

EVALUATION OF LOCALLY MANUFACTURED CYLINDRICAL SCREEN FILTERS

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ABSTRACT

The present study aimed to evaluate the proper cylindrical screen filters are manufacturing locally in Egypt. The cylindrical screen filter materials are available locally. The evaluations are test under different sources of water (surface water and ground water).

The operating characteristics of cylindrical screen filters predicated by knowledge of different mesh per linear inch, some hydraulic properties and effect of water quality on the operation age.

The study reveals that some cylindrical screen filters can be used after sand filters when the source of water is surface water and located directly after pump station when the source of water is ground water.

Screen filters are best selected for water source with low solid's concentration as insurance for (clean water) or as secondary filter downstream of a pre-filter. This is especially valuable because it can help identify faults in any micro irrigation system. The construction, measuring theory, operation, tests results and applications of two different sites will be described herein.

INTRODUCTION

Many different types of cylindrical screen filters are available on the local market at low cost, which are used mainly in pressurized irrigation systems. These filters are increasing with increasing the agriculture irrigated area under pressurized irrigation system (1.6 million fed.) El-Gindy (1997).

Keller and Karmeli (1975) mentioned that in screen filters, the hole size and total amount of open area determine the efficiency and operation limits. The screen filter is efficient for the removal of very fine particles from the irrigation water, but tends to be rapidly clogged by heavy loads of algae and other organic material. It is customary to clean the filter when the pressure head drop is about 2.0 m. or at a fixed time determined in advance. The factors should be considered when estimated, the appropriate discharge for a given screen filter are: quality of water,

filtration area, desired volume of water to be passed between cleaning cycles, and allowable pressure drop on the filter surface.

Burce (1985) mentioned that screen product in this category function much like cartridges and strainers, expect that they are designed for much higher flow rates (about 91 m³/h or 400 U.S. gpm per housing) and are capable of greater solid's retention. To accommodate higher flow rate, screen filters have more filtration surface area per inlet size than cartridges and strainers. Flushing is accomplished with little interruption to the operation of the irrigation system.

Pierce and Mancuso (1985) said that exceeding recommended flow rates cause rapid build-up of collected contamination and excessive flushing or cleaning. Operation at higher than recommended pressure levels may cause damage to both the screen filter housings and filter cartridge.

Zeier and Hills (1987) found that sand size is the main factor effecting the character of screen filter plugging. Fine sands cause a factor pressure drop across the screen filter than the coarse sand for similar quantities. Coarse sand needs a greater filter element storage volume in order to increase the time between filter cleaning, all other left the same. Increasing the volume available for sand storage would be more beneficial than increasing mesh area. The shape of the filter element should favor greater mesh surface areas for a given filter volume.

James (1988) mentioned that cylinder screens made of stainless steel or nylon are the most common type of screen filter used in trickle systems. The size of screen openings and hence the minimum particle size retained by the screen is determined by the number of weirs per inch. The screen mesh should be selected that the screen retains all particles larger than one-sixth the size of the smallest passage (openings) in the trickle system.

Keller and Bliesner (1990) said that where they are suitable, screen-mesh filter provide a simple and efficient means for filtering water. The maximum recommended flow rate through a fine screen should less than 135 L/S per m of screen open area. The wire or nylon meshes abstract much of open area.

Awady (1991) stated that many factors of fact on the function and capacity of water filtration for trickle irrigation. They include: 1) Source of water, and amount and nature of sediments and other causes of emitter clogging carried by water; 2) area served, plant grown, micro limatogical, and soil factors; 3) type and size of filter; 4) Time between successive cleaning services; 5) Fertilizers, pesticides and other water treatment additives which may result in precipitation of

solids, or from compounds that precipitate; and 6) type and size of trickle, and operation pressure.

Ravina et al. (1992) explained that reliable long term operation of most emitter types was achieved with filtration at 80 mesh (180 micron m opening) combined with daily chlorination and bio monthly lateral flushing. The difference between the levels of emitter clogging at 80 mesh filtration and 120 mesh was found to be insignificant. Hence, 80 mesh is the level of filtration recommended for manual flushing check filters in drip irrigation systems using reservoir waters. There is expected to minimize risks associated with rapid plugging of the filters.

