EFFECTS OF SDI FILTRATION ON WASTEWATER QUALITY FOR IRRIGATION

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ABSTRACT

In order to assessment of SDI system application in the condition of wastewater reuse, three treatments with three replications were design. These treatments included check treatment with drinking water (CH), surface drip irrigation with wastewater (DI) and subsurface drip irrigation with wastewater (SDI). In addition, before pipeline, a SDI filtration designed to improve biological index of wastewater. The results of this research showed that the BOD_5, TSS and nitrogen component decreased during filtration acceptably. But the microbiological factors didn't improve completely. In this condition, injection of wastewater below the soil surface (SDI system) could decrease the surface microbiological pollution significantly as compare to CH. In concluded the SDI system recommended in the wastewater reuse condition and application of new system of drilling considered for installing, monitoring and maintenance of SDI.

INTRODUCTION

Drip irrigation applies water both precisely and uniformly, in comparison with furrow and sprinkler irrigation, resulting in the potential to reduce subsurface drainage, control soil salinity, and increase yield (Henson & May, 2004). Subsurface drip irrigation (SDI) is a kind of drip irrigation which is defined by ASAE S526.1 "Soil and Water Terminology" (ASAE, 1999) as "application of water below the soil surface through emitters, with discharge rates generally in the same range as drip irrigation". Figure 1 shows the SDI system. A large number of studies have been presented about this system during the last 10 years. These studies show that SDI has advantages include improved water and nutrient management, potential for improved yields and crop quality, greater control over applied water resulting in less water and nutrient loss through deep percolation, and reduced total water requirements (Ayers et al., 1999).

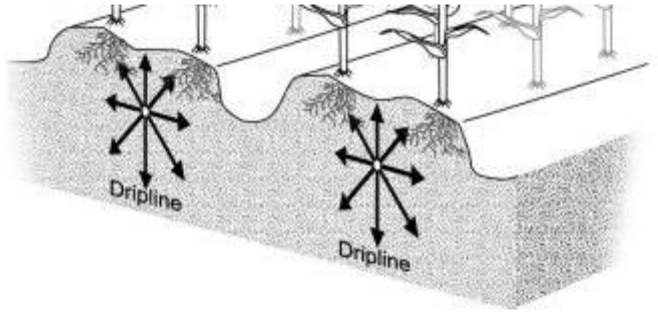

Figure 1. Subsurface drip irrigation (K. State University, 2006)

Filtration of water in a SDI system is shown to improve the water quality with regards to health concerns. Piluk (1995) showed that filtration with a 1 to 6 mm diameter sand filter and a discharge of 244-406 $Lm^{-2}d^{-1}$ produced the best result in comparison to the other filter diameters and discharge rates for decreasing the bacterial index in wastewater. With a 610-910 mm thickness for the mentioned filter, the total nitrogen (TN) decreased to 75% (Piluk 1995). Venhuizen (1996) showed that use of a sand filter with 1.04 mm effective diameter and a discharge of 561.5 $Lm^{-2}d^{-1}$ decreased BOD_5 in wastewater by 96 percent. Geoflow Institute (2000) advises a filter with a 0.1 mm diameter for the BOD_5 to be below 25 mg/l. Regard to the number of emitters per unit area, Ruskin (2000) showed that using one emitter with a discharge rate 43 $Lm^{-2}d^{-1}$ was suitable where there is heavy soil and with a BOD_5 less than 30 mg/l.

MATERIAL AND METHODS

The southern sewage treatment plant of Isfahan, Iran, treats sewage of approximately 800,000 people per day. Most of the treated effluent flows into the Zayandehrood River and a smaller amount is used for irrigation of suburban farms and gardens. The treatment plant uses a fully completed activated sludge and secondary treatment processes.

For research purposes, a plot was selected in the vicinity of the treatment plant such that the treated wastewater was accessible when needed. A small drip-irrigation pumping station was designed and connected to the outlet of a wastewater sump (Fig. 2). The subsurface drip irrigation filtration system included a sand filter and a screen filter. The sand filter contained two layers of fine and medium sands; the upper-layer sands had an effective diameter of 0.5 mm and a thickness of 60 cm, and the lower layer had an effective diameter of 1 mm and a thickness of 30 cm.

