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RESEARCH ARTICLE

Hydraulic study of different filters used in drip irrigation system

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ABSTRACT

Among the irrigation systems used today, trickle irrigation is one of the most efficient methods, but potential clogging of the emitter and the relatively high capital investment precludes the wide usage of this system. This research conducted had the objective of comparing filtration efficiency and head loss for sand, screen and disc filter used in drip irrigation system. Removal efficiency of the filters and pressure drop with elapsed time with different levels of sediment load concentrations *i.e.* 100, 200, 300, 400 mg/l for different flow rates was recorded. The results of the experiment indicated that there was no definite trend between filtration efficiency with elapsed time and flow rate. However, relationship between filtration efficiency and sediment load concentration indicated that filtration efficiency decreased with increase in level of sediment load concentrations. The filtration efficiency of the disc filter was more and followed by screen and sand filter respectively. The result of experiment indicated that pressure drop across the filters increased for well water as well as for water with different level of sediment load concentrations with elapsed time and flow rates. Head loss evolution in disc filter was faster than screen and sand filters. But for well water pressure drop across the sand filter was more, followed by disc and screen filter respectively due to frictional losses. It was found that time required to develop 5 m of pressure drop across the disc filter was minimum, followed by screen and sand filter, respectively. Results indicated that there was inverse relationship between filtration efficiency and pressure drop. Comparative study shows that disc filter was better than screen and sand filter, but it requires more frequent cleaning for efficient and reliable performance, followed by screen and sand filter, respectively.

KEY WORDS : Filters, Time of concentration, Contour interval, Drip irrigation system

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INTRODUCTION

Drip irrigation has given a significant part of the farming community which is used on a wide variety of crops. Drip irrigation can deliver water and nutrients in precise amount and at controlled frequencies directly to the plants root zone. Efficiency of drip irrigation is near about 90 per cent as compared to other irrigation methods. In India, only 41.2 million ha area is under irrigation, out of which only 0.15 per cent (61,800 ha) is under drip irrigation system (Mohanalakshmi *et al.,* 2010). In Maharashtra total area under drip irrigation is ha. But, without proper filtration system, some problems encountered in operating drip systems particularly those related to the clogging of emitters. Filtration is the key to the success or failure of a drip irrigation system. Selection of a filter depends on the types and amount of contaminants in the irrigation water Bhagyawant *et al.* (2008) .

Considering the above aspects, the research work on "Hydraulic study of different filters used in drip irrigation

Specifications	Sand filter	Screen filter	Disc filter
Inlet/outlet diameter	2" male thread	2" male thread	2" male thread
Maximum pressure	2 kg/cm^2	2 kg/cm^2	2 kg/cm^2
Maximum flow rate	20 m^3/hr	20 m^3/hr	20 m^3/hr
Net weight	65 kg	15 kg	3 kg
Maximum temperature	60ºC	60ºC	60ºC
Filter length (L)	78.2 cm	50 cm	41.6 cm
Filter width (A)	50 cm	17.5 cm	26 cm
Filtering media	3-5 mm sand	120 mesh	120 mesh
Materials	Mild steel	Mild steel	Polypropylene
Filtration area	1769 cm^2	835 cm^2	950 cm^2
Filtration volume	153467 cm^3	1676 cm^3	1225 cm^3

system" was conducted during year 2010-2011 at Department of Irrigation and Drainage Engineering, with the following specific objectives *i.e.*, to evaluate the filtering efficiency of different filters used in drip irrigation, To study the hydraulic performance of various filters and to suggest the suitable filter for drip irrigation system to suit the local conditions.

EXPERIMENTAL PROCEDURE

The experiment was conducted at the Department of Irrigation and Drainage Engineering, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola which is situated in Vidarbha region of Maharashtra.The entire unit consisted of 5 HP pump with by pass arrangement, plastic tank (3000 lit.), sand filter (20 m^3/hr), screen filter (20 m^3/hr) and disc filter(20 m^3/hr), pressure gauges, water meter, stop watch and pipe network. Water samples from farm ponds, reservoirs, open wells, bore wells were collected and by using volumetric method, sediment load was calculated. According to sediment load in water samples, concentrations were decided.

