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Performance Evaluation of Low-Cost Filter in Field Condition

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Authors' contributions

This work was carried out in collaboration among all authors. Author KN designed the study, evaluate the performance of the low cost filter, wrote the protocol and approved the final draft of manuscript. Author SR managed the analysis of study. Authors TT, AS and TA helped in collecting experimental data and wrote the first draft of manuscript respectively. All authors read and approved the final manuscript.

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ABSTRACT

The parameters require for maintaining the crop's health and the integrity of the irrigation system has a relation with quality of irrigation water. In Micro irrigation appropriate filtration is very much important to prevent clogging. Filtration unit is one of the main components in micro irrigation system that too, Primary filter is more important to be installed along with the unit, when the water source is from open reservoir and other water sources. Though it is essential, the primary filter is not being installed by the farmers due to its high cost. Hence this study is an attempt to fabricate low-cost filter and to evaluate its performance with different filter media layer. A low-cost primary filter for drip irrigation system is fabricated. Different filter media layer like silex sand (fine silex, coarse silex), pebbles with different sizes are selected. The results revealed that the removal efficiency of filter using silex sand and pebbles were 71% in terms of turbidity, 78% in terms of total suspended solids removal at flow rate of 12 m^3 /hr. This fabricated low-cost filter will be cost effective for small farm applications.

Keywords: Fabricated primary filter; different filter media; turbidity; total suspended solids and filter efficiency.

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1. INTRODUCTION

Drip irrigation is also known as trickle irrigation. This is slow and even application of low-pressure water to soil and plants using plastic tubing placed directly at the plants root zone. Drip Irrigation can reduce about 15 per cent of cultivation cost, save about 47 per cent of water resources and electrical energy, and augment about 49 per cent of productivity over conventional flood method of irrigation [1]. Trickle emitters use small orifices or long flow paths with small diameters to deliver required irrigation water in small flow rates. The small emitters become clogged easily with either organic particles such as algae, weeds, and leaves, or with inorganic solid particles such as sand, silt, and clay [2]. Non-removal of these substances can lead to accumulations of dirt within the emitters and the rest of the equipment.

Filtration is the key to the success or failure of a drip irrigation system [3]. Filtration unit is essential equipment in drip irrigation system. Filtration system in drip irrigation, can effectively reduce the accumulation of the impurities and then slow down blockage in the pipe network and components such as emitters, solenoid valves, etc [4].

Namara et al. [5] reported that the successful adoption of micro irrigation technologies require the fulfilment of three basic factors: the technologies need to be technically and economically efficient; the target beneficiaries need to be aware of the technical and economic superiority of the technologies and the technologies must be accessible to potential users.

Roberts et al [2] stated that the cost of commercial sand filters, when added to the cost of drip line and pumping hardware, increase the total cost of the drip irrigation system. And it was also suggested that if the drip irrigation systems are to be accessible to small-scale farmers, filtration systems need to be as inexpensive as possible.

In outlook of above, an attempt was made to fabricate low-cost filter with different filter media and its performance was evaluated in the field conditions.

2. MATERIALS AND METHODS

The experiment was conducted at the Department of Soil and Water Conservation Engineering, Tamil Nadu Agriculture University, Coimbatore. In this studylow-cost filter was fabricated using different combination filter media. Silica sand, fine silex, coarse silex and pebbles (half inch and one inch) are used as filter media for the filter unit. Methodology of the study is shown in Fig. 1.

2.1 Design of low-cost filters

Existing conventional sand filter body is developed with mild steel which is expensive. The purpose of the study is to fabricate a low-cost filter. Hence mild steel is replaced with Poly Vinyl Chloride (PVC) material in fabrication of the low-cost filter unit.

