Analysis of water quality parameters and discharge rate through conventional and geotextile based filter

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Abstract— *Groundwater is the water found beneath the ground surface at a certain depth which moves slowly through geologic formations of soil, sand and rocks known as aquifers. Groundwater recharge through artificially designed structures has been proven as a viable option for augmentation of its resources as it also helps in utilization of surplus runoff which otherwise is unutilized. Currently, conventional filters are mostly used in recharge wells which include different layers of boulders and aggregates ranging from biggest size in the bottom layer and smallest layer at the top. There are certain issues regarding these filters such as reduction in recharge rate due to its clogging after certain amount of time and complex and time consuming maintenance. Due to this, geotextile based filter was introduced in comparison of conventional filter which can be used in recharge wells. In this, mechanically bonded non woven geotextile was used. Water quality parameters such as pH, TDS, TSS, Turbidity, Total Hardness, Calcium, Chloride & Sulphate and discharge rate were analyzed from both types of filters before and after filtration with the help of a model constructed for testing of both type of filters. It was seen that the reduction in the values of TDS, TSS, and Turbidity was more in case of geotextile based filter as compared to the conventional filter. There were minimal changes in other parameters after filtration from both the filters. Discharge rate from geotextile based filter was also more as compared to the conventional filter. Rate of clogging was somehow more in case of geotextile based filter but it had no significant effect on its discharge rate.*

Keywords: Groundwater, Artificial recharge, Water quality parameters, Discharge rate, Conventional filter, Geotextile based filter.

1. INTRODUCTION

There has been a constant decrease in the level of groundwater. It is due to the over exploitation of its resources and reduction of unpaved land due to urbanization. There are different types of structures constructed for the augmentation of groundwater recharge but the rate of declination is much more as compared to the rate of recharge. Artificial recharge wells consisting of conventional filters for the recharge of groundwater are clogged after a certain amount of time. After that, cleaning and maintenance of these filters in a complex and time consuming process. Due to this, alternative methods are being introduced to replace these kinds of filters. Geotextile fabrics can be used as filters due to its porosity and retention properties. There are different types of geotextile fabrics available which are used for different purposes. Non Woven geotextiles are mostly used for filtration purposes due to its complex structure which retains soil particles and allows water to pass freely through it. However clogging rate of geotextile fabrics is more as compared to conventional filter but it does not have a significant effect on the discharge rate through it.

2. GEOTEXTILE AS FILTERS

Geotextiles are porous textiles, a class of geosynthetics, polymeric materials used in various infrastructure projects due to features such as self-restrained properties, rapid installation, and volumetric compactness (Koerner and Soong, 1995). These synthetic fibers are composed of: (polypropylene, polyethylene or polyester), thickness (denier) and length (filaments or short staples). The main characteristic that controls engineering behavior is the composition of fibers from the manufacturing process.

Geotextiles are commonly used in erosion control and drainage applications. Some of the applications include slopes, dam embankments, shorelines shielded with rip rap, flexible block mats and concrete filled fabric formed systems. In all these applications, geotextiles are used for retention of soil particles while allowing fluid to pass freely. But the fact is that, primary purpose of using geotextiles is filtration for which they are widely used.

Non Woven geotextiles are the fabrics mostly used for filtration purposes. Staple fibers or continuous filaments are bonded by mechanically entangling the fibers with barbed needles. Most commonly used non woven geotextiles are needle punched geotextiles.

Figure 1: Non woven geotextile

3. EXPERIMENTAL PROGRAM

Following research program includes the study of water quality parameters such as pH, TDS, TSS, Turbidity, Total Hardness, Calcium, Chloride & Sulphate before and after filtration from both type of filters i.e. conventional and geotextile based filter and their discharge rates. For analyzing water quality parameters and discharge rate, a model was constructed having both the filters installed in it. Conventional filter consisted of six layers of aggregates ranging from 60mm in the bottom layer and 2mm in the top layer. Thickness of conventional filter was 300 mm. Whereas two layers of mechanically bonded non woven geotextile fabric were used in geotextile based filter. The thickness of fabric used was 3mm having a pore size of 200 micron and design permeability of 100 m^2/sec. Samples were taken from both the filters. Collected water samples were tested in the laboratory for the following parameters. Discharge rate was also analysed from both the filters using the model.