Soil was collected from dry bed of river. Sieve analysis was performed and the particles passed through 400 micron size were collected. The different sediment load concentrations of 100, 200, 300, 400 mg/l were prepared with water for the study.

The filtration efficiency was calculated by using the formula given by equation:

$$\mathbf{Fe = 100\,x\left(1 - \frac{S_o}{S_i}\right)}$$

where,

F_e - Filtration efficiency (%)

S_o - Component concentration of filter outlet, (mg\l)

S_i - Component concentration of filter inlet, (mg\l).

EXPERIMENTAL FINDINGS AND ANALYSIS

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Chemical analysis of water :

Chemical analysis of water was carried out to determine the quality of water. Water source was open dug well. The results obtained are presented in Table 1.

Table 1 depicts that, the water quality parameters such pH, EC, HCO_3, Cl, Ca+Mg, Na, K, S.A.R. and R.S.C.

were 7.56. 1.00 ds/m, 1.4, 1, 1.8, 2.0, 0.5 mg/l, 2.22 and 0.4 mg/l, respectively. It was found to be, water quality was salty.

Drop across the filters for well water :

The pressure drop across the sand, screen and disc filter tested by passing well water with elapsed time at flow rate 2.5 lps, are presented in Table 2.

From the Table 2 it is observed that the maximum pressure drop of 1.92m, 1.5m, 1.4m of water was found in sand disc and screen filter, respectively. It is cleared that pressure drop gradually increased with time. For well water pressure drop was maximum in sand filter as compare to screen and disc filter, due to frictional losses. Pressure drop does not exceed the permissible limit of 2 m of water forclean water. These result agree with Karmeli and Keller (1975).

Efficiency and pressure drop at 100 mg/l concentration :

Efficiency with elapsed time and corresponding pressure drop with elapsed time for different filters are presented in Tables 3 (a) and (b), respectively.

The filtration efficiency found in sand, screen and disc filter in the range of 64.2 to 77.5 per cent for sand filter,

Table 1 : Chemical analysis of water

Sr. No.	Water quality parameter	Observation
1.	pH	7.56
2.	EC (ds/m)	1.00
3.	HCO_3 (mg/l)	1.40
4.	Cl (mg/l)	1.00
5.	(Ca+Mg) (mg/l)	1.80
6.	Na (mg/l)	2.00
7.	K (mg/l)	0.50
8.	S.A.R.	2.22
9.	R.S.C (mg/l)	0.40
10.	Water quality	C_3, S_1

Table 2 : Drop across the filters for well water

Elapsed time (min.)	Pressure drop (m of water)		
	Sand filter	Screen filter	Disc filter
0	0	0	0
10	0.3	0.1	0.15
20	0.37	0.2	0.3
30	0.5	0.4	0.45
40	0.8	0.52	0.7
50	1.1	0.6	0.8
60	1.2	0.8	0.9
70	1.35	0.92	1
80	1.4	1.1	1.2
90	1.5	1.21	1.26
100	1.6	1.32	1.4
110	1.8	1.35	1.45
120	1.92	1.4	1.5

70.2 to 84.5 for screen filter and 65.4 to 94.2 per cent for disc filter, respectively at 1.91 lps., depicts that there was no definite trend in filtration efficiency and elapsed time. Efficiency was maximum in disc filter, followed by screen and sand filter, respectively.

Table 3(b) contain result of 100 mg/lit sediment load concentration and flow rate of 1.91 mg/l with regard to pressure drop evolution in sand, screen and disc filters with time.

Efficiency and pressure drop at 200 mg/l concentration :

Efficiency with elapsed time and corresponding pressure drop for 200 mg/l concentration and 2.25 lps discharge are presented in Tables 4 (a) and (b).

