 32.95 ($cm^3/cm^2/sec$). After filtration, at 0.5 lit/min flow rate, fabric shows air permeability 28.87 ($cm^3/cm^2/sec$) and at flow rate 1.5 lit/min fabric shows air permeability 31.67($cm^3/cm^2/sec$). This is due to density of fabric and increase in flow rate of filtration.

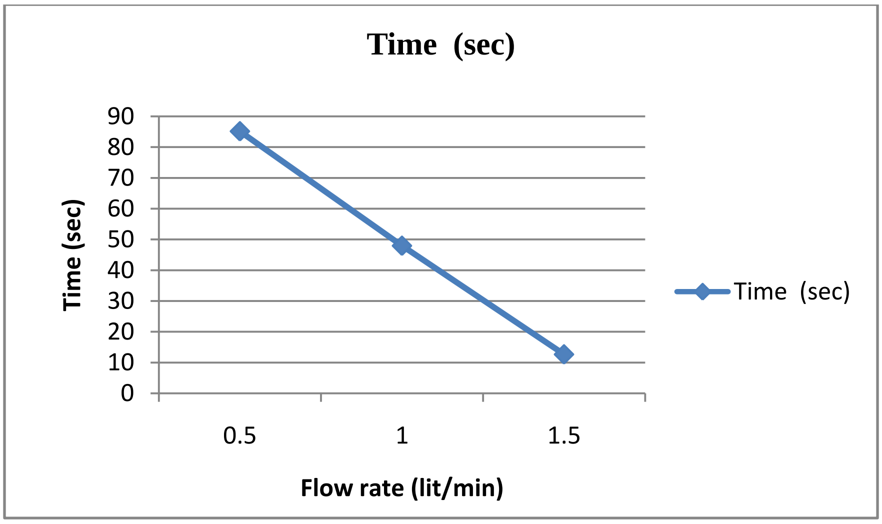

Figure 4.4 - Effect of flow rate on time (sec)

The above Table 4.1 and Figure 4.4 it is observed that decrease in time with the increase in flow rate of filtration. At 0.5 lit/min flow rate, the fabric requires 85.16 sec. time and at 1.5 lit/min flow rate, the fabric requires 12.64 sec. time for effluent filtration. This is may be because of increase in flow rate of filtration and weave of fabric.

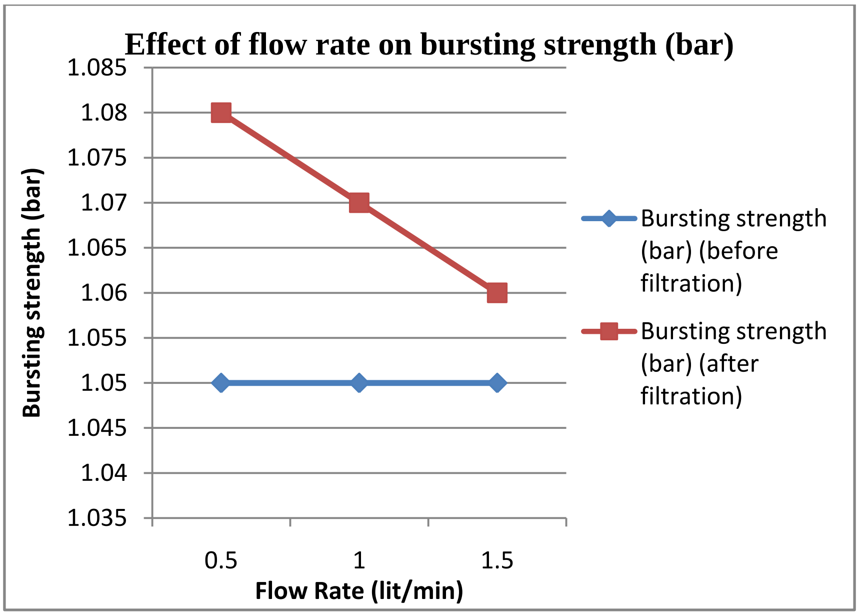

Figure 4.5 - Effect of flow rate on bursting strength (bar)

The above Table 4.1 and Figure 4.5 it is observed that increase in bursting strength with increase in flow rate of filtration at after filtration. Before filtration, fabric shows bursting strength 1.05 bar. After filtration, at 0.5 lit/min flow rate, fabric shows bursting strength 1.08 bar and at flow rate 1.5 lit/min fabric shows bursting strength 1.06 bar. This is due to density of fabric and increase in flow rate of filtration.