Ravina et al. (1993) reported that the performance of filters after primary filtration by 120 mesh filters was better than after filtration with 40 mesh primary filters or without primary filtration. The performance of the manual downstream filters with non- filtered water and after 40 mesh filtration was similar.

Barbagallo et al. (1994) stated that different screen filters have been used in experimental filtration equipment using primary effluent (with is the diameter of the circle with the same area of the screen opening) and the area ratio (ratio between open area and total of the screen). A support made of a size plated net has been set up in respect of the currently used perforated plate, this metal support increases filtration cycle duration (time to get a prefixed hydraulic head drop and the amount of filtered water volumes per screen area unit).

Chauhan (1995) said that screen filters constitute an important of drip component of drip irrigation system. Screen filters are useful for removing suspended inorganic materials but cannot remove large amount of suspended and organic particles without reducing the flow and thus requiring frequent flushing.

Niekerk (1995) reported that most of these filters make use of internally filtered water to clean themselves, but if the water is so dirty that the elements of the filters are blocked before they themselves are clean, they cannot function any longer.

Parwal et al. (1995) reported that filtration of irrigation water in micro irrigation system is used for preventing clogging of individual parts of the system. Three types of filters, hydro cyclone's sand or media and screen are used individually or in combination to achieve the desired objective. The study relates to flow of clean water through screen filters, besides studying the applicability of a procedure for determining pressure drop.

Philips 1995 reported that most filtration equipment installed in micro irrigation system is being operating at less than optimum levels. A screen filter has operational limitations. Screens utilize a single barrier of woven fabric or similar device to separate the suspended solids from the water. Any failures in the integrate of the filter barrier will allow contamination to pass down stream into the irrigation systems resulting in plug age or obstruction of the water application device.

Sagi et al. (1995) explained that filters installed at the head of the drip irrigation systems to prevent emitter clogging were not effective in the case of colonial protozoa and sulfur bacteria, regardless of the filter type.

El-Bagoury (1998) reported that increasing size of suspended particles from 12 to 375 μm lead to increasing filtration efficiency from 90 to 97%, 80 to 94% and 70 to 90% at concentration of contamination 10, 250, and 750 PPM, respectively. The optimum duration between back washing was 3 hours based on lead drop of 5m with 15 PPM of contamination at discharge rates 9.5 m^3/h for river water. The duration can be increased to 10 hours daily by decreasing the filter inlet discharge rate to 3.5 m^3/h .

MATERIAL AND METHODS

Materials:

All apparatus and experiment were carried out in the Gezert El-Dahab and El-Harm for green houses in two different qualities' waters: surface and ground water, respectively. The first control head depends on the surface water in the irrigation and consists of centrifugal pump, sand filters, injection fertilizer pump, and screen filters with different mesh. The second control head depended on the ground water in the irrigation and consists of turbine pump; fertilizer injection pump and screen filter with different mesh. The specifications of two different pumps' units are used in two different locations (centrifugal and turbine pumps) as shown in Table (1). The two different filtration system units are used as shown in Table (2). The irrigation water supply was Nile water (surface water) and (well) groundwater and its analyses are shown in Table (3).

Table (1) The specification of engines of the pumping units used with different sources of water

Pump's Type	Source of Water	Engine Types	Pump Max. Head (m)	Pump Max. Discharge (m ³ /h)	Suction Pipe Diameter (inch)	Delivery Pipe Diameter (inch)	Industrial Country and Model	Date of Industrial	Power (hp & kW)	Engine Speed (r.p.m.)
Centrifugal	Surface	Diesel	40	50	3	3	China	1985	25 hp	2900
Turbine	Ground	Electrical	90	50	3	3	Egypt	1989	18 kW	2500