The data shows that there was no definite trend between efficiency and elapsed time. Maximum efficiency was found in disc filter and followed by screen and sand filter, respectively. Twelve back cleaning operations were needed for disc filter, while one each for sand and screen filter.

Efficiency and pressure drop at 300 mg/l concentration :

The filters were tested at 2.3 lps flow rate with 300 mg/l concentration and results are presented in Tables 5(a)

Table 3a : Efficiency at 100 mg/1 concentration

Elapsed time (min.)	Efficiency (%)		
	Sand filter	Screen filter	Disc filter
10	76.9	84.5	94.2
20	75.8	83.2	87.2
30	76	80.4	84.9
40	73.3	81.2	87.2
50	77.5	79.1	92.2
60	70.2	80.1	82.2
70	69.8	77.4	71.1
80	65.3	76.2	89.2
90	68	75.5	70.4
100	64.2	70.2	80.4
110	68.3	72	68.2
120	65.2	74.1	65.4

Table 3 b: Pressure drop at 100 mg/l concentration

Elapsed time (min.)	Pressure drop (m of water)		
	Sand filter	Screen filter	Disc filter
10	1.3	0.2	4
20	1.5	0.7	5*
30	1.6	1	3
40	1.9	1.2	5*
50	2	1.4	2.2
60	2.4	1.6	5*
70	2.9	2	3.5
80	3.2	2.5	5*
90	3.9	3.1	3.2
100	4.2	3.6	5*
110	4.8	4	3.1
120	5*	4.5	5*

and (b).

The efficiency was in the range of 26.5 to 49.3 per cent for sand, 19.4 to 50 per cent for screen and 28.5 to 51.2 per cent for disc filter. Table 5(a) shows that there was no definite trend between filtration efficiency and elapsed time. Higher value of efficiency were found in disc filter and followed by screen and sand filter, respectively. Similar results were obtained for flow rate of 2.4 and 2.5 lps flow rate and sediment load concentration of 200 mg/l (Benami and Ofen, 1984 and Jiusheng and Chen, 2009).

In the same manner, Efficiency with elapsed time and corresponding pressure drop for 2.5 lps for 400 mg/l concentration, depicts that there was no definite trend between filtration efficiency and elapsed time. It was found that filtration efficiency was in the range of 9 to 31.4 per cent in sand filter, 13.49 to 41.2 per cent in screen filter and 10.9 to 48.7 per cent in disc filter.

Table 4a : Efficiency at 200 mg/l concentration

Elapsed time (min.)	Efficiency (%)		
	Sand filter	Screen filter	Disc filter
10	72	76	80.5
20	72.9	74	78.2
30	75	71	69.5
40	63	68	82.3
50	62.7	69	71.4
60	68	69.9	72.3
70	69.4	70	73.9
80	54	62	70.2
90	52	47.2	71.4
100	56	72	70.4
110	49	60	65.5
120	51	62	62.2

Table 4b: Pressure drop at 200 mg/l concentration

Elapsed time (min.)	Pressure drop (m of water)		
	Sand filter	Screen filter	Disc filter
10	1	2.1	5.01*
20	1.3	2.4	4.89*
30	2	2.55	5*
40	2.5	2.6	5.02*
50	2.8	2.72	5*
60	3	2.9	5*
70	3.2	3.2	5.02*
80	3.8	3.7	5*
90	4.25	4.2	4.98*
100	4.6	5*	5*
110	5*	2.1	5.03*
120	2	2.6	5*

Behaviour of efficiency :

The filter was tested for it's efficiency corresponding to 5 m of pressure drop with three different flow rates for each sediment load concentration of 100, 200, 300, 400 mg/l and results are presented in Table 6.

