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Effect of flushing frequency and filtration in emitters clogging

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ABSTRACT : Clogging of emitters is one of the most important aspect that affects the performance of micro irrigation systems. Emitters clogging may be due to poor quality of water that is being used or may be due to inadequate pressure under which the system in operation or precipitates resulting during the fertigation process or improper functioning of filtration units that are installed in the system. Inorder to have emitters free from clogging frequent flushing of the entire micro irrigation systems is essential. Apart from this the back flushing or cleaning of different filtration units installed in the system by monitoring the pressure drop is also needs to be flowed. Studies also indicated that continuous monitoring of emitter flow and operation of the drip irrigation system at 100 kPa (1 kg/cm^2) pressure are essential for early detection of clogging problems and for identifying the flushing frequency. As the micro irrigation systems are gaining popularity in India a review of studies carried out on the flushing frequency of emitter and filtration units is presented in this paper.

KEY WORDS : Emitters, Flushing, Filtration, Frequency, Flow velocities

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Micro irrigation systems have many advantages over other conventional irrigation systems. One of the major challenges in these systems is to keep emitters free from clogging. The causative factors for emitter clogging could be due to physical particles, biological agents and chemical composition of water. The most common physical causes of clogging of drip emitters are sand particles, which are usually found in surface water (Fig. 1). Other suspended solids may be too large to pass through the emitter's opening and might clog it. Under certain conditions, silt-sized particles can form larger aggregates that may cause clogging. Drip irrigation systems provide a favorable environment for bacteria, fungi and algae that can cause slime accumulation. Bacterial slime can be a direct cause for clogging of drippers, but it can also induce mineral particles to stick together and form aggregates large enough to clog the emitter openings.

This phenomenon is specifically significant when manganese, sulphide and iron are present in the water. Water that contain high levels of these elements, and have a pH above 7.0, might potentially cause clogging of drip emitters. Presently, drip irrigation system is being used for application of fertilizers along with the irrigation also. Due to interaction of the fertilizers with the chemical compounds present in water, the solubility of the fertilizers are effected, resulting in clogging of emitters. Common guidelines used to assess the clogging potential of drip emitters are presented in Table 1.

Emitter clogging problems and frequency of flushing:

With the decreasing good quality water resources for irrigation, there is an increasing trend toward the use of marginal waters which are either stored from storm runoff, treated sewage effluents etc. Emitter clogging hazards are a major concern in selecting drip irrigation systems for use with marginal waters. Reservoir waters contain a variety of phytoplankton and zooplankton, that develop during storage according to the specific conditions prevailing in the reservoir. Suspended particles, which can agglomerate with filaments, slimy or otherwise sticky by-products of microbial activity, are also abundant, especially in earthen reservoirs (Adin, 1987; Ravina *et al.*, 1992). Most clogging factors can be found in the wastewater effluents if used in drip irrigation systems without from care in operation and maintenance of the system. There are also aquatic organisms that can grow and proliferate with in the pipe line system and, in certain circumstances, develop into a biomass that can clog almost any component of the drip irrigation system (Nakayama and Bucks, 1991). Such problems might be intensified by longer supply lines and slower stream velocities (Ravina *et al.*, 1992). Emitter

Fig. 1 : Sediment deposition in CNB-3

Table 1 : Guidelines to assess the clogging potential of drip emitters

Constituent	Level of concern		
	Low	Medium	High
pH	< 7.0	7.0 – 8.0	> 8.0
Iron, mg/l	< 0.2	0.2-1.5	> 1.5
Manganese, mg/l	< 0.1	0.1 – 1.5	> 1.5
Hydrogen sulphide, mg/l	< 0.2	0.2-2.0	> 2.0
Total dissolved solids, g/l	< 500	500-2000	> 2000
Total suspended solids, mg/l	< 50	50 –100	> 100
Bacteria count (no./ml)	<10,000	10,000-50,000	>50,000

Source: Pitts *et al.* (2003)

clogging, which is formed in a short time due to irrigation systems' running under an inadequate pressure or owing to water quality, not only negatively influences uniformity of water distribution but also causes inadequate irrigation (Yavuz *et al.*, 2010).

The type of the emitter, its location along the lateral, quality of water, operating pressure, type of filtration system and flushing frequency generally affect emitter clogging. Emitter clogging is directly related to irrigation water quality, which appears a function of the amount of suspended solids, chemical constituents of water and micro organism activities in water (Gilbert *et al.*, 1979). During irrigation some clogging due to micro organism activities take place in cases when wastewater is used (Ravina *et al.*, 1997; Capra and Scicolone, 2004, 2007; Ould Ahmed *et al.*, 2007). In locations where the amount of the ingredients as dissolved calcium, bicarbonate, iron, manganese and magnesium are excessive in irrigation water, the emitters are clogged by the precipitation of these solutes (Gilbert *et al.*, 1979; Hills *et al.*, 1989).

