JOURNAL OF PURE AND APPLIED MICROBIOLOGY, Sept. 2015. Vol. **9**(3), p. 1987-1992

Investigation of Effects of Irrigation Thorough Wastewater on Coliform Accumulation and Anions Leaching Concentrations

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(Received: 06 April 2015; accepted: 19 August 2015)

Water scarcity is one of the major restrictions for agricultural activities. This study was carried out to investigate the effect of wastewater on the soil quality features in the Islamic Azad University Branch khorasgan in four treatments with three replications in 2014. Four irrigation treatments include furrow irrigation with normal water (FN), furrow irrigation with wastewater (FW), surface drip irrigation with wastewater (DI), subsurface drip irrigation with wastewater (SDI), respectively. Soil samples were taken from four depths (zero to 15, 15 to 30, 30 to 45 and 45 to 60 cm) in two stages, before and after treatment. The use of wastewater will increase the electrical conductivity of the soil. The results showed that the soil Electrical Conductivity increases, and there is a statistically significant difference between treatments at a depth of 15 cm. There is a significant difference at a depth 15 cm about concentration of chloride and sulfate as well. Although the total amount of Coilform and Coliform is higher than the allowable threshold, the use of SDI treatment has greatly reduced the value of these parameters in the topsoil severely. In contrast, the values of these two parameters increased significantly FW and DI irrigation

Key words: Chloride, Coliform, Drip Irrigation, Furrow Irrigation, Sulfate, Wastewater.

Urban wastewater is the most common renewable source to compensate for water shortages and it has been used for a long time, especially for irrigation in agriculture. The amount of water consumption allocated to itself the highest share among all uses in agriculture. Water scarcity has reached the crisis condition in many parts of the country[1]. In fact, the use of wastewater for irrigation is dependent on irrigation. It should be noted that the method used should have the lowest risk to the health of workers and the environment in the choice of irrigation method[2].Tabatabai *et al*. (2009) reported an increase in salinity and sodium adsorption ratio of leaching was found at a depth of 60 cm and in the furrows, because of the depth of 90 cm leaching that is not consistent with the results of this study in investigation of the irrigation effect with treated urban wastewater on soil properties in arid and semi-arid climate [3]. Oron *et al*. (1999) showed that the drip method has less problems associated with the use of wastewater irrigation of agricultural products[4]. Nasr and Najafi (2009) results indicated that FW irrigation had the most anions and cations while in SDI have minimum anions and cations in comparison with other treatments[5]. Pedrero and Alarcon (2009) found mix of reclaim wastewater and well water

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had more microbiological quality and also showed that cause to increased salinity (SO_4, NO_3, PO_4, Cl and HCO_3) in the soil[6]. Gatta *et al*. (2015) soil microbial community samples substantially stated that varied between the two water treatments. These data show that while fecal indicators are not modified, the community compound and dynamics of the total bacterial population in soil is induced by the diverse state of these waters used for irrigation[7]. Al-Jaboobi *et al*., (2014) reported that irrigation with wastewater led to significance increase of SO_4, Cl and HCO_3 in comparison with water normal[8]. Kumar and Chopra (2010) in examination, effect sugar mill effluent on chemical soil, showed that increase Cl, SO_4,-CO_3,-HCO_3-and-NO_3-soil[9]. Drip irrigation system has the highest efficiency in irrigation with waste water among the different ways. But the limiting factor of this system is the suspended solids and organic waste, which leads to blockage of the emitters and filter and thus it is problematic. The aim of this study is to evaluate the effect of irrigation with wastewater in the Islamic Azad University Branch Khorasgan (WW) and NW on some anions concentration and Coliform of the soil when using two irrigation methods SDI and DI.

MATERIALS AND METHODS

Field-experiment

This study was carried out on a piece of land with an area of 1200 square meters in the olive plant pilot in 2007 (about six months, spring and summer). The climates is arid and semi-arid with an average rainfall 122.4 mm and mean annual evapotranspiration 5711 mm and also the mean annual temperature 14.1°C. Based on American method, the soil region is in a large group Calci gypsids .Tables 1 and 2 show the primarily characteristics of the soil and wastewater respectively.

Experimental Design and Treatments

This study was carried out with four treatments and three replications in a randomized complete block design. Treatments include: furrow irrigation with normal water (FN), furrow irrigation with wastewater (FW), surface drip irrigation with wastewater (DI), sub-surface drip irrigation with wastewater (SDI).

Irrigation schedule:

Irrigation schedule (days) for two treatments of FN and FW were once every week and for both SDI and DI treatments triple every week. Discharge irrigation treatments were 8 and 2 L/h for the DI and SDI and in the furrow about 75 L/h, that these numbers were calculated for the summer. Irrigation period was estimated triple every week in DI and SDI systems because the amount of water leaks from pipes. Most of the water in the furrow penetrates in the soil (Except for the part of water that is consumed on evaporation and plant-uptake). Wastewater was treated before entering the irrigation systems using physical treatment by filtration (sand filter). Treated wastewater was used in this study. Samples taken from wastewater (WW), normal water (NW) and treatment effluent (TE) for four times were analyzed (Table 2).