The fabricated unit contains the filter body made of PVC material with a diameter of 30cm and height of 150 cm. Fig. 1 shows the layout and installation of filter unit with combination of different filter media layer. The fabricated unit is provided with necessary inlet and outlet fitting (4 kg/cm^2) with perforation to allow water to pass through and also for back washing arrangement. The fabricated unit consists of a main filter body fitted with flange (Fig 2.) at both the ends for strengthening the fabricated unit during the operation. Four gate valves are provided in the fabricated unit, one at the inlet, one at the outlet and other two for backwashing purpose. Three pressure gauges are provided to fabricated unit, one at the inlet, one at the outlet and the other one at the top of the unit in order to measure the pressure difference occurring in the unit while operation. A flow meter is provided before the outlet in order to measure the flow rate of the irrigation water at different pressure. The filter unit is fixed with air release valve to remove the air pockets from the filter. The fabricated filter is made with sufficient opening for easy removal and refilling of the filter media.

2.2 Filter Media Arrangements

In the fabricated low-cost filter, 5 layers of different filter media is provided for filtration. From the bottom, each layer is filled with pebbles of one inch in size for about 30 cm, filled with pebbles of half inch size for 15 cm, filled with Coarse Silex for 15 cm, filled with fine Silex for 15 cm and filled with sand for 15 cm respectively (Fig. 3).

2.3 Working Procedure of Filter

Water from the source when passes through different the layer of filter media the large sized

sediments and algae get trapped in the top layer (sand). The large sized sediments and algae remains in the top layer of the media. Water then passes through the next layers of fine silex and coarse silex, again for filtration. Water which is filtered twice by the silex layer is again allowed to pass through the layer of pebbles with different sizes of half inch and one inch. A layer of sand supports the silex and pebbles arrangement, which permits passage of filtered water to move freely and also allows the back wash water to move uniformly upwards. A perforated arrangement connected with the unit allows the filtered water, to the main outlet pipe. The perforated arrangements are designed to prevent the passage of the filter media particles along with the irrigation water. (Plate 1).

2.4 Operation of Backwashing

Back washing is the procedure that flushes clean water through a filter tank in reverse direction to the normal operating direction, in order to remove the intercepted organic material and suspended particles from the filter media. The fabricated low-cost filter is cleaned by back-washing periodically. Back washing is made frequent enough to hold the pressure drop within the prescribed design limits. Water is pumped in the reverse direction through the filter, loosening the sand layer. The suspended particles are thereby separated from the sand layer and flushed away through the back wash line provided in the filter unit. This back-flushing can be performed manually. Backwash valve is also used as a Bypass valve. Rate of flow was controlled by using the bypass valve.

2.5 Filter Efficiency

Analysis of turbidity, Total suspended solids and Dissolved oxygen of the irrigated water were done in order to find the filter efficiency of the fabricated filter. The samples were collected from the inlet and outlet point from the filter installed in the field for three irrigation period. Filter removal efficiency is computed as a measure of the ability of the sand filter to remove suspended particles from the inlet water sample. Filter removal efficiency is determined in terms of turbidity and DO respectively using the following formula [6].

$$RE_y = \frac{Y_i - Y_0}{Y_i} X\ 100$$

Where,

RE_y -Removal efficiency for the physical parameter with "y" being turbidity or DO
Y_i- Physical parameter values before filtering
Y_0- Physical parameter values after filtering.