Puig-Bargues *et al.* (2010) studied the effect of flushing frequency on emitter clogging in micro irrigation with effluents. Three flushing frequency treatments (no flushing, one flushing at the end of each irrigation period and a monthly flushing during the irrigation period) was studied in surface and sub surface drip irrigation systems that operated using a wastewater treatment plant effluent for three irrigation periods of 540 hours each. The irrigation systems had two different emitters, one pressure compensating and the other not, both placed in laterals 87 meters long. The study indicated that the emitter discharge of the pressure compensating (PC) emitter did not vary along the lateral significantly. However, in the non pressure compensating (NPC) emitter, average emitter discharge was smaller at the beginning and at the end of the laterals, where more totally clogged emitters were found. Emitter clogging was greater when no drip line flushing was carried out. However, no significant differences were observed between flushing intervals carried out at a velocity of 0.6 m/s. The PC emitter performed similarly in surface and subsurface drip irrigation systems, but the NPC emitter was more prone to be clogged when it was used with subsurface drip irrigation with an average of 4 per cent of emitters completely clogged. The main cause of clogging was bio-film formation. The study concluded that flushing at a flushing velocity of 0.6 m/s was adequate when it was performed monthly or only at the end of the irrigation season even when municipal tertiary effluents are used in drip irrigation (Table 2).

A study was conducted by Dehghanisanij *et al.* (2004) to assess the impact of Biological Clogging Agents (BCA) induced changes on water discharge rate and distribution uniformity from i) emitters with different water flow Cross Section Area (CS), Pressure Compensation (PC) systems and inbuilt Filtration Areas (FA), and ii) filters either made of urethane, sand or disc. The emitter discharge rate increased with increasing CS, FA and working pressure and decreased when the emitters were on-line and with increasing BCA counts. Because BCAs are the only dynamic variable the study

Table 2 : Pressure uniformity (U_p) and distribution uniformity (DU) for each emitter type in the surface and subsurface irrigation units at the end of irrigation periods

Emitter	Flushing frequency	Surface								Subsurface	
		0 h		540 h		1080 h		1620 h		1620 h	
		U_p	DU	U_p	DU	U_p	DU	U_p	DU	U_p	DU
PC	No flushing	99.8	95.1	99.9	94.2	99.8	83.2	99.8	76.0	99.7	54.0
	Seasonal	99.8	94.3	99.9	93.0	99.8	91.7	99.6	95.1	99.7	80.1
	Monthly	99.8	94.3	99.9	96.0	99.8	94.0	99.8	84.5	99.7	87.7
NPC	No flushing	98.5	96.5	98.8	96.3	98.1	86.2	97.9	67.8	97.3	24.3
	Seasonal	98.0	97.0	98.8	96.3	97.9	96.5	97.9	87.1	97.6	47.0
	Monthly	98.3	95.1	98.6	95.5	98.1	89.9	98.0	93.9	97.5	69.4

Source: Puig-Bargues *et.al.* (2010)

concluded that BCA induced clogging is a major issue when filters were not installed in field irrigation lines. The filter performance assessment based on the number of backwashing required to restore the working pressure to the recommended level indicated that BCA filtering by the sand filter was highest, followed by disc and urethane, respectively.

Ravina *et al.* (1997) concluded in their study that emitter and filter clogging hazards are associated mainly with mucous products of microbial activity when using reclaimed waters. They recommended to use a 80 mesh (175 micron) filter for the secondary downstream safety filters when such waters are being used in drip irrigation systems. The study also indicated that flushing of the drip laterals once every two weeks was found to be quite satisfactory when using stored effluent. It was suggested that close monitoring of pressures and flow rates in the filters and drip laterals is most important aspect when water of sewage origin is used in irrigation for detecting early clogging problems.

Emitter clogging and effects on drip irrigation systems performance was studied by Yavuz *et al.* (2010). Laboratory test results indicated that about 16 per cent of 3 year used emitters do not have any flow under operating pressure of 100 kPa. Emitters must be flushed by reducing pH of the irrigation water before or after each irrigation season. Inorder to prevent any precipitation due to acid used for flushing, the Ca and Na contents of irrigation water must be taken into consideration. They concluded that continuous monitoring of emitter flow and operation of the drip irrigation system at 100 kPa pressure are essential for early detection of clogging problems and for identifying the flushing frequency.

Biological clogging of six emitters working for 1000 hours with different effluents with low suspended solid levels was studied by Duran-Ros *et al.* (2009). The study indicated that emitter clogging was affected mainly by emitter type, location along the lateral and interaction between these two factors. Emitter placed after disc filters had the smallest flow rates, and those protected by screen and sand filters the largest. However, only sand filtration significantly reduced turbidity and suspended solids in the two effluents used.

