Original Research Article

Development and Evaluation of Low Cost Drip Filter

ABSTRACT:

Irrigation water is many a time contaminated with physical, chemical and biological impurities. Proper filtration is of paramount importance to prevent clogging in drip irrigation system thereby aiding in reduced maintenance of the micro irrigation system. This study was conducted on Development and Evaluation of Low cost filters in the Network project on "Engineering Interventions in Micro Irrigation Systems (MIS) for improving water productivity" under Consortia Research Platform on Farm Mechanization and Precision Farming during 2018 to 2020. The objectives of the study are to develop low cost filters and to test the developed system in the field for efficiency in terms of pressure drop throughout discharge and quality of output. It was observed that the discharge from the filter increases as the time increases. Pressure drop and head loss in the filter system increases with flow rate. Filtration efficiency is a percentage of sand particles divided by the TSS removed by the filter. Efficiency of the filter increased from 25% to 64% (double chamber filter) and 23% to 62% (single chamber filter) with flow range of 5 m^3/h to 30 m^3/h.As flow rate increases, soil particles retained and efficiency of the filter increased with increase in head loss. Filter materials and screen filter removed the sand particles effectively. Uniformity coefficient of0.95 was observed in single chamber filter which is suitable for small farm application.

Keywords: Drip irrigation, Discharge, Filter efficiency, Screen filter and Coefficient of uniformity

1. INTRODUCTION:

Drip irrigation also known as trickle irrigation or micro irrigation is an efficient method of applying water at a low rate over a long period of time at frequent intervals with low pressure delivery systems. The water supplied from different sources contains dissolved and suspended impurities which can lead to physical, chemical, biological restrictions in the emitter resulting in uneven application rate of water. Uniformity is greatly reduced even when one to five per cent of the emitters are clogged (Nakayama and Bucks, 1981). Due to clogging of emitters, the maintenance cost of system is increased and life of system is reduced. Capra and Scicolone (2004) observed that the performance of drip irrigation systems using waste water is mainly limited by emitter clogging and this discourages farmers from introducing it. Nakayama *et al*. (1978)reported that adequate water filtration is essential requirement for consistent emitter operation. The filters commonly used in drip irrigation system are sand or gravel filter, screen filter, hydro cyclone filter or centrifugal separator and disc filters. Sand media filters consist of layered beds of graded sand and gravel placed in one or more cylindrical tanks. Sand media filter is widely in drip irrigation where water contains organic impurities such as algae and fungi etc or inorganic suspended impurities such as sand, silt or clay. When too much foreign materials have accumulated within the sand bed, it becomes difficult to force the water though the filter, and the head loss across the filter is increased. Gideon et al. (1982) found out quality of effluent produced by a media filter depends upon the flow rate through the filter, and on the type of sand used. Rodgers et al. (2004) reported that accumulation of biomass and deposition of suspended solids at the surface of a sand filter can lead to clogging of the filter media. Converse and Tyler (2004) observed that clogging of filter media is of less concern, when using coarse sand. Wadate and Khanal (1997) found that there was a poor relationship between filtration efficiency and sediment load concentration showing that the filtration efficiency decrease with sediment load concentration. Khaire et al. (2008) found that pressure drop across the sand media filter increases with increase in flow rate of clean water and water with sediment load of different concentration. The pressure drop across the sand media filter increased with increase in sediment load concentration levels. Water filtration is very important for micro irrigation systems. Appropriate filtration can help to extend the life and improve the maintenance of the irrigation system. For drip or sprinkler emitters, filtration is a basic need to avoid clogging. Currently there are different kinds of filters used in drip irrigation system, viz., Screen filters, Disc filters, Hydro cyclone filters, etc. Even though these filters are readily available in market, the deciding factor is the price at which available. Hence, the study was conducted to develop low cost filters with optimal selection of the shelf components as well filtering media and to test the developed system in the field for efficiency in terms of pressure drop throughout discharge and quality of output.

2. MATERIALS AND METHODS:

The experiment was conducted on “Development and Testing of Low cost filters” during 2018 to 2020.

2.1 METHODOLOGY:

Irrigation wateris mostly found contaminated with physical, chemical and biological impurities. Proper filtration is of paramount importance to prevent clogging in drip irrigation system thereby aiding in less maintenance of the irrigation system.