Table (2): Specification of the two filtration units

Specifications	Filtration unit
<u>1- Media filters</u>	
- Bed area (m ²)	0.565
- Recommended maximum flow rate (m ³ /h).	60
- Maximum pressure (bar).	10
- Filtration capacity (m ³ /h/m ²).	106.19
- Number of tanks.	2
- Inlet and outlet diameter (inch).	3
- Housing mm.	1000
- Tank diameter (mm).	600
- Wall thickness (mm).	5
- Thickness of media layers (mm).	600
- Back washing diameter (inch).	2
- Under drain types.	cylindrical
- Affective diameter of media (mm).	1
- Material of filters.	Stainless steel
- Painting material.	Epoxy
<u>2- Screen filters (mesh)</u>	
- Housing length (mm).	420
- Housing diameter (mm).	170
- Housing thickness (mm).	3
- Maximum discharge (m ³ /h).	40
- Maximum pressure (bar).	10
- Screen cartridge diameter (mm)	150
- Screen cartridge length.	420
- Number of mesh per linear (inch).	100, 120, 160, 200
- Material of housing.	Stainless steel
- Material of cartridge.	P.V.C.
- The hole diameter on the cartridge (mm).	10
- The distance between holes (mm).	10

Table (3): Chemical analysis of surface and ground water

Type of Water	p ^H	EC mmhos/cm	Anions (Meq/l)				Cations (meq/l)			
			Ca ⁺⁺	Mg ⁺⁺	Na ⁺	Ka ⁺	Cl ⁻	Co ³⁻	So ⁴⁻	Hco ³⁻
Surface	7.4	0.473	0.473	0.5	0.98	1.4	2.18	1.3	0.9	0.4
Ground	7.0	1.8	0.8	0.4	0.3	0.1	0.75	0.3	0.25	0.5

Methods:

The field measurements were carried out in two different locations in two different sources of water. The first experiment consists of two vertical media filters, connected parallel and followed with screen filters with different meshes (100 mesh, 120 mesh, 160 mesh, 200 mesh). The thickness of media inside each filter 60 cm. above the under drains arranged as follow from the top to the bottom according to El-Tantawy (1992):

Particle diameter (mm):	4	2	1	2	5
Media thickness (cm):	5	5	40	5	5

The types of local media are used as the same standard specification of the foreign one (red granite) according to the tests of El-Tantawy (1997). The second experiment system consists screen filters with different meshes (100 mesh, 120 mesh, 160 mesh, 200 mesh). The two filtration units were used for irrigation green houses. The conditions of the measurement in both experiments were same, where the operating pressure was 2.2 bar inlet pressure with 0.3 bar and 0.1 bar pressure loss through two filtration units at starting filtration process respectively. The volume of filtered water (m³), filtration cycles (hr) and mean flow rates (m³/h) were measured and estimated the time consumed to increase to pressure loss every 0.1 bar. One liter water samples were collected before and after screen filter at each 0.1 bar pressure loss to estimate the sediment's concentration in (mg./l.) in the two cases (150 mg./l in surface water and 40 mg./l in ground water) for calculating filtration efficiency (percentage) (E_f) in each collected screen filter. The back washing occurs when the pressure difference between inlet and outlet media filters 0.7 bar El-Tantawy 1997. The following equation was used for estimating (E_f).

* Filtration efficiency (%) (E_f)

$$(E_f) = (S_s - S_i / S_s) * 100 \quad (1)$$

where:

S_s = The sediment's concentration in the entrance of water (mg./l).

S_i = The sediment's concentration in the filtered water (mg./l).

- The back washing process was carried out at pressure at 1.0 bar for each sample. This process continues from 8-12 min for each case.

A group of indicators was taken to indicate the field evaluation of each selected local screen filters and also to arrange it according to its priority of use. These indicators are represented with the following equations:

* Pressure loss (bar) (P)

$$P = P_i - P_o \quad (2)$$

where:

P_i = average pressure before screen filters (bar).

P_o = average pressure after screen filters (bar).

* Flow rate (m³/h) (q)

$$q = V_f / T \quad (3)$$

where:

V_f = volume of water passing through filtration unit (m³).

T = filtration cycle (h).