4.2. Nonwoven fabric

4.2.1. Effect of Needle Punching Density of fabric on GSM of fabric.

Table 4.2 – Effect of needle punching density of fabric on GSM of fabric.

Needle punch density	Flow rate (lit/Min)	paramenter	GSM (gm/m^2)
200	0.5	Before filtration	264.520
		After filtration	292.738
	1.0	Before filtration	264.520
		After filtration	280.137
	1.5	Before filtration	264.520
		After filtration	272.294
400	0.5	Before filtration	384.208
		After filtration	412.037
	1.0	Before filtration	384.208
		After filtration	402.626
	1.5	Before filtration	384.208
		After filtration	402.185
600	0.5	Before filtration	537.400
		After filtration	565.619
	1.0	Before filtration	537.400
		After filtration	559.208
	1.5	Before filtration	537.400
		After filtration	558.688
800	0.5	Before filtration	724.000
		After filtration	779.011
	1.0	Before filtration	724.000
		After filtration	767.515
	1.5	Before filtration	724.000
		After filtration	761.455

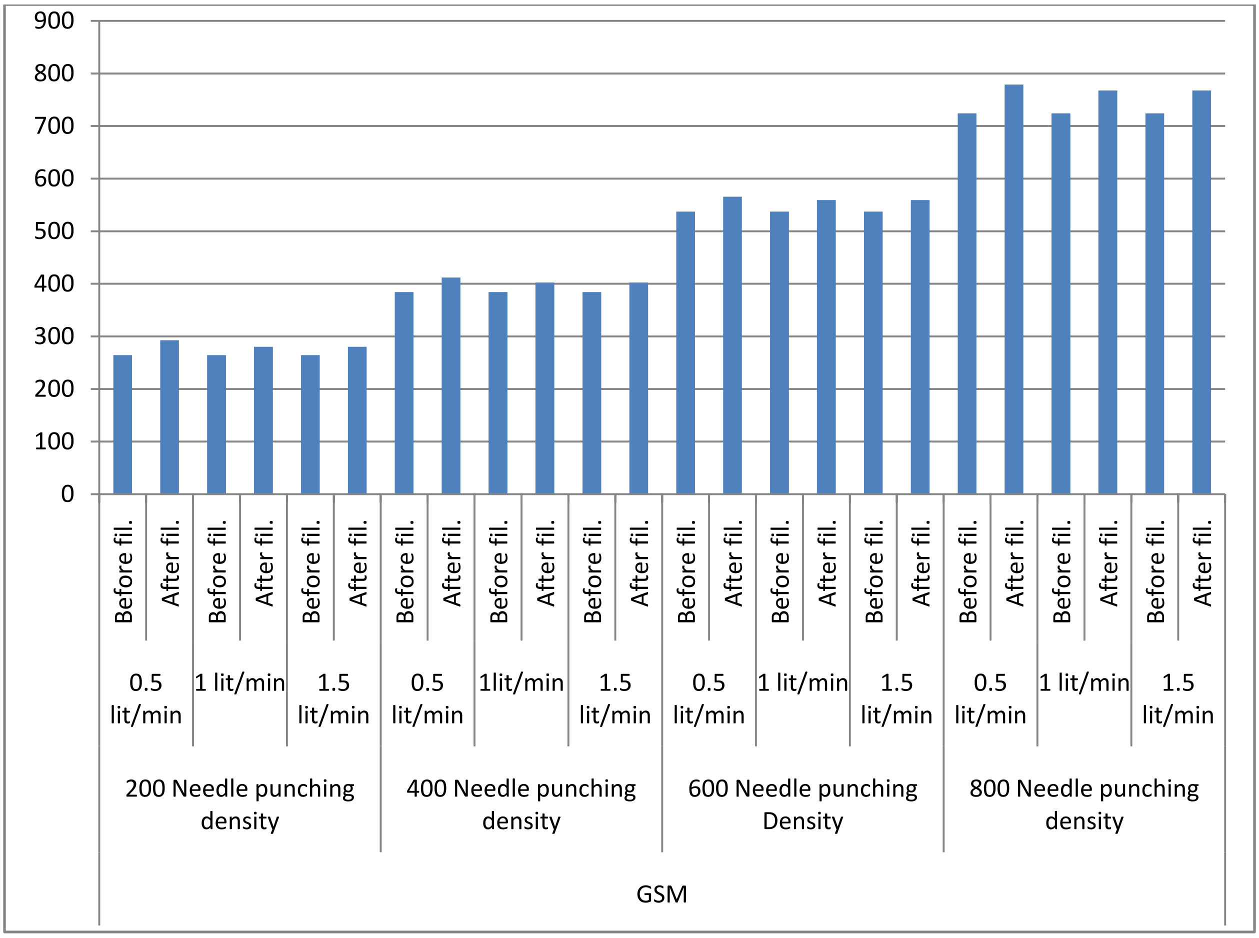

Figure 4.6 - Effect of needle punching density of fabric on GSM of fabric.

The above Table 4.2 and Figure 4.6 it is observed that there is increase in GSM with the increase in needle punching density. The fabric shows increase in GSM from 264.520 gm/m² to 724.00 gm/m² before filtration for 200 and 800 needle punching density respectively. The