The test involves the following methodologies:

1. Design and Development of low-cost filters
2. Evaluation of developed low cost filters
3. Filter media with envelope made of poly vinyl chloride (PVC) is attempted
4. The low-cost filter has been tested at lab for its durability, strength and filter efficiency.

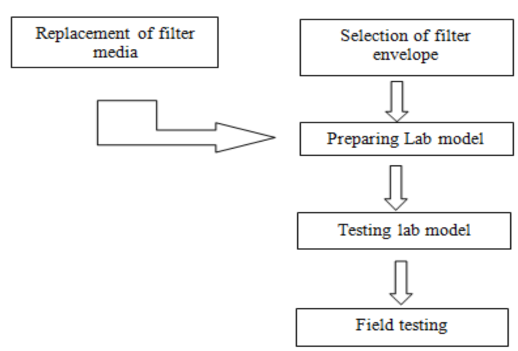

Fig. 1. Flow chart for development and evaluation of low cost filter

2.2 DESIGN OF FILTER:

The objective of the project is to fabricate and test a low cost media filter. In sand filters, conventionally, mild steel is used for the filter body whereas PVC is used for the fabrication of the proposed model to reduce the cost of the filter. Also there is no other option to reduce the cost rather than changing the filter body. The designed units contain single and double chambers (Figs. 2 and 3) of 30cm diameter PVC pipes of 1 m depth. Water inlet pipes of 5 cm PVC have perforations to allow the inlet water to pass through the media.