4. CONSTRUCTION OF MODEL

The purpose of this construction was to collect samples before and after passing from both the filters and to calculate discharge rate from both filters. The samples collected were then tested in the laboratory for the parameters stated. A model was created in which both the filters were placed. It consisted of four water tanks with the capacity of 500 liters and a cylindrical drum which was cut in two equal parts and the bottom of these drums were closed and made water tight. These drums were properly cleaned and steel frames in the form of a mesh were made according to the size of the drum. These frames were placed inside the drum at the level of 130 mm above the bottom of the drum to support both the filter media to be placed inside them. These frames were provided with the rectangular openings to allow free flow of water. In these drums, both the filters were placed. Two of the cylindrical tanks and both drums were provided with the outlet for the flow of water. Water tanks were also provided with the stop valve for controlling the flow of water.

Figure 2: Model consisting of both filters

Figure 3: Conventional filter (left) and Geotextile based filter (right)

5. RESULTS AND OBSERVATIONS

5.1 Water Quality Testing

The tests were performed on different water samples. Water samples shown below were created artificially by adding sand, soil and other contaminants as present in the surface runoff. The contaminants added were in different quantities for different samples and these contaminants were added in more quantity as compared to surface runoff at the proposed area to check the limits of both the filters and for comparing their results. Ten different samples with different amount of contaminants added to them were used in the filter. The results are described as under:

Table1: Water quality parameters of sample 1 after passing through both filters.

S.No	Parameters	Water sample	Conventional filter	Geotextile based filter
1	pH	7.95	7.88	8.0
2	TDS(mg/l)	220	218.25	219
3	TSS(mg/l)	34	19	15
4	Turbidity(NTU)	26	12	10
5	Total Hardness (mg/l)	142	139	140
6	Calcium(mg/l)	42.29	41.53	41.87
7	Chloride(mg/l)	30.12	28.24	28.9
8	Sulphate(mg/l)	28	25	23

Table2: Water quality parameters of sample 2 after passing through both filters.

S.No	Parameters	Water sample	Conventional filter	Geotextile based filter
1	pH	7.94	7.82	7.90
2	TDS(mg/l)	202.75	199	198.50
3	TSS(mg/l)	83	62	51
4	Turbidity(NTU)	68	46	35
5	Total Hardness (mg/l)	126	123	124
6	Calcium(mg/l)	39.57	37.9	36.1
7	Chloride(mg/l)	34.5	32.04	32.49
8	Sulphate(mg/l)	22	18	16

Table3: Water quality parameters of sample 3 after passing through both filters.

S.No	Parameters	Water sample	Conventional filter	Geotextile based filter
1	pH	7.69	7.65	7.68
2	TDS(mg/l)	356	351	349.25
3	TSS(mg/l)	365	312	277
4	Turbidity(NTU)	259	233	206
5	Total Hardness (mg/l)	220	215	216
6	Calcium(mg/l)	58.81	55.93	56.2
7	Chloride(mg/l)	41.23	39.17	38.72
8	Sulphate(mg/l)	117	99	107

Table4: Water quality parameters of sample 4 after passing through both filters.

S. No	Parameters	Water sample	Conventional filter	Geotextile based filter
1	pH	7.76	7.68	7.75
2	TDS(mg/l)	238.3	235.7	231
3	TSS(mg/l)	378	297	235
4	Turbidity(NTU)	275	191	146
5	Total Hardness (mg/l)	140	131	127
6	Calcium(mg/l)	45.68	42.17	40.28
7	Chloride(mg/l)	38.52	36.24	35.4
8	Sulphate(mg/l)	64	58	55

Table5: Water quality parameters of sample 5 after passing through both filters.

S.No	Parameters	Water sample	Conventional filter	Geotextile based filter
1	pH	7.9	8.06	8.0
2	TDS(mg/l)	289	283	280.5
3	TSS(mg/l)	421	347	298
4	Turbidity(NTU)	236	200	155
5	Total Hardness (mg/l)	186	182	179
6	Calcium(mg/l)	61.10	58.33	55.8
7	Chloride(mg/l)	43	41.4	39.2
8	Sulphate(mg/l)	48	43	44

Table6: Water quality parameters of sample 6 after passing through both filters.