* Flow rate reduction percentage (Qr)

$$Qr = (Q_s - Q_i / Q_s) * 100 \quad (4)$$

where:

Q_s = Flow rate at the start (m³/h).

Q_i = Flow rate at any time (m³/h).

* Filtration capacity (m³/h/m²) (Fc)

$$F_c = Q / A \quad (5)$$

where:

Q = Flow rate passed through filters (m³/h).

A = Filtration bed area (m²).

* Time consumed for cubic meter filtering (min./m³) (T)

$$T = (1 / Q) * 60 \quad (6)$$

* Filtration cycle (h)

The time consumed between two excessive back cleaning process (h.).

* Filtration costs

The economic study of selected local screen filter was necessary. The gained satisfaction about technical results should be accompanied with economic study. This study required the following items.

- 1- Price of housing (L.E.)
- 2- Price of cartridge (L.E.)
- 3- The operating age (h.)
- 4- The filtered water during the operating age (m^3/h)
- 5- Maintenance requirements during operating age (L.E./h.)

To compare between the different selected local screen filters and the foreign one economically, the following indicators were considered:

Cost of filtration cubic meter (Piaster)

$$\text{Cost of filtration} = \text{Total operation age (h)} * \text{Mean flow rate (m}^3/\text{h)} * \text{Price of screen filter (L.E.)} \quad (7)$$

where:

Annual operation age (h.) = Daily operation (8 h.) * Number of operation days per year (350 days) = 2800 h./year, assume 15 days for maintenance.

Total operation time (h.) = Annual operation (h./year) * Operation age (years).

Assume operation age three and five years for local and imported one, respectively.

RESULTS AND DISCUSSION

The main objective of field engineering tests are for measuring and evaluating the performance the selected four screen filters (100 mesh, 120 mesh, 160 mesh, 200 mesh). The tests include the filtration cycle, flow rate reduction percentage, pressure loss, time consumed for filtering cubic water meter, mean flow rate, and filtration efficiency. All the measurements were done during field operation. The pressure loss through two filtration units 0.3 bar and 0.1 bar after back washing at the inlet. If the pressure loss is increasing to 0.7 bar and 0.4 bar the filtration unit needs to cleaning, then the back-washing process must be started by reversing the direction of water through the filters and by passing the effluent. The results of field tests can be summarized as shown in Figs. (1 to 8) and Tables (4 & 5) and are as follows:

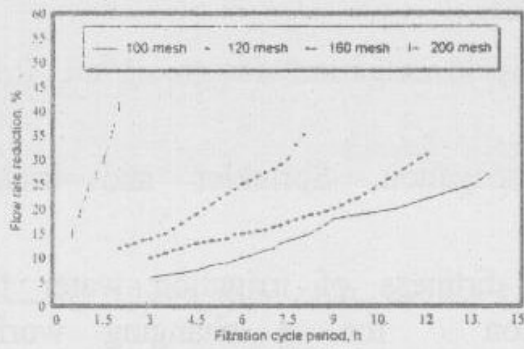


Fig.(1): The relationship between filtration cycle and flow rate reduction % with surface water.

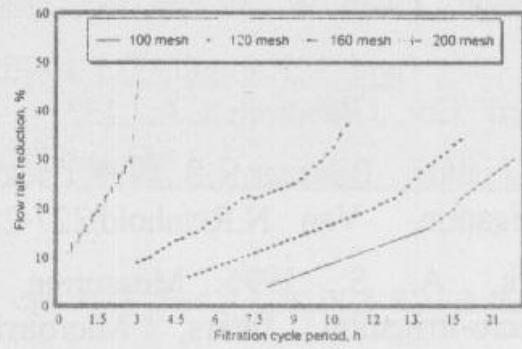


Fig.(2): The relationship between filtration cycle and flow rate reduction % with ground water.