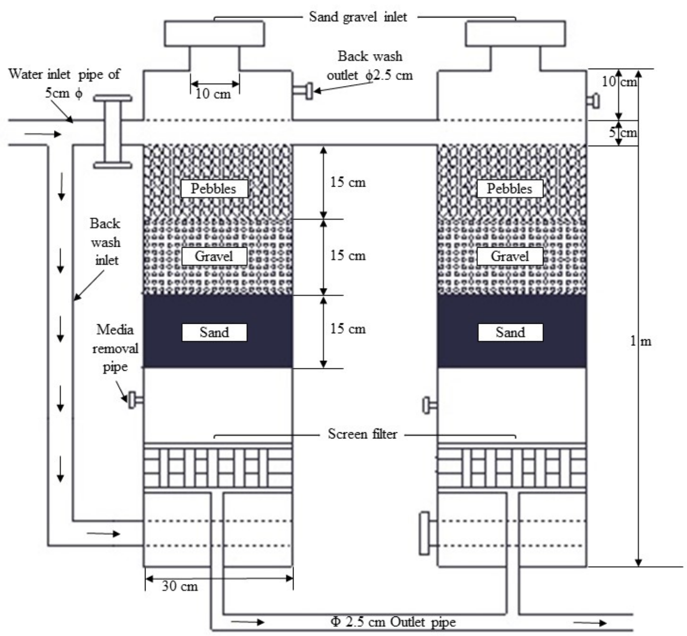

Fig. 2. Design Drawing of Double Chamber low cost sand filter

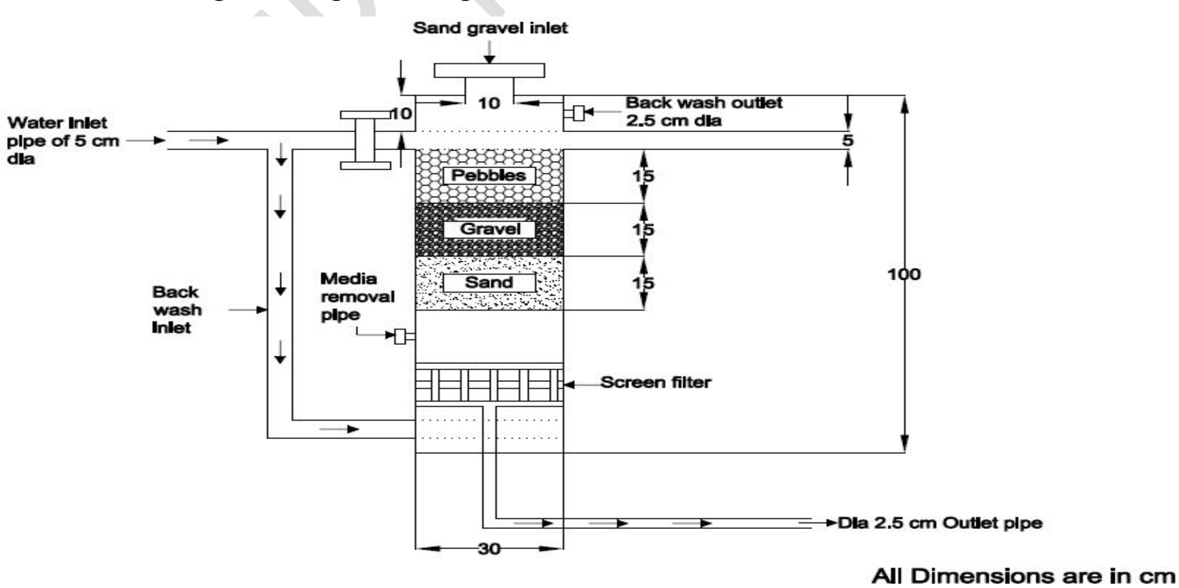

Fig. 3. Design Drawing of Single Chamber low cost sand filter

2.2.1 Filter Media:

There are different filter media available for filtration of sand particles from the irrigation water. Among the different kind of filters, the gravel media filter guaranteed the best performance (Capra & Scicolone, 2004). In the developed single and double chamber filter, there are 3 layers of filtering media, namely pebble, gravel and sand, each of them having a 30 cm thickness (Figure 3). During the filtration process, water passes through the first layer of pebbles decreases in its velocity and the large sized sediments start settling on the pebbles surface. Leaving the large particles, water then passes through the gravel bed and filtered again, water which is filtered twice again allowed passes through the sand layer of 30 cm. Below the sand layer, there is an arrangement with apertures to collect the filtered water, which in turn is connected to the main outlet pipe. The apertures are designed in such a way that they won't allow any sand particulates or inert material into the pipes and only the water can pass through them. A 2.5 cm diameter outlet pipe of PVC material facilitates the free discharge of water through it. The outlets of both the chambers are connected. Backwash inlet is provided for cleaning the filter periodically.

Fig.4. Layers of sand, gravels and pebbles

Fig. 5. Developed Double Chamber Low Cost Filter

3. RESULTS AND DISCUSSION:

To investigate and evaluate the performance of filter centrifugal pump was used in the laboratory. Bypass valves and flow control valves are also provided to maintain desired flow rate. Pressure gauges are installed in the inlet and outlet of the filter. Discharge, velocity, pressure drop, flow rate, head loss and efficiency of filter have been observed for both the filters.

3.1 DISCHARGE vs TIME AND FLOW RATE vs PRESSURE DROP:

It was observed that the discharge from the filters increases as the time increases. The constant discharge with respect time was due to the constant pressure drop maintained throughout the filter system (Figure 6). The rate of discharge may vary due to the difference in pressure drop and concentration of irrigation water (Mailapalli et al., 2007). Similarly pressure drop increased with increased flow rate (Figure 7). This is because when the pipe diameter is constant, the flow rate will be constant and there won't be any change in pressure (Patil et al 2013).The filter pressure drop values increase in the presence of sand and with increasing bed depth and decreasing sand effective size (Chang et al., 1999).