Soil-Sampling

Soil samples were collected from the depths of zero to 15-30, 15-30 and -45-60 cm. In this study, samples were investigated after transfer to the laboratory in accordance with standard methods of soil analysis (Table 3).

Statistical produce

The effect of wastewater was investigated in the irrigation treatments FW, DI, SDI using SPSS 19 statistical program without control and the respective shapes were drawn by the custom software EXECLL compared to FN.

RESULTS AND DISCUSSION

Table 4 shows the results of the chemical analysis of the soil before irrigation and after six months of wastewater irrigation in the treatments. The results show that the treatments SDI, DI and FW that was irrigated with wastewater (WW), causing an increase in EC of the soil and concentration of chloride, sulfate and bicarbonate of solution compared to FN. The results also showed that the pH value remained almost constant until the end of experiment. This study indicates the buffering power of the studied soil.

Salinity

In fact, the water movement has an important role in the accumulation of salt in the soil surface layer due to evaporation in the capillarity tubes. So that irrigation course should be low for the transfer and wash out of soil from the surface to the depths. So that the soil is always moist and salt does not move to the soil surface. The average salinity in SDI, DI and FW were 2.43, 4.52 and 3.29 dS/m respectively. Less salinity in SDI than FW and DI systems was due to state of the emitter and the more distribution of flow and discharge rates. Decrease in EC with depth in treatment comparison with DI method is more than the other two treatments SDI and FW.

Sulfate

The mean sulfate in DI, FW, FN and SDI were 9.45, 6.0, 7.58 and 4.10 me/l respectively. The use of waste water increases the amount of sulfate in the soil. Perhaps more salts of sulfate in DI compared to other systems because of this: Since the discharge distribution is less, the leaching is also low in DI. Salts are transferred to the surface because of evaporation in the irrigation FW. Thus it is due to the accumulation of sulfate in the stack.

Table 1. Some basic characteristics of the soil

Texture	OM %	ρb (g/cm^3)	*ρs (g/cm^3)	EC (dS/m)	pH
Clay loam	0.51	1.38	2.6	1.42	7.50

Chloride

The mean concentration of soil chloride in treatments DI, FW, FN and SDI were 38.19.4, 17.75 and 19.25 me/l respectively. The average Chloride concentration decreases with increasing depth, Chloride concentrations decrease with increasing depth is for two reasons:

1. Evaporation that causes the accumulation of salts in the soil surface by the capillaries.
2. Chloride ion mobility is more than sulfate. Then the Chloride salts accumulate in the more depth of soil than the sulfate due to leaching effect. DI irrigation system has the highest concentration of chloride compared to FN. This increase is probably due to the distribution of discharge, leaching and soil texture. Because concentrations of chloride leaching in DI are lower than SDI. Because the discharge distribution of dropper DI system is less than SDI, then average chloride will be more in DI[16]. The average concentration of soil bicarbonate in treatments, SDI, DI, FW was 8 and FN was 7.08 me/l respectively. Organic materials are an important factor in reducing the salts motion from wastewater irrigation in depth of soil profile due to the high specific surface area of absorption. The amount of organic matter decreases with increasing depth[17].

Table 2. Chemical analysis of water and wastewater –khorasgan university wastewater

Type of water	pH	EC(dS/m)	HCO_3^-	Cl^-(me/l)	SO_4^{2-}	TSS¹(mg/l)	SI	SAR²	BOD⁵	COD⁴(mg/l)
WW	8	0.9	4.5	3.68	2.82	437	3	2.7	18.	212
NW	7.5	0.55	2.35	2.75	0.9	44	1.1	0.5	28.9	58.43
TE	8	0.75	4	3.2	2.2	142.5	1.46	2.6	114.5	180

1-Floating materials 2-saturation index 3- sodium absorption ratio 4-biochemical needed oxygen 5-chemical-needed-oxygen
WW: wastewater, NW: normal water, EF: Effluent, TE:Treatment Effluent

Table 3. Exanimate studied soil

Test	Analyzed material	Method of test	reference
Soil texture	Soil	hydrometer bicus	Lee and Bvadr, 1986
Coliform	Soil	StandardMethod	APHA,1985
NO_3	Soil	steam distillation	Page-et al.,1982
EC	Soil and waste water	detector	Page et al., 1991
HCO_3	Soil and waste water	Titration	Page et al., 1991
Cl	Soil and waste water	Titration	Kalut, 1986
SO_4	Soil	Barium Chloride	Tendon, 1998

N-NO_3

Mean value of N-NO_3 were 0.39 and 0.36 mg/l respectively irrigated FW and FN. Results indicated that there was significant difference between soil irrigated with FW and FN. The concentration of N-NO_3 in soil irrigated with FW was more than FN. NO_3 is a non- reactive ion and it was leached easily but in this research the soil texture is Clay loam and it has high capacity for retention of NO_3. Mean values of N-NO_3 in SDI, FW, DI and FN were 31.59, 34.08, 31.15 and 33.51 respectively. Depth and irrigation system did not have any effect on N-NO_3 concentration. Jemai *et al*. (2013) showed that soil NO_3 content, after irrigation was significantly greater in surface layer. The lowest NO_3 content was observed in 20-40cm depth[18].