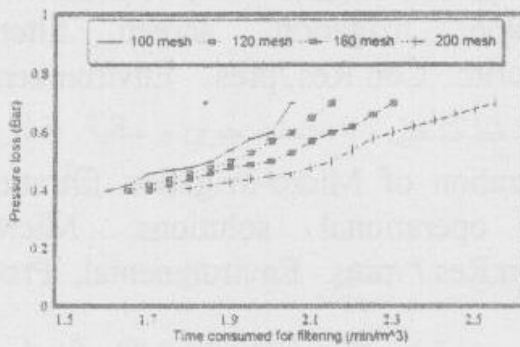


Fig.(3): The relationship between the time consumed for filtering cubic meter and pressure loss with surface water.

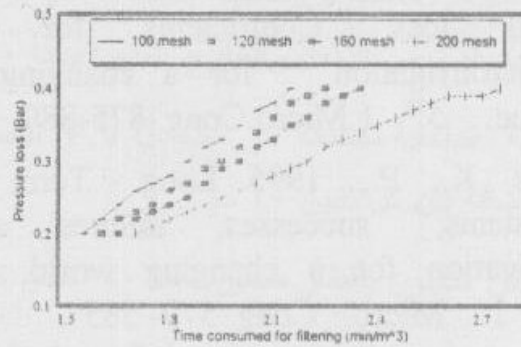


Fig.(4): The relationship between the time consumed for filtering cubic meter and pressure loss with ground water.

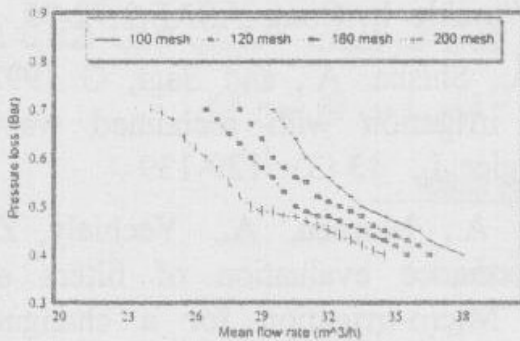


Fig.(5): The relationship between mean flow rate and pressure loss with surface water.

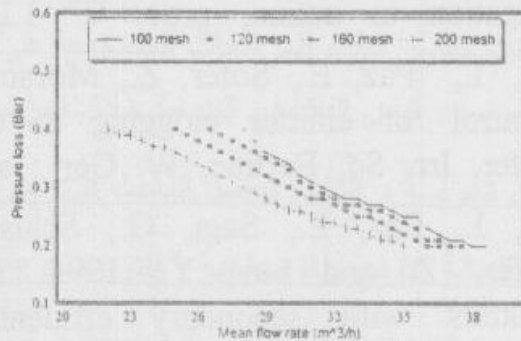


Fig.(6): The relationship between mean flow rate and pressure loss with ground water.

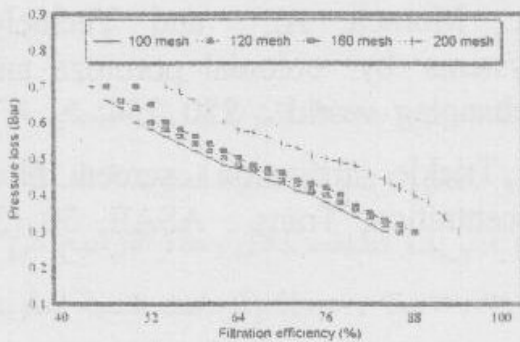


Fig.(7): The relationship between filtration efficiency and pressure loss with surface water.

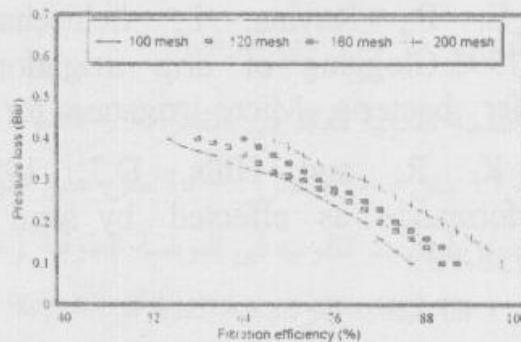


Fig.(8): The relationship between filtration efficiency and pressure loss with ground water.