fabric shows increase in GSM after filtration. At lowest flow rate 0.5 lit/min. 800 needle punched density fabric showed highest GSM 779.011 as compare to all GSM after filtration. This may be due to high needle punching density of fabric. Lowest flow rate increased the retention time of suspended solids during filtration. The results of GSM gives the clear idea regarding removal of TSS at slow flow rate.

4.2.2 Effect of needle punching density of fabric on air permeability of fabric

Table 4.3 - Effect of needle punching density of fabric on air permeability of fabric

Needle punch density	Flow rate (lit/Min)	Paramenter	Air permeability (cm³/cm²/sec)
200	0.5	Before filtration	67.46
		After filtration	17.59

	1.0	Before filtration	67.46
		After filtration	29.66
	1.5	Before filtration	67.46
		After filtration	50.00
400	0.5	Before filtration	28.03
		After filtration	7.34
	1.0	Before filtration	28.03
		After filtration	19.60
	1.5	Before filtration	28.03
		After filtration	34.67
600	0.5	Before filtration	10.33
		After filtration	6.54
	1.0	Before filtration	10.33
		After filtration	9.19
	1.5	Before filtration	10.33
		After filtration	9.57
800	0.5	Before filtration	6.93
		After filtration	5.37
	1.0	Before filtration	6.93
		After filtration	6.43
	1.5	Before filtration	6.93
		After filtration	6.65