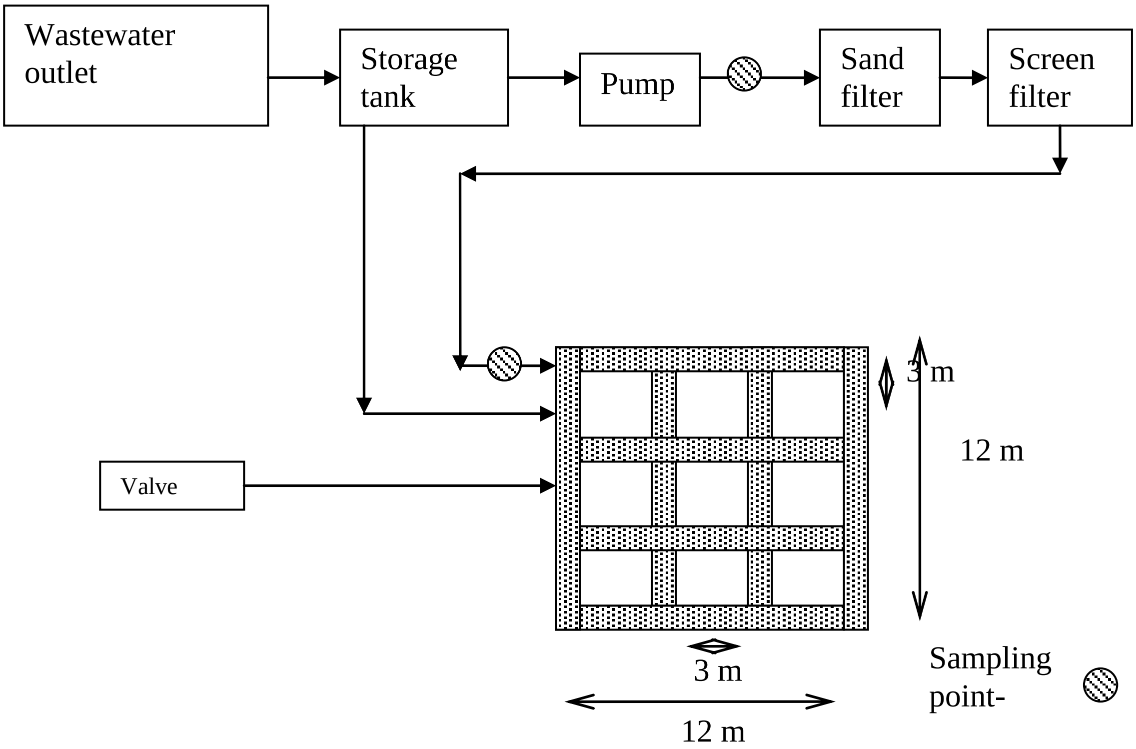

Figure 2. Setup of the field experiment

The screen filter is cascaded with a 100 micron (150 meshes) steel screen placed after the sand filter. System outflow was regulated for a 2.5 m^3 hr^{-1} m^{-2} and 4.7 drippers m^{-2}. After SDI filtration a study field was design with three treatments by three replications in 3 m x 3 m (9 m^2) plots during the winter of 2003. The treatments were included check treatment with drinking water (CH), SDI system in depth of 30 cm with wastewater (SDI) and surface drip irrigation with wastewater at the soil surface (DI). The experiment was conducted for 12 months.

Wastewater samples were collected at the end of each month. For the drip irrigation systems (DI and SDI) the samples were taken both before and after of the process of filtration (Fig. 2). All wastewater samples were analyzed immediately after sampling. Properties determined were; five day biological oxygen demand (BOD_5), total suspended solids (TSS), nitrate-N (NO3-N), nitrogen of ammonium-N (NH_4-N), total nitrogen (TN), total bacterial count (TBC), total number of coliform (TC), number of fecal coliform (FC), and number of nematodes (NE). Standard methods of wastewater analysis were performed according to APHA (1995).

Soil surface samples from the 0-5 cm depth were collected immediately after the final irrigation at the end of each month. Samples from the soil’s surface (0-5 cm) were analyzed for; total number of coliforms (TC) and fecal coliforms (FC).