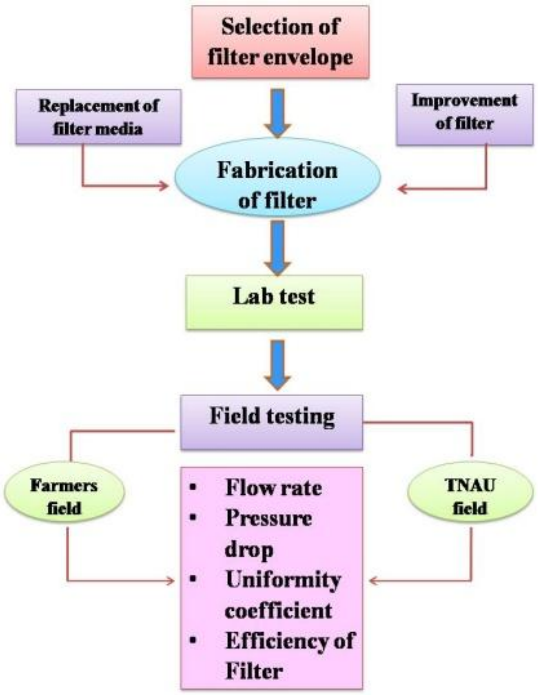

Fig. 1. Flow chart showing the methodology of the study

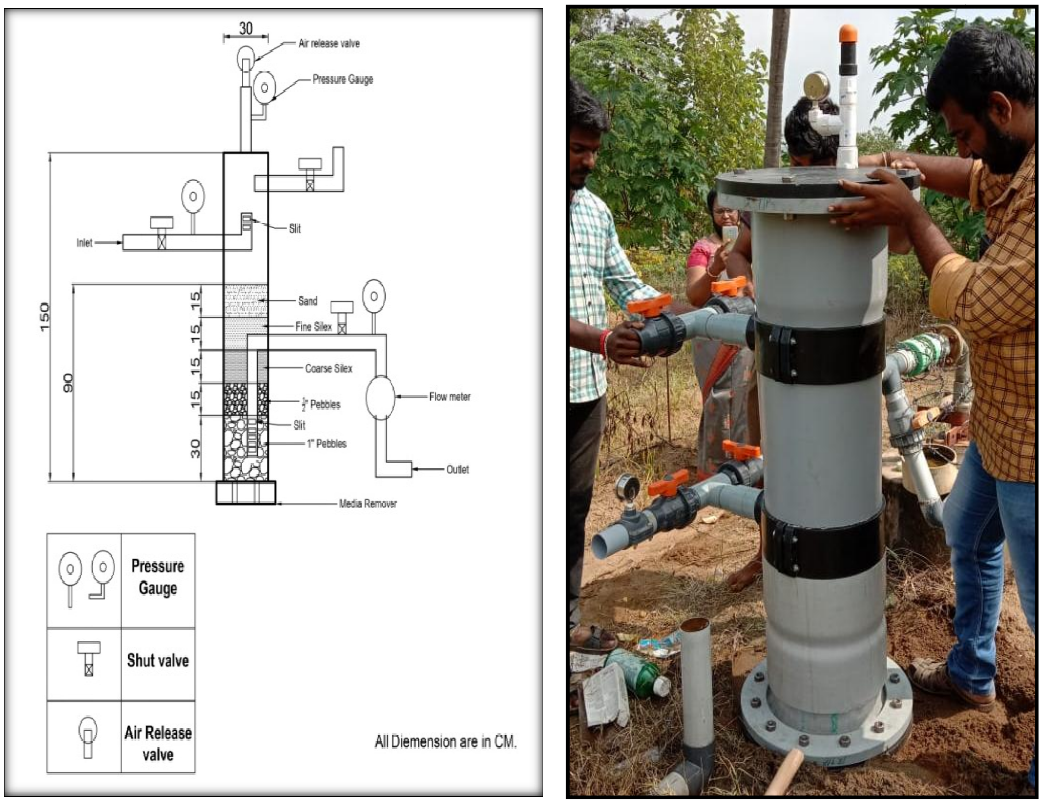

Fig. 2. Layout and installation of fabricated low-cost filter unit with silica sand, silex and pebble media

Silica Sand | Fine Silex | Coarse Silex | Pebbles – ½" | Pebbles-1"

Fig. 3. Different types of filter media used in the fabricated filter

2.6 Uniformity Coefficient

An important objective of any micro irrigation system is uniform distribution of water delivered through the emitters on the lateral line. [7]. The discharge from the emitters at different points of emission was measured for a particular period of time. Catch can method is used to calculate the Coefficient of uniformity of drip irrigation system [8] (Fig 4). The uniformity coefficient is computed by the following formula.