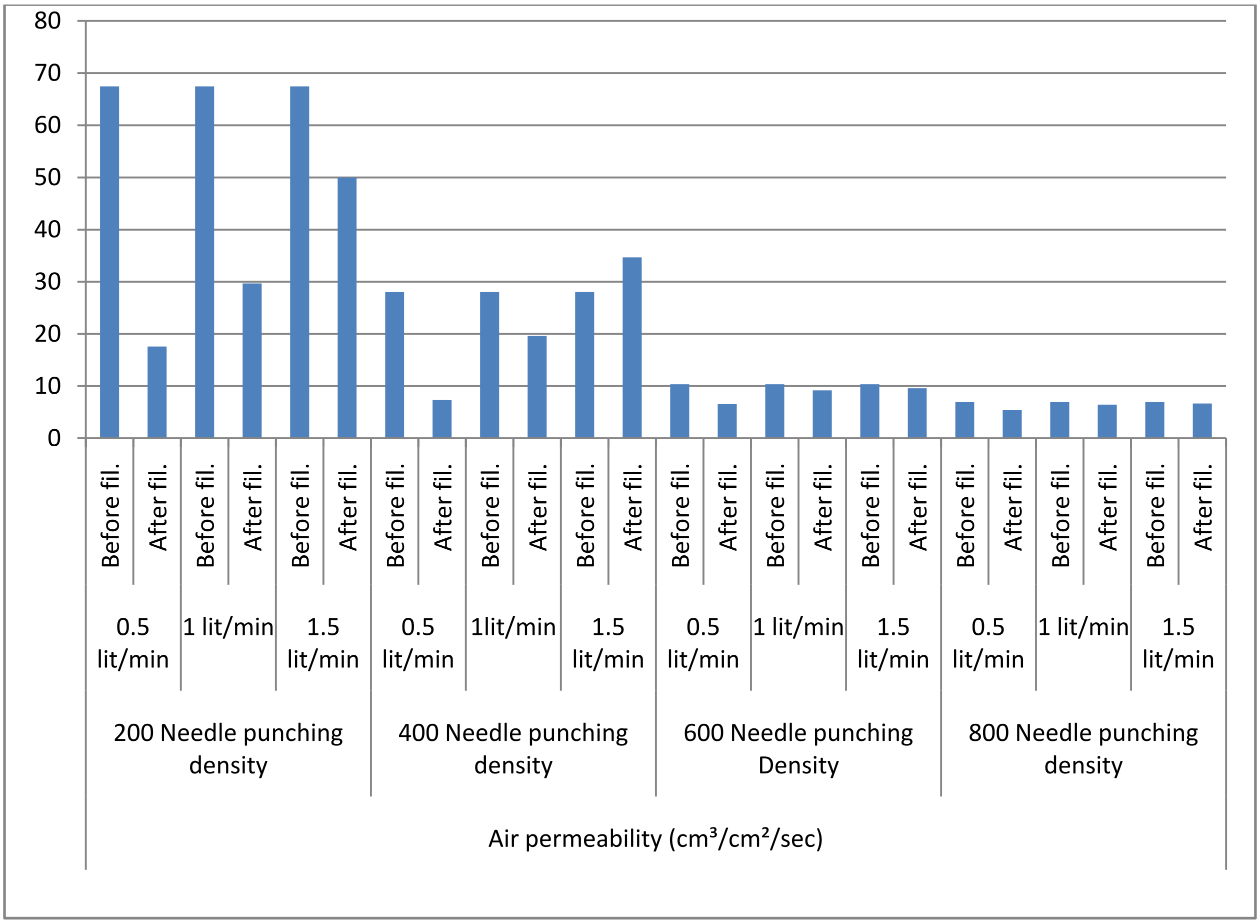

Figure 4.7 - Effect of needle punching density of fabric on air permeability of fabric

The above Table 4.3 and Figure 4.7 shows that as the needle punching density increases air permeability decreases in before and after filtration. The 200 needle punching density fabric shows air permeability 67.46($cm^3/cm^2/sec$) and the 800 needle punching density fabric shows air permeability 6.93($cm^3/cm^2/sec$)at before filtration.After filtration the 800 needle punching density fabric at flow rate 0.5 lit/min after filtration shows lowest air permeability 5.37($cm^3/cm^2/sec$). This is due to increase in fabric density with needling density and with this reduction in pore size.Lowest flow rate increased the retention time of suspended solids during filtration which blocked the pores of fabric so it reduced the air permeability of fabric.

4.2.3. Effect of needle punching density of fabric on filtration efficiency of fabric

Table 4.4 –Effect of needle punching density of fabric on filtration efficiency of fabric

Needle punch density	Flow rate (lit/Min)	Filtration Efficiency (%)
200	0.5	25.00
	1.0	18.00
	1.5	7.50
400	0.5	30.00
	1.0	25.83
	1.5	12.83
600	0.5	41.66
	1.0	37.50
	1.5	16.66
800	0.5	65.83
	1.0	61.83
	1.5	35.00