RESULTS AND DISCUSSION

The results of this research showed that the averages of BOD_5 were estimated about 34.6 and 15.3 mg/l before and after SDI filtration respectively. US-EPA (1992) presented 30 and 10 mg/l as two level standards for industrial and salad (uncooked) crops. Based on this recommendation and Fig. 3, 66.7 percent of samples before SDI filtration were been more than EPA standard level of industrial crops. SDI filtration caused to decrease the BOD_5 of all samples less than the first standard level. The average and standard deviation of removal efficiency of SDI filtration was estimated about 54.6 percent and 14.7, respectively. Therefore the SDI filtration could improve the effluent for industrial crops irrigation.

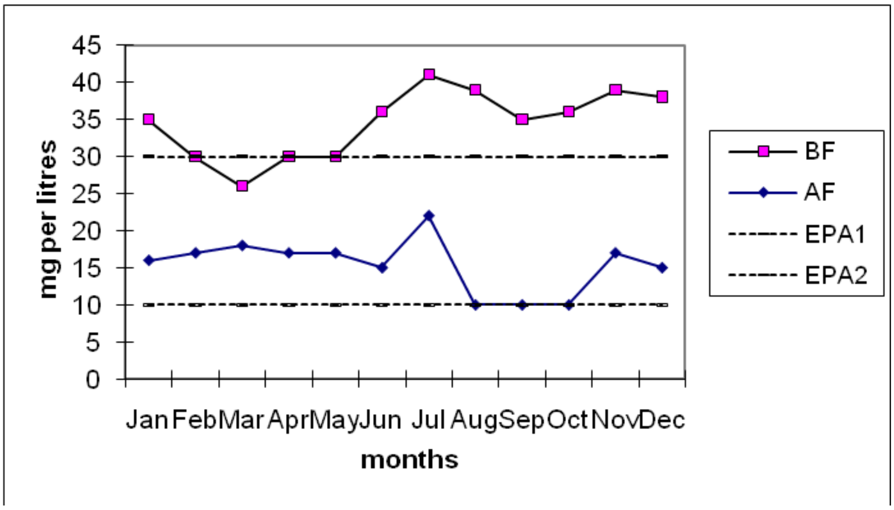

Figure 3. BOD_5 variation before and after SDI filtration

US-EPA (1992) recommaded that the total suspended solides (TSS) must be 30 mg/l or less before application wastewater for irrigation of agricultural crops. The TSS analysis of the samples of this research through the study showed that all of the TSS values were more than the permitted level of EPA. The results showed that SDI filtration caused to decrese 44 pecent of TSS, therefore TSS reached about the EPA recammandation in most of months. The rang of removal efficancy of TSS were between 13 and 65 percent and it depends to backwash performance and volume of suspended solides during the filtration. Because of inflow TSS variable, constant period for backwash performance caused different rang for RE and outflow TSS. Inaddition didn't obsereve any clogging in the emitters. Figure 3 shows the variation of TSS before and after filtration during the research.

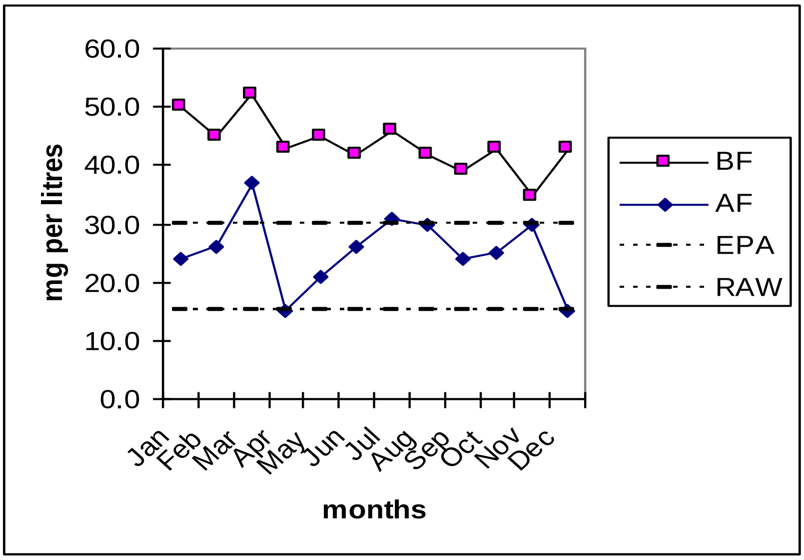

Figure 4. TSS variation before and after SDI filtration

Table 1 shows the nitrogen component of wastewater before and after filtration. Based on this table the removal efficiency of total nitrogen was about 44 percent. The average of nitrogen of ammonium estimated 29 mg/l before filtration while 82 percent of this parameter removed during the filtration. The BF value of NH4 was more than FAO standard level for sensitive plants. In this condition, the effects of SDI filtration caused to decrease this value less than standard level. In this study, nitrogen concentration had low level value and it was less of permitted value.