The Table 6, shows that maximum efficiency was found in lower sediment load concentration (100 mg/l) as

Table 5a : Efficiency 300 mg/l concentration

Elapsed time (min.)	Efficiency (%)		Elapsed time (min.)	Efficiency (%)
	Sand filter	Screen filter		Disc filter
10	45.5	47	7	49.2
20	48	49.5	13	49.6
30	46.3	45	19.3	46.5
40	47	50	24.5	42.3
50	49.3	34.8	32	51.2
60	40.3	32.9	38	45.2
70	39.9	30.9	46	44.4
80	38.8	29.2	52	43.2
90	39	23.4	60	43
100	31.1	21.5	76	42.5
110	26.5	19.4	81	41.3
120	29.7	23.4	88	40
			94	39.2
			102	28.5
			109	29.5
			115	29.9
			121	30.2

Table 5 b : Pressure drop at 300 mg/l concentration

Elapsed time (min.)	Pressure drop (m of water)		Elapsed time (min.)	Pressure drop (m of water)
	Sand filter	Screen filter		Disc filter
10	2.2	1.01	7	5*
20	2.39	2	13	5*
30	2.45	2.5	19.3	5*
40	2.9	2.81	24.5	5*
50	3.1	4.1	32	5*
60	3.54	5*	38	5*
70	3.8	2.2	46	5*
80	4.1	2.9	52	5*
90	4.6	3.2	60	5*
100	5*	3.4	76	5*
110	2.1	4	81	5*
120	2.6	4.5	88	5*
			94	5*
			102	5*
			109	5*
			115	5*
			121	5*

Table 6 : Behaviour of efficiency corresponding 5 m of pressure drop

Sediment load (mg\l)	Flow rate (lps)	Efficiency corresponding 5 m of pressure drop (%)		
		Sand filter	Screen filter	Disc filter
100	1.91	65.2	69.23	87.2
	2.05	61	69.44	70.2
	2.5	63.5	72.3	82.5
200	2.25	49	72	80.5
	2.4	69.3	43.1	72.5
	2.5	59.9	65.4	80.4
300	2.3	31.1	32.9	49.2
	2.5	40.6	42.5	76.2
	2.6	48.7	27.18	71.2
400	2.5	31.8	33.4	45.2
	2.6	26.2	19.5	22.2
	3.1	29.4	23.4	35.5

compared to higher sediment load concentration (400 mg/l).Maximum and minimum values of efficiency obtained in sand, screen and disc filter were 69.3, 69.44, 87.2 and 26.2, 19.5, 22.2, respectively (Amini and Troung, 1998).

Effect of sediment load concentration on filter performance :

Effect of sediment load concentration on filter performance was studied by using four different concentration 100, 200, 300, 400 mg/l at 2.5 lps flow rate for each concentration depicts that shows that maximum efficiency in sand, screen and disc filter were found to be 63.5, 72.3, 82.5 for 100 mg/l concentration and 31.8, 33.4, 45.2, for 400 mg/l sediment load concentration, respectively. It is clear that removal efficiency decreases with increase in sediment load concentration Amini and Troung (1998).

Conclusion :

–There was no definite relationship between filtration efficiency with elapsed and system flow rate, but efficiency of filter decreased with increase in level of sediment load concentrations. Filtration efficiency was more in disc filter followed by screen and sand filter, respectively.

– Pressure drop across the sand, screen and disc filter increases with increase in elapsed time for well water. Pressure drop across the sand, screen and disc filter increases with increase in level of sediment load concentrations. Also pressure drop across disc filter was more faster, followed by screen and sand filter, respectively.

– Filtration efficiency of the filters and pressure drop across the filters at different level of sediment load concentrations indicated that filtration efficiency and pressure drop across the filters were inversely related to each other. Comparative study shows that disc filter was better than screen and sand filter, but it requires more frequent cleaning for efficient and reliable performance followed by screen and sand filter, respectively.

– Results concluded that for a better suspended particle removal control, disc filter can be used with frequent cleaning to prevent the clogging of micro irrigation system.

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