S.No	Parameters	Water sample	Conventional filter	Geotextile based filter
1	pH	7.40	7.58	7.69
2	TDS(mg/l)	251.5	249	244.25
3	TSS(mg/l)	765	691	653
4	Turbidity(NTU)	689	616	564
5	Total Hardness (mg/l)	167	164	160
6	Calcium(mg/l)	53.64	51.18	49.30
7	Chloride(mg/l)	37.81	35.64	33.72
8	Sulphate(mg/l)	38	35	34

Table7: Water quality parameters of sample 7 after passing through both filters.

S. No	Parameters	Water sample	Conventional filter	Geotextile based filter
1	pH	7.87	7.75	7.82
2	TDS(mg/l)	319	311.5	308
3	TSS(mg/l)	753	625	587
4	Turbidity(NTU)	639	534	505
5	Total Hardness (mg/l)	191	186	183
6	Calcium(mg/l)	61.12	57.48	55.9
7	Chloride(mg/l)	38.54	37.32	35.1
8	Sulphate(mg/l)	62	58	54

Table8: Water quality parameters of sample 8 after passing through both filters.

S. No	Parameters	Water sample	Conventional filter	Geotextile based filter
1	pH	8.30	8.10	8.25
2	TDS(mg/l)	241.5	236	233.75
3	TSS(mg/l)	1100	807	770
4	Turbidity(NTU)	994	798	684
5	Total Hardness (mg/l)	137	134	129
6	Calcium(mg/l)	37.82	34.60	32.14
7	Chloride(mg/l)	19.36	17.88	16.2
8	Sulphate(mg/l)	79	74	76

Table9: Water quality parameters of sample 9 after passing through both filters.

S.No	Parameters	Water sample	Conventional filter	Geotextile based filter
1	pH	7.34	7.31	7.32
2	TDS(mg/l)	347	338	334.5
3	TSS(mg/l)	551	374	359
4	Turbidity(NTU)	484	325	314
5	Total Hardness (mg/l)	209	202	197
6	Calcium(mg/l)	64.73	60.30	57.96
7	Chloride(mg/l)	39.52	36.41	32.26
8	Sulphate(mg/l)	71	67	65

Table10: Water quality parameters of sample 10 after passing through both filters.

S.No	Parameters	Water sample	Conventional filter	Geotextile based filter
1	pH	7.16	7.14	7.10
2	TDS(mg/l)	250	243	237
3	TSS(mg/l)	718	591	548
4	Turbidity(NTU)	649	537	483
5	Total Hardness (mg/l)	171	165	161
6	Calcium(mg/l)	52.38	49.54	46
7	Chloride(mg/l)	24	22.54	20
8	Sulphate(mg/l)	58	54	52

From the above stated results, following were the observations:

pH:

From the above stated results, pH was observed within the range of 7.1 to 8.3. There were minimal changes in pH value before and after filtration from both the filters. The range of pH was found within the limits of BIS.

Total Dissolved Solids (TDS):

In the above stated results, TDS of all the samples before and after filtration was found within the limits of BIS. It was noted that that the rate of reduction in TDS values after filtration from both filters was more with the passage of time and the reduction was more in geotextile based filter as compared to the conventional filter.

Total Suspended Solids (TSS):

From the following results, it was analysed that there was a certain decrease in values of TSS after filtration from both the filters. The depreciation was about 15% to 25% in case of conventional filter and 25% to 30% in case of geotextile based filter. These values of turbidity were much more than the limits prescribed by BIS.

Turbidity:

According to the results, there was a certain percentage of decrease in turbidity after filtration from both filters but the values of all samples were much higher than the limits prescribed by BIS. There was about 15% to 23% decrease in the values in case of conventional filer and 21% to 32% decrease in case of geotextile based filter.

Total Hardness and Calcium:

From the following results, it was observed that there was a gradual and minimal decrease in the values of total hardness and calcium with the passage of time after filtration from both the filters. The rate of depreciation was more in case of geotextile based filter as compared to the conventional filter. Values of all the samples were in the limits stated by BIS.