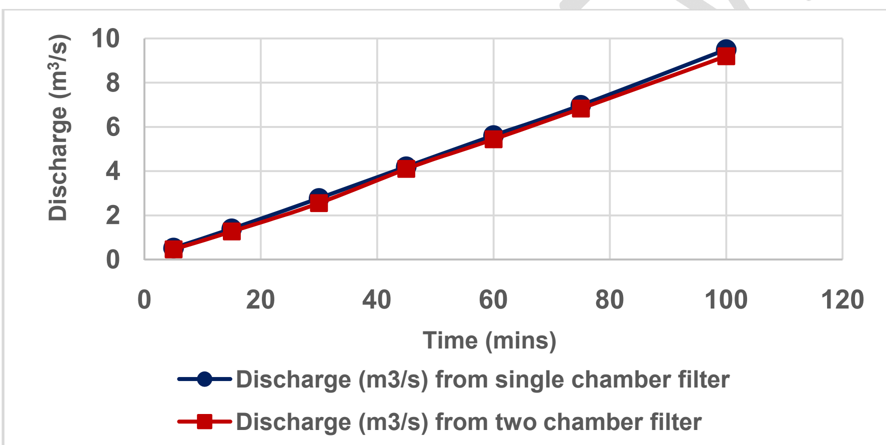

Fig. 6. Discharge vs Time

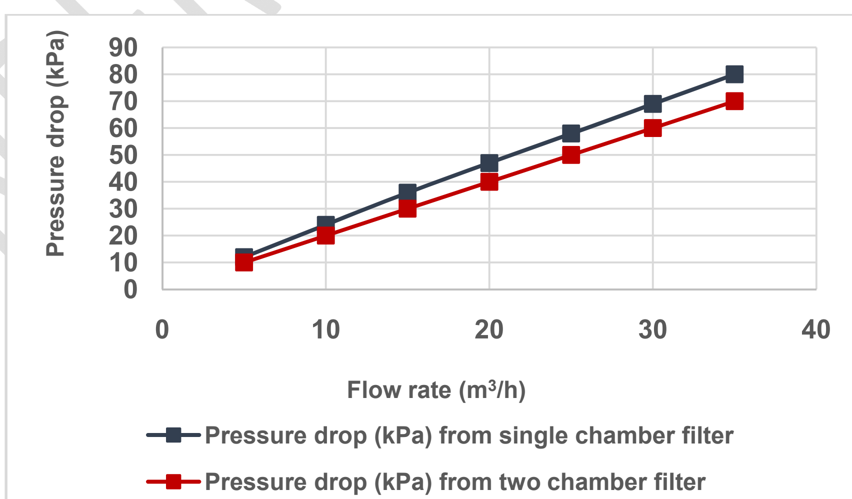

Fig. 7. Flow rate vs Pressure drop

3.2 HEAD LOSS vs FLOW RATE:

Head loss produced by sand filter is considered important to study the effect of filter underdrain (Arbat et al., 2014). In developed filter, head loss increased with flow rates (Figure 8). Similar result was observed by Demir, et al., 2009. Head loss is affected by the water flow velocity in the filter (Mesquita et al., 2012). Head loss curve is not linear as flow rate increases soil particles also increase for the constant filtration rate (Khan et al., 2017). The head loss results for the filter condition emphasize the importance of the geometry, the spatial arrangement, and the number of underdrains in the analysis of pressure drop variation in the sand filters (Arbat et al., 2014).

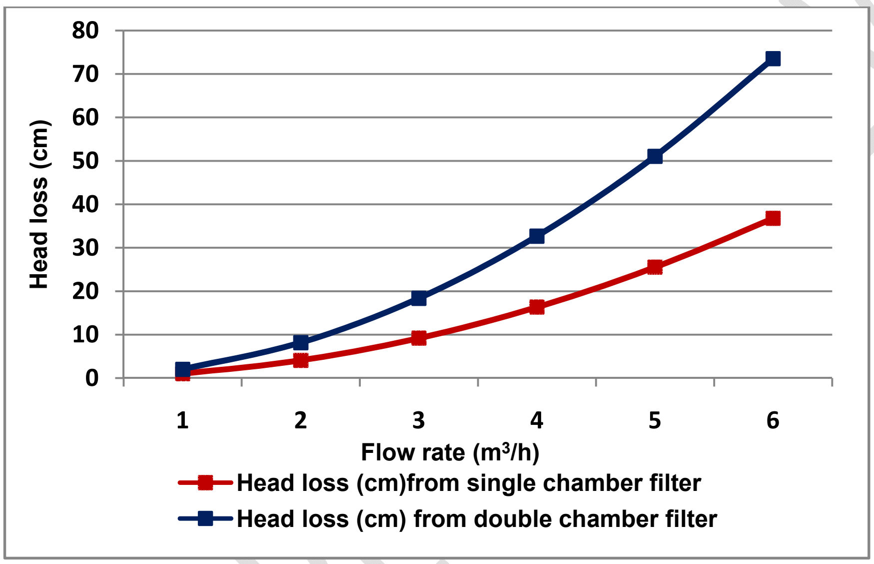

Fig. 8. Head loss vs Flow rate

3.3 FILTRATION EFFICIENCY vs FLOW RATE:

Filtration efficiency is a percentage of sand particles divided by the TSS removed by the filter. With a specific end goal to calculate the rate of particles separated from the filter and determine the filtration percent, firstly, the weight of dry filter papers was weighed and afterward a liter of irrigation water before going into filtration system was taken in a beaker, and poured through a filter paper. The filter paper was taken carefully and dried, then the filter paper was weighed again. The difference of filter paper weight in the two stages represented the weight of suspended material in sample water with 1 liter volume. As such a sample of water emitting from the central control system was taken and the amount of suspended material was calculated and filtration percentage determined. (Ghaffari and Soltani, 2016).