$$E_u = \left[1 - \frac{1.27}{\sqrt{N_e}} C_v\right] \frac{Q_{min}}{Q_{avg}}$$

Where,

E_u= Emission uniformity in percent,

N_e - Number of point source segments
C_v – Coefficient of variation
Q_{min} - The minimum discharge rate, lph
Q_{avg} - The average rate of discharge, lph

3. RESULTS AND DISCUSSION

Flow rate in the filter was measured during the field trial at different pressure of 2, 2.2 and 2.5 kg/cm2 respectively which is shown in Fig. 4. Maximum flow rate of 12m^3/hr was observed in the filter unit. The highest flow rate was recorded when the pressure increased. The rate of discharge may vary due to the difference in pressure drop [9].

The pressure drop of 0.1 kg/cm^2 was observed in field trail. Coefficient of uniformity was calculated during the operation of the filter unit. The Higher value of uniformity distribution indicated that the there was no clogging in drip line for the entire field.

Plate 1. Explanation of working procedure of the low-cost filter to farmers

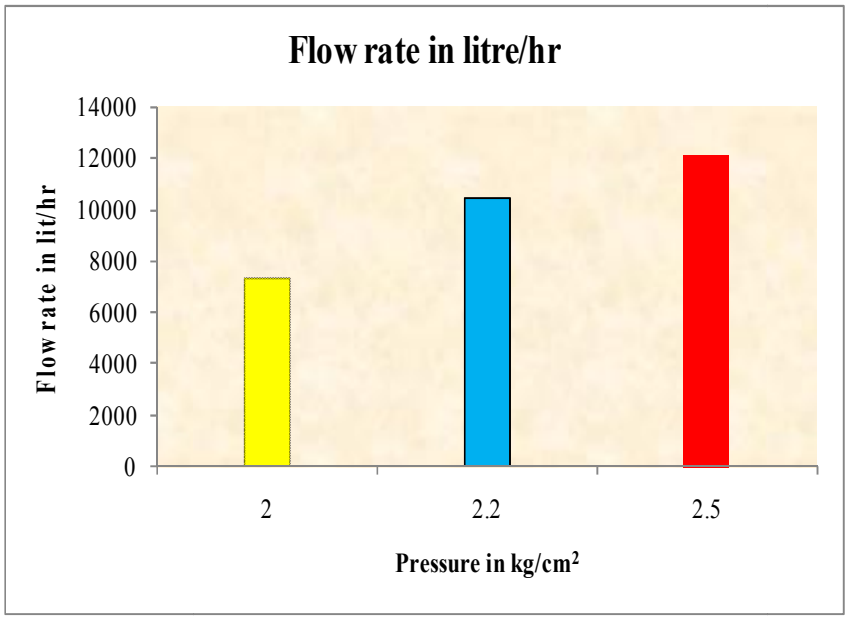

Fig. 4. Flow rate of silica sand, silex and pebble media filter

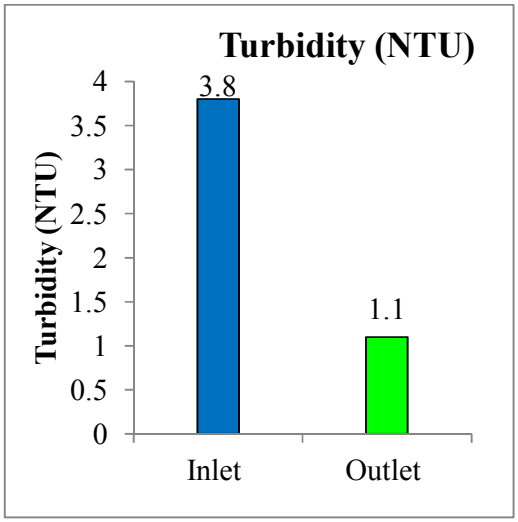

Fig. 5. Rate of turbidity removal

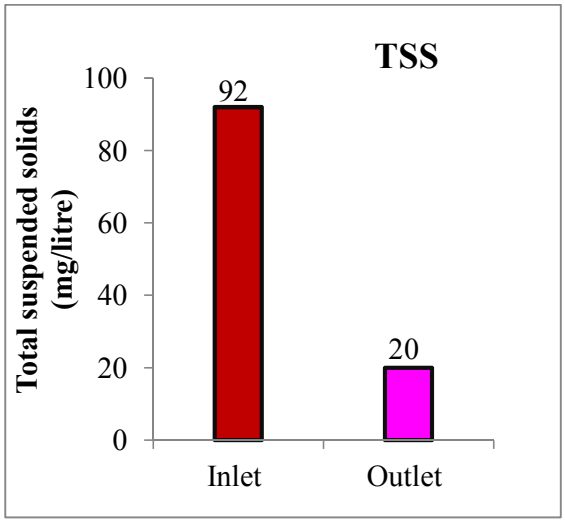

Fig. 6. Rate of TSS removal

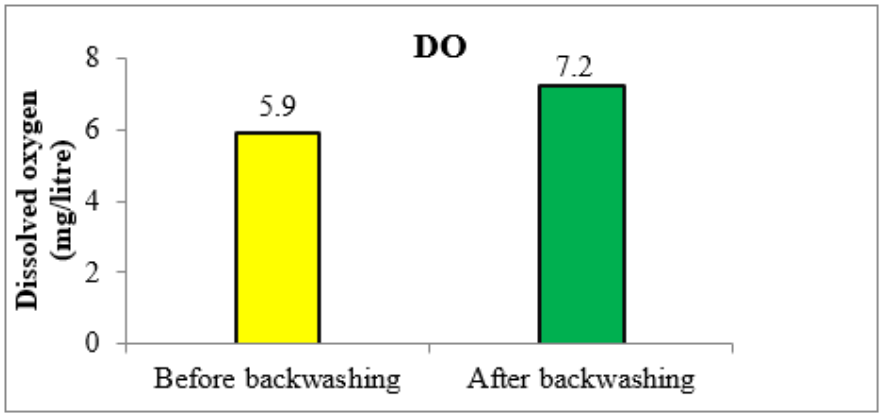

Fig. 7. Rate of recovery of Dissolved Oxygen

The rate of turbidity, total suspended solids and dissolved oxygen level in the sample from the filter having silica sand, silex and pebble media was measured.