Table (4): Evaluation of the screen filters tested with surface water under different pressure loss

No	Screen Mesh	Filtration Cycle (h)		Time Consumed for Filtering m ³ (min./m ³)		Flow Rate Reduction (%)		Filtration Efficiency (%)	
		0.4 bar	0.7 bar	0.4 bar	0.7 bar	0.4 bar	0.7 bar	0.3 bar	0.7 bar
1	100	3	14	1.6	2.06	6	27	85	45
2	120	3	12	1.67	2.17	10	31	87	48
3	160	2	8	1.7	2.31	12	35	92	53
4	200	0.5	2	1.76	2.54	15	41	98	55

Table (5): Evaluation of the screen filters tested with ground water under different pressure loss

No	Screen Mesh	Filtration Cycle (h)		Time Consumed for Filtering m ³ (min./m ³)		Flow Rate Reduction (%)		Filtration Efficiency (%)	
		0.2 bar	0.4 bar	0.2 bar	0.4 bar	0.2 bar	0.4 bar	0.1 bar	0.4 bar
1	100	8	24	1.56	2.14	4	30	87	55
2	120	5	16	1.6	2.27	6	34	90	58
3	160	3	11	1.65	2.34	9	37	94	64
4	200	0.5	3	1.7	2.73	12	45	98	68

- The present study succeeded to prove the possibility of using local screen filters in pressurized irrigation system in Egypt where the pressure loss through filtration units at starting time 0.3 bar and 0.1 bar under surface and ground water respectfully as follow:
- The time consumed for filtering cubic meter through four local screens filters types (100 mesh, 120 mesh, 160 mesh, 200 mesh) differs at starting filtration process under different two different qualities of water 9%, 8% surface and ground respectively.
- The flow rate reduction percentages of filtration units with surface water and ground water types were equal at the beginning and their value was almost zero.
- The filtration cycle in both two filtration units with local screen filters types were 3 h, 3 h, 2 h, 0.5 h, with surface water and 8 h, 5 h, 3 h, 0.5 h. for screen filters 100 mesh, 120 mesh, 160 mesh, 200 mesh respectfully. The reduction in the filtration cycle means high filtration efficiency.
- The filtration efficiencies of the filtration unit with surface water through screen filter 100 mesh decreased 13% from screen filter 200 mesh, while the screen filters 100 mesh with ground water decreased to 11% from 200 mesh respectively.

- At the pressure loss of 0.7 bar, with surface water, in case of screen filters 100, 120 mesh the filtration cycle is long (14 h, 12 h), time consumed for filtering m^3 of water is less (2.06 & 2.17 min./ m^3), the flow rate reduction % is low (27% & 31%) and the filtration efficiency is (lower 45% & 48%) respectfully. The otherwise in case of screen filters 160 & 200 mesh the filtration cycle is low (8 h. & 2 h.), Time consumed for filtering m^3 is high (2.31 & 2.54 min./ m^3), flow rate reduction % is high (35% & 41%) and filtration efficiency is high (53% & 55%) respectively, so we recommend used to filtration unit with screen filter 160 mesh because the filtration efficiency is higher than 50%.
- At the pressure loss of 0.4 bar, with ground water (less sedimentation in the water), in case of screen filters 100, 120 mesh the filtration cycle is long (24 h., & 12 h.). Time consumed for filtering m^3 of water is less (2.14 & 2.27 min./ m^3), the flow rate reduction percentage is low (30% & 34%) and the filtration efficiency is (lower 55% & 58%) respectively . The otherwise in case of screen filters 160& 200 mesh the filtration cycle is low (24 h. & 16 h.), time consumed for filtering m^3 is high (2.34 & 2.73 min./ m^3), flow rate reduction % is high (37% & 45 %) and filtration efficiency is high (64% & 68 %) respectively, so we recommend the utilization of filtration unit with screen filter 100 mesh because the filtration Efficiency is higher than 50% and less following cleaning process.
- The costs of local material for screen filters are lower than the foreign types for different diameters are less than 60%.

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