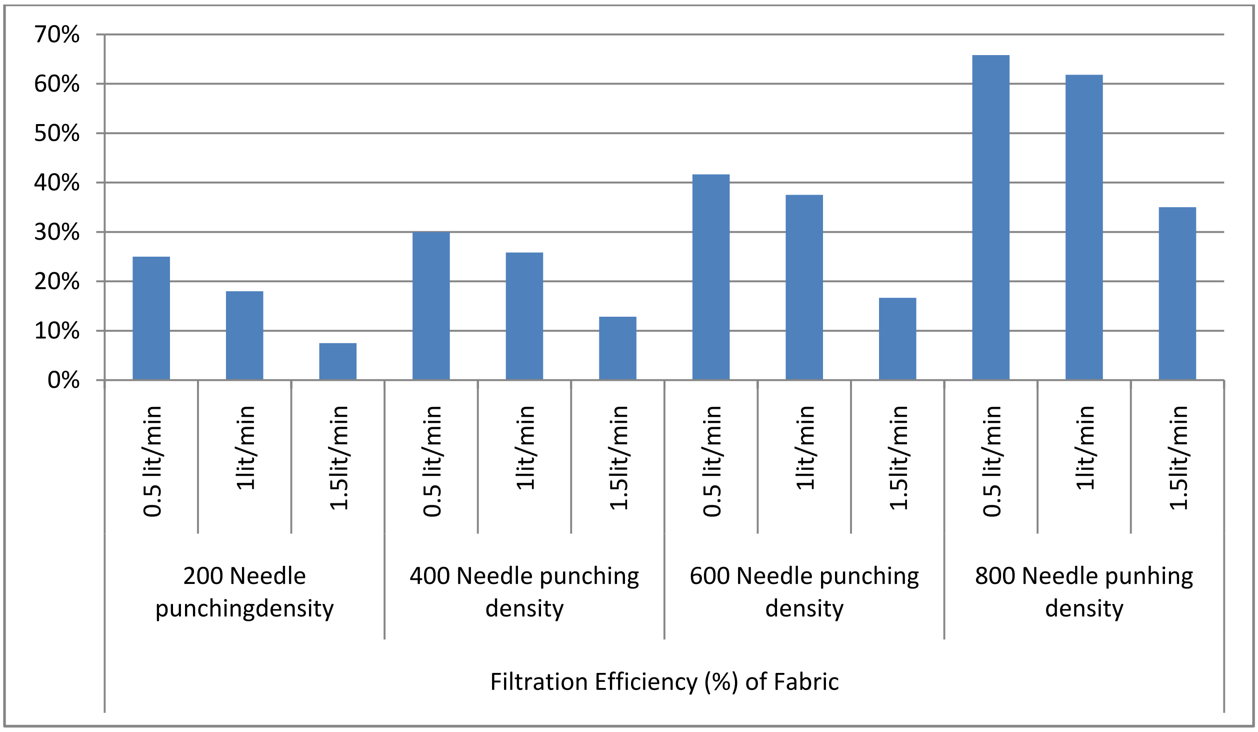

Figure 4.8 - Effect of needle punching density of fabric on filtration efficiency of fabric

The above Table 4.4 and Figure 4.8shows increase in filtration efficiency of fabric with increase in needle punching density. From the Table, it is observed that at 800 needle punching density at the value of raw effluent was 600 mg/lit and after passing through the filter fabric at flow rate 0.5 lit/min the TSS shown was reduced 205 mg/lit. and this gives highest efficiency 65.83% in TSS reduction. The reason for the increase in filtration efficiency with increase needle punched density is due to decrease in air permeability of nonwoven fabric. Lowest flow rate increased the retention time of suspended solids during filtration which blocked the pores of fabric so it reduced the air permeability and water permeability of fabric.

4.2.4 Effect of needle punching density of fabric on bursting strength of fabric

Table 4.5 - Effect of needle punching density of fabric on bursting strength of fabric

Needle punch density	Flow rate (lit/Min)	Paramenter	Bursting Strength of Fabric (bar)
200	0.5	Before filtration	17.32
		After filtration	21.58
	1.0	Before filtration	17.32
		After filtration	20.87
	1.5	Before filtration	17.32
		After filtration	17.49
400	0.5	Before filtration	24.08
		After filtration	29.66
	1.0	Before filtration	24.08
		After filtration	27.05
	1.5	Before filtration	24.08
		After filtration	25.59
600	0.5	Before filtration	36.68
		After filtration	40.17
	1.0	Before filtration	36.68
		After filtration	39.68
	1.5	Before filtration	36.68
		After filtration	38.55
800	0.5	Before filtration	41.87
		After filtration	43.68
	1.0	Before filtration	41.87
		After filtration	42.57
	1.5	Before filtration	41.87
		After filtration	41.78