The frequency of flushing depends on the amount of debris removed. In some systems, the water quality is very good, and only very small amounts of debris are found. In those cases, only infrequent flushing (weekly, bi-weekly, or monthly) flushing is required. Pipelines should be flushed at least once a month during irrigation season (Boman, 2011). In other systems, a large amount of debris accumulates in the pipelines each time the irrigation system operates. An example is systems that use pond water containing large amounts of suspended algae, clay and silt particles. In those cases, it may be necessary to flush laterals during each irrigation, using automatic flush valves. For permanent irrigation system installations, systems may be idle for weeks or months at a time during off-seasons or in rainy months when irrigation is not required. It is a good idea to start these systems and flush them every four to six weeks even when irrigation is not required. The potential for system plugging is typically highest when hot, humid climate conditions favour bacterial and algae growth in pipelines. Operating and flushing the system during these times (even though irrigation is not necessary for plant growth) can help remove plugging sources before they accumulate to the point that large chemical shock treatments are required to reclaim the system. The duration of flushing depends on many factors, especially the water quality and system design. Before a system is installed, it is difficult to accurately estimate the time required to adequately flush a pipeline. Fortunately, in the field, it is simple to determine when a system is adequately flushed. Flushing should occur until the water discharged runs clean. This normally only requires a short time a minute or two because the debris mainly accumulates at the end of the pipeline near the flush valve. Depending on the system, design, amount and type of debris, and the flushing velocity, longer times may be required for some systems. For proper flushing to occur, the discharge velocity must be high enough to both dislodge and transport particulate matter from the pipelines. Researchers who have studied this problem do not all agree on the exact minimum velocity needed, however, a minimum velocity of 0.3 m/s is recommended in the ASAE national micro irrigation standards (ASAE, 1998). Other researchers recommend a minimum velocity of 0.6 m/s, especially where larger particle sizes need to be discharged. The 0.6 m/s minimum velocity is often recommended for micro-sprinkler systems where coarser filters than those required for drip emitters are used. These coarser filters (due to the large micro-sprinkler orifice sizes) allow larger particles to enter the system with the irrigation water, and therefore, require higher flushing velocities. In general, flushing velocity should be as high as possible in order to

Table 3 : Minimum flow velocities required for flushing of micro irrigation laterals, submain and mains

Sr. No.	Pipe size, mm	Required flow rate (lps) for 0.3 m/s
1.	13	0.06
2.	19	0.11
3.	25	0.17
4.	32	0.30
5.	38	0.40
6.	51	0.76
7.	64	1.07
8.	76	1.64
9.	102	2.65
10.	152	5.80
11.	203	9.77

Source: Boman, 2011

dislodge and transport as many particles as possible, but never less than 0.3 m/s. Higher flushing velocities will aid particle removal and shorten the flushing time needed. It is rarely possible to flush all laterals at once because sufficient velocity will not be available for all laterals. Rather, open only a few flush valves at once, allow them to operate, and then close them before moving to the next valves. Flushing order is manifolds first, and then the laterals served by the manifolds that have just been cleaned. Table 3 indicates the adequate flushing velocity that is being obtained for the polyvinyl chloride (PVC) pipes commonly used for micro irrigation manifolds and laterals. Because velocities are difficult to measure in the field, this table shows flow rates that will produce 0.3 m/s in commonly used pipe sizes. These flow rates should be doubled to 0.6 m/s for micro-sprinkler irrigation systems or other systems where larger particle sizes must be flushed.

Conclusion :

Clogging of various components influences the performance of micro-irrigation systems. The clogging can be by a variety of reasons. Recognizing this, needs a comprehensive management on each of the activity involved in the system *i.e.*, quality of water, filtration units, type of emitters, location of emitters, chemical water treatment, types of chemicals injected into the system, flow rates, flow velocities, and routine pipeline flushing. Therefore, addressing the issue of emitter clogging can't be looked in isolation. The frequency of flushing of the whole system depends on the amount of material that is to be removed. When water quality is poor, flushing may be required with each irrigation depending upon the filtration systems adopted. It is recommended to use sand filter as well as screen filter if wastewaters are recycled through MIS. When the flow velocities are lower than the recommended the flushing frequency increases. The type of emitter and their location on the lateral line also influences the flushing frequency. The pressure compensated emitters need less frequent flushing as compared to non pressure compensated. Studies also indicated that continuous monitoring of emitter flow and operation of the drip irrigation system at 100 kPa (1 kg/cm^2) pressure are essential for early detection of clogging problems and for identifying the flushing frequency

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