It was observed, after the filtration, the rate of turbidity level was reduced from 3.8 NTU to 1.1 NTU. It was observed that the total suspended solid in outlet sample was 20 mg/l while 90 mg/l was observed in the inlet water sample. The turbidity removal efficiency was 71 % and TSS removal efficiency was 78% for fabricated filter unit. (Fig. 5 and 6) Dissolved Oxygen was increased from 5.9mg/l to 7.2mg/l in the filter unit during the backwash processing. (Fig. 7).

4. CONCLUSION

The presented work aims to develop low-cost filter. The filter body was replaced with PVC and existing filter media was replaced with available media like silica sand, silex pebbles. It was concluded that the cost of fabricated low-cost filter will be around Rs. 8500 /- (if manufactured using HDPE in large scale) compared to existing sand filter about Rs.22, 500 to Rs.25, 000. Flow rate increases with increase in pressure in the filter unit. Pressure drop of 0.1 kg/cm^2 was observed in fabricated low-cost filter under field trial. From the study it was observed that the filter removal efficiency was 71 %(turbidity removal) and 78% (TSS removal) for the fabricated filter unit. Dissolved oxygen level of filtration water was increased which favors the plant growth. The removal and refilling of the filter media are very easy. Usage of primary filter is very important for any micro irrigation system. Due to the high cost of the primary filter farmers avoid using of the primary filter unit. Awareness should

be created for using primary filter for any micro irrigation system. This fabricated low-cost filter will be cost effective if manufactured using HDPE in large scale for small farm applications and it can be a user-friendly primary filter unit.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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