Chlorides:

The values of chloride content in all the samples stated above are within the limits of BIS. However, some depreciation was seen in the values before and after filtration from both filters and rate of depreciation was more in case of geotextile based filter.

Sulphates:

There were minimal changes (increase or decrease) in values of sulphate ions present in the above stated samples before and after filtration from both filters. However, the values were within the limits of BIS.

5.2 Discharge Rate

Discharge rate is the amount of water passing through the filter in one second. It is denoted by Q. It was calculated for the both filters i.e. conventional and geotextile based filter. For this 100 liters of water was allowed to pass from both the filters and the time was noted down with the help of a stop watch. Quality of water taken was same for both the filters and the test were performed for ten times.

Following were the results:

Table11: Discharge rate through conventional filter (F1) and geotextile based filter (F2)

S.No	Amount of water (lt)	Time taken by F1 (sec)	Time taken by F2 (sec)	Discharge rate (lt/sec)	Discharge rate (lt/sec)
1	100	220	136	0.458	0.735
2	100	223	138	0.448	0.724
3	100	230	143	0.434	0.699
4	100	254	162	0.393	0.617
5	100	279	187	0.358	0.534
6	100	296	215	0.337	0.465
7	100	317	242	0.315	0.413
8	100	331	266	0.302	0.375
9	100	345	284	0.289	0.352
10	100	362	304	0.276	0.328

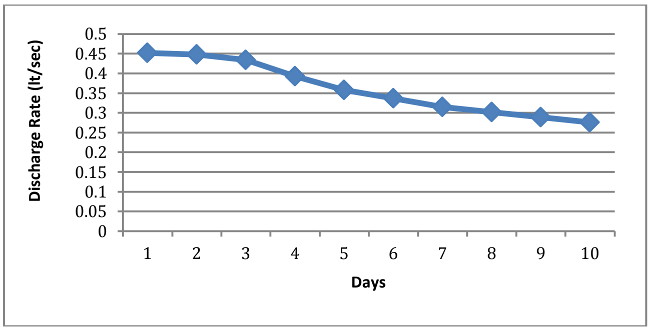

Chart 1: Discharge rate variation (F1)

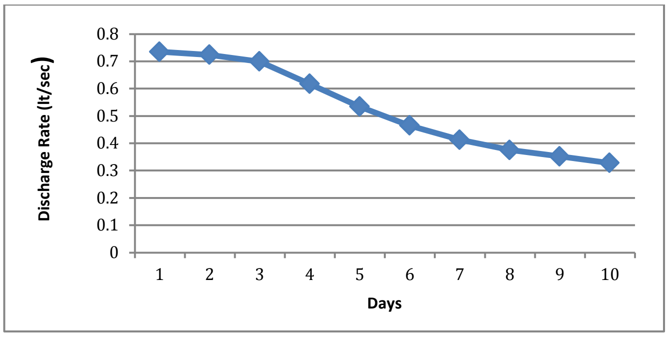

Chart 1: Discharge rate variation (F2)

From the above stated results, it was observed that there was a decrease in discharge rate with respect to time in case of both the filters. It may be possible due to the reduction in the size and number of pores present in both the filters which allows water to pass through it. Discharge rate through geotextile based filter was about 40% to 70% more than in case of conventional filter. However, the variation (decrease in discharge rate with respect to time) was slightly more in case of geotextile based filter as compared to the conventional filter. It states that the clogging rate of geotextile filter is slightly more than conventional filter.

6. CONCLUSION

- TSS and Turbidity were reduced after filtration from both the filters but the reduction was high in case of geotextile based filter.
- Slight reduction in TDS was observed after filtration but rate of depreciation was more in case of geotextile based filter.
- All other values were within the BIS limits and there was minimal or no decrease in them after filtration from both filters.
- Water samples taken from the site showed a consistent amount of decrease in the values of TSS, Turbidity, TDS, Hardness and chloride after filtration through geotextile based filter.
- Discharge rate was more in case of geotextile based filter.
- Cleaning of both filters installed in the model was done and time required for cleaning of geotextile based filter was much lesser as compared to conventional filter.
- After cleaning, geotextile fabric can be reused as a filter.

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