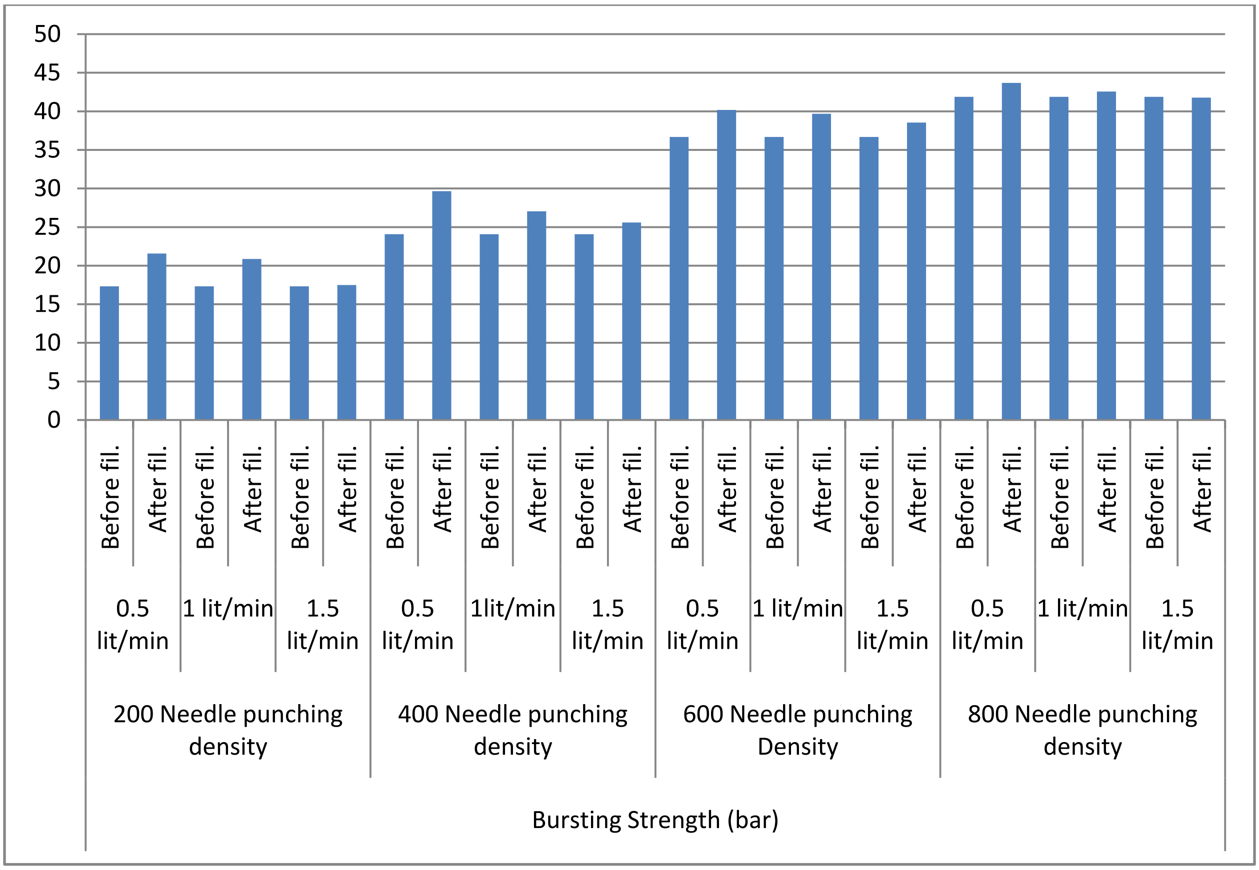

Figure 4.9 - Effect of needle punching density of fabric on bursting strength (bar) of fabric

The above Table 4.5 and Figure 4.9 shows increase in bursting strength with increase in needle punching density at before and after filtration. The 200 needle punching density fabric and 800 needle punching density fabric shows bursting strength 17.32 bar and 41.87 respectively at before filtration.After filtration the 800 needle punching density fabric shows highest bursting strength 43.68 bar at after filtration. This is due to increase in needle punching density of fabric which increases compactness of fabric and effect of lowest flow rate.