Coliform

Surface Soil samples were taken at several times and the amounts of total forms of fecal levels were measured immediately after studied irrigation treatments. The results were compared based on Duncan test. Mean values of Coliforms in SDI, FW, DI and FN were 2620000, 22900000, 30000000 and 450085 MPN/100ml respectively. Most of total Coliform and fecal forms were detected in surface

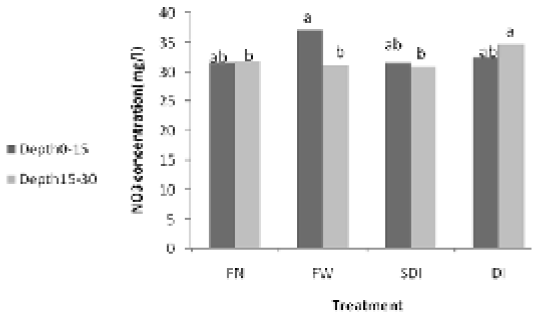

Fig. 1. Effect of NW and WW on soil N-NO_3 under FN, FW, SDI and DI. Means followed by the same letters are not significantly different according to the Duncan test at $P < 0.05$

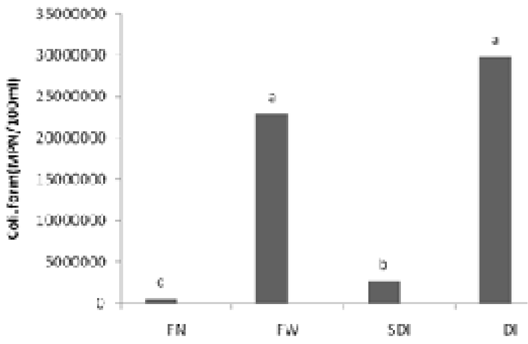

Fig. 2. Effect of NW and WW on soil Coliform under FN, FW, SDI and DI. Means followed by the same letters are not significantly different according to the Duncan test at $P < 0.05$

Table 4. Comparison of mean for some chemical features of soil before and after irrigation with sewage water

Sampling time	Depth(cm)	Treatment	pH	EC (dS/m)	SO_4^{2-}	HCO_3^-	Cl^-
Beginning of Period	0-15	FN	7.44	1.98	1.03	9	8
	15-30		7.50	1.42	0.51	14	45
	30-45		7.56	0.55	0.39	4	11
	45-60		7.41	0.98	0.39	3	7
End of period	0-15	FW	7.62	5.06	11	7.33	32.00
	0-15	DI	7.27	8.6	16.5	8.6	64.00
	0-15	SDI	7.48	4.05	4.7	9	32.00
	15-30	FW	7.52	2.67	9.5	10.3	9.33
	15-30	DI	7.28	4.29	6.2	6	35.33
	15-30	SDI	7.29	2.87	3.36	7.3	18.33
	30-45	FW	7.52	1.83	3.03	10	6.66
	30-45	DI	7.36	2.25	4.03	8.3	13.00
	30-45	SDI	7.42	2.09	2.26	8	16.66
	45-60	FW	7.35	3.59	3.56	10	7.5
	45-60	DI	7.18	2.93	11.06	5.3	12.00
	45-60	SDI	7.14	1.96	6.06	7.6	10.00

drip irrigation treatments based on the results. Furrow Irrigation treatment is in the next line due to being wide of stacks and sampling of the heap in terms of the accumulation of these two characteristics. Control with SDI and DI treatments had the lowest level of Coliform and fecal form in the topsoil. So they have shown no significant difference in the level of 5% in Duncan test. Najafi *et al*. (2015) reported that the least Coliform numbers were apperceived in the subsurface drip irrigation procedure[19]. Therefore, the subsurface drip irrigation can decrease the wastewater replication problem at soil.

CONCLUSION

The use of waste water increases the soil salinity especially in the surface layers. The highest and lowest salinity belongs to the SDI and DI systems respectively. The irrigation system has an effect on the salinity and soil anions in the soil profile. Utilization of wastewater causes increased Coliforms and total Coliforms. The most number of Coliforms was attributed DI.

ACKNOWLEDGEMENTS

I hereby thank Islamic Azad University Branch of khorasgan because of the moral and financial support.

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