As flow rate increases, soil particles retained and efficiency of the filter increased with increase in head loss. In such cases, back flushing frequency will increase. Figure 9 shows the percent of sand particles removed with increasing flow rates. In contrast to the experimental conditions, irrigation water has different concentrations and types of solids in suspension, which will affect the dynamics of energy loss processes in the filtering equipment. Under these conditions, the sand particle size chosen will result in different removal efficiencies, with smaller sand effective sizes promoting higher efficiencies (Nakhla and Farooq, 2003; Elbana et al., 2012).

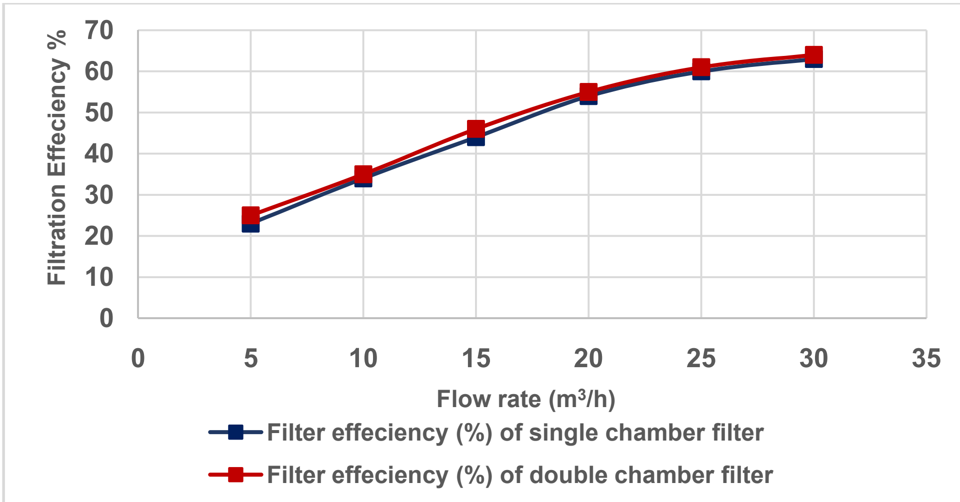

Fig. 9. Filtration Efficiency vs Flow Rate

It has been observed that efficiency of the double chamber filter increased from 25% to 64% and single chamber filter increased from 23% to 62% with flow range of 5 m^3/h to 30 m^3/h. Filter materials and screen filter removed the sand particles effectively. The filtration system has to be back flushed frequently.

3.4 COEFFICIENT OF UNIFORMITY:

The efficiency of drip irrigation depends on the uniformity of distribution of water throughout the field area. The discharge from the drippers at different points of emission was measured for a particular period of time at 50 kPa pressure. Catch can method was used to calculate the Coefficient of uniformity of drip irrigation system (Raina *et al*., 1999). The Uniformity Coefficient of the drip irrigation system was found to be 0.95. The high value of Uniformity Coefficient indicated the excellent performance of drip irrigation system in supplying water uniformly throughout the laterals.

4.0 CONCLUSION:

The study concludes that, the efficiency of the filter increased from 25% to 64% (double chamber filter) and 23% to 62% (single chamber filter) with flow range of 5 m^3/h to 30 m^3/h. Filter materials and screen filter removed the sand particles effectively. The filtration system has to be back flushed frequently.Filtration efficiency of single chamber and double chamber filter was almost similar with respect to other parameters studied. Also to reduce the cost further single chamber filter can be preferred. The uniformity coefficient of single chamber filter on the field test was found as 0.9516. Hence, in order to reduce the cost of drip system, single chamber filter is preferred which is suitable for small farm applications.

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