4.2.5 Effect of needle punching density of fabric on Time required for filtration

Table 4.6 – Effect of needle punching density of fabric on Time required for filtration

Needle punch density	Flow rate (lit/Min)	Time (Sec)
200	0.5	36.01
	1.0	9.65
	1.5	5.47
400	0.5	37.55
	1.0	15.98
	1.5	10.25
600	0.5	43.45
	1.0	30.86

	1.5	12.50
800	0.5	56.01
	1.0	40.87
	1.5	15.99

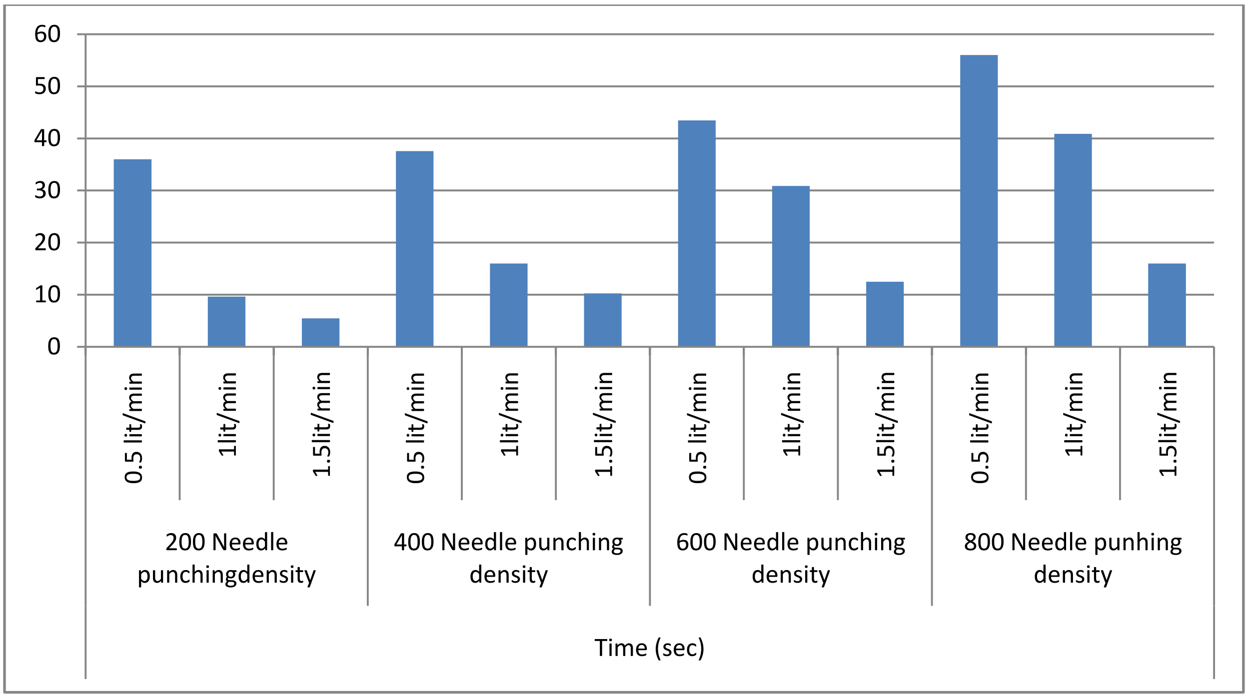

Figure 4.10 – Effect of needle punching density of fabric on Time required for filtration

The above Table 4.6 and Figure 4.10shows increase in time with the increase in needle punching density of fabric. Fabric of 800 needle punching density required highest time 56.01 sec. for effluent filtration at flow rate 0.5 lit/min. This is may be because of increase in needle punching density with decreasing of air permeability and water permeability and lowest flow rate of effluent filtration.

CONCLUSION

From above results and discussion it is observed that,

- Woven fabric shows highest filtration efficiency 4.00% at 0.5 lit/min.
- Single layer nonwoven fabric having 800 needle punching density shows highest filtration efficiency 65.83% at 0.5 lit/min. as compare to 200,400,600 needle punched density fabric and other two flow rates.

Hence, we can conclude that nonwoven fabric has better filtration efficiency than woven filter fabric at lower flow rate. Results also indicate that nonwoven fabric having lower air permeability which is responsible for better filtration efficiency. GSM of nonwoven fabric increases at lower flow rate as compare to woven fabric. Also observed that woven fabric takes more time for filtration than nonwoven fabric.At single layer nonwoven fabric bursting strength of nonwoven fabric gets decreased as compare to woven fabric. So for better water filtration efficiency or to remove TSS from effluent, the nonwoven filter fabric having higher needle punch density can be used in effluent treatment plant.

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