Table 1. Effects of SDI filtration on Nitrogen component

Satuation	Parameters	NO3	NH4	TN
BF	Ave	1.28	29.16	60.3
	Rang	1.1-1.5	21-35	51-75.4
	Stdv	0.19	6.5	10.7
AF	Ave	0.61	4.6	33.9
	Rang	0.55-0.8	3.7-6.5	27-44
	Stdv	0.13	1.3	7.3
RE	Ave	53	82	44.1
	Rang	48-55	82-84	41.6-47
	Stdv	3.1	0.7	2.3
Standards	Rowe-A	5	50	60
	Rowe-B	10	50	70
	FAO-1	5	5	-
	FAO-2	30	30	-

Biological pollution is one of the main problems in the condition of wastewater reuse for agriculture. The analysis of samples showed that the all of index microbiological values were more than standard values. The averages of removal efficiency of SDI filtration on total bacterial count (TBC), total coliform (TC), fecal coliform (FC) and nematods were estimated about 98.9, 97.6, 93.2 and 55.6 percent, recpectively (Table 2). But the application of SDI filtration couldn't improve these factors completely.

Table 2. Effects of SDI filtration on microbilogical index of wastewater

Satuation	Parameters	TBC	TC	FC	NE
BF	Ave	$8.6*10^6$	$4.6*10^6$	$3.4*10^4$	3.5
	Rang	$6.9*10^6$-$1.1*10^7$	$3.4*10^6$-$6.2*10^6$	$2.7*10^6$-$4.6*10^6$	0-6
	Stdv	$1.8*10^6$	$1.1*10^6$	$8.4*10^3$	2.5
AF	Ave	$9.3*10^4$	$1.1*10^5$	$2.3*10^3$	1.5
	Rang	$7.4*10^4$-$1.3*10^5$	$8.8*10^4$-$1.5*10^5$	$1.8*10^3$-$3.2*10^3$	0-3
	Stdv	$2.3*10^4$	$3.1*10^4$	$6.5*10^2$	1.3
RE	Ave	98.9	97.6	93.2	55.6
	Rang	98.87-98.98	97.4-97.8	92.9-93.6	50-66
	Stdv	0.04	0.18	0.26	9.6
Standards	Nakayama	10^4	-	-	-
	WHO	-	-	1000	1
	EPA	-	-	200	0

Tables 3 and 4 show the average values of total coliform and fecal coliform of soil surface. According these tables, although the SDI filtration didn't improve microbiological carefully, but application of SDI system in 30 cm below the soil decreased soil surface pollution significantly. The results showed that the TC and FC of SDI had different significant as compare to DI at 5 percent level.

Table 3. Average values of total coliform in the 0-5 cm soil depth

Treatment	First sampling	Second sampling	average
CH	10^7	$2*10^5$	(a)$6*10^6$
DI	10^{11}	$2*10^6$	(b)$6*10^{10}$
SDI	$7*10^5$	$3*10^5$	(a)$5*10^5$

Table 4. Average values of total coliform in the 0-5 cm soil depth

Treatment	First sampling	Second sampling	average
CH	$3*10^4$	$1*10^3$	(a)$1*10^4$
DI	$2*10^{10}$	$2*10^5$	(b)10^{10}
SDI	$4*10^4$	$2*10^3$	(a)$2*10^4$

In conclusion application of SDI can decrease the wastewater reuse problems. This system is suitable for irrigation of landscapes, agricultural farms and gardens by wastewater. In this method, it is very important to injection wastewater through the root zone area to improve to improve the wastewater quality with regards to health concerns, therefore installing, monitoring and maintenance of SDI system need to use new drilling system such as trenchless technology.

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