Journal of Soil Science and Environmental Management Vol. 1(2), pp. 030-033, March 2010
Available online at http://www.academicjournals.org/JSSEM

Full Length Research Paper

The effect of irrigation by domestic waste water on soil properties

Hossein Hassanpour Darvishi[1], Mohammad Manshouri[2] and Hossein Aliabadi Farahani[3]*

[1]Islamic Azad University, Shahr-e-Qods Branch, Iran.
[2]Department of Water Sciences and Engineering, Science and Research Branch, Islamic Azad University, Tehran, Iran.
[3]Member of Young Researchers Club, Islamic Azad University, Shahr-e-Qods Branch, Iran.

Accepted 16 February, 2010

To investigate the beneficial impacts of domestic waste water on soil properties, we conducted an experiment in the lysimeter by measuring certain features essentially related to soil characteristics. The objectives in this study were (i) the domestic waste water in filtration by soil and (ii) the effect of domestic waste water on soil properties. In this experiment, we had 15 lysimeters that 1 - 5 lysimeters were irrigated by domestic waste water and primary drainage water was accumulated from these lysimeters and 6 - 9 lysimeters were irrigated by primary drainage water and secondary drainage water was accumulated and 10, 11 and 12 lysimeters were irrigated by secondary drainage water. In order to compare soil properties, 13, 14 and 15 lysimeters were irrigated by agronomical water and finally, soil and water properties were analyzed in each stage. The results showed that, soil could filter the domestic waste water and reduced BOD_5 and COD of domestic waste water. Also, irrigation with domestic waste water increased nutritive elements in soil that can be source of nutrition for plants. The findings may give applicable advice to commercial farmers and agricultural researchers for management and proper use of water.

Key words: Irrigation, domestic waste water, soil properties.

INTRODUCTION

The rapid population growth in many municipalities in the arid and semiarid of world continues to place increased demands on limited fresh water supplies. Many cities and districts are struggling to balance water use among municipal, industrial, agricultural, and recreational users. The population increase has not only increased the fresh water demand but also increased the volume of waste water generated. Treated or recycled waste water (RWW) appears to be the only water resource that is increasing as other sources are dwindling. Use of RWW for irrigating landscapes is often viewed as one of the approaches to maximize the existing water resources and stretch current urban water supplies (USEPA, 1992). Sewage, often untreated, is used to irrigate 10% of the world's crops, according to the first ever global survey of waste water irrigation. This is a largely hidden practice and is outlawed in many countries. However, many farmers, especially those in urban areas, use sewage because it is free and abundant, even during droughts, and, being full of nitrates and phosphates, acts as an effective fertilizer. The use of waste water by farmers will not go away. It can't be ignored or dealt with by imposing bans on its use. Municipal policy-makers and planners need to confront reality and face the challenge in innovative ways (Scott et al., 2004). Irrigation is an excellent use for sewage effluent because it is mostly water with nutrients. For small flows, the effluent can be used on special, well-supervised "sewage farms," where forage, fiber, or seed crops are grown and can be irrigated with standard primary or secondary effluent. However, agronomic aspects related to crops and soils must also be taken into account (Bouwer and Idelovitch, 1987). Irrigation may be defined as the application of water to soil for the purpose of supplying the moisture water which is essential for plant growth.

Irrigation plays a vital role in increasing crop yields and stabilizing production. In arid and semi-arid regions, irrigation is essential for economically viable agriculture, while in semi-humid and humid areas, it is often required on a supplementary basis (Oron et al., 1986). In a field,

*Corresponding author. E-mail: aliabadi.farahani@yahoo.com.

Table 1. The analysis of lysimeters soil before planting.

Soil texture	Sand (%)	Silt (%)	Clay (%)	K (mg/l)	P (mg/l)	Na (mg/l)	FC (%)	PWP (%)	pH	SAR	Ca (mg/l)	Mg (mg/l)	EC (Ds/m)
Loam	42	28	30	201.41	5.12	30.21	13.7	6.14	7.2	8.72	12.01	14.12	5.68

FC = Field capacity. PWP = Permanent wilting point. pH = Power hydrogen. SAR = Sodium adsorption ratio. EC = Electrical conductivity.

Table 2. The analysis of domestic waste water.

PO_4^{-3} (mg/l)	HCO_3^- (mg/l)	Na (mg/l)	Ca (mg/l)	Mg (mg/l)	TSS (mg/l)	SAR	Cl (mg/l)	pH	EC (Ds/m)	BOD_5 (ppm)	COD (ppm)
5.07	5.10	24	14.7	15.01	208.81	5.81	1.82	7.2	4.8	150	232

TSS = Total suspended solids. BOD_5 = Biological oxygen demand. COD = Chemical oxygen demand.

experiment was carried out on a sandy soil in Agadir region and two types of water were used: the rainfall supplemented with treated waste water irrigation of which five treatments were tested in leaf, root, content of nitrogen, phosphorus, potassium, calcium and magnesium was increased proportionally to the irrigation doses. The electrical conductivity of the soil increased from the start to the end of the experiment. The evaluation of soil nutrients for the three soil layers indicated their accumulation with increasing irrigation dose (Mosab, 2000). The objective of Mancino and Pepper (1992) was to determine the influence of secondarily treated municipal waste water irrigation on the chemical quality of Bermuda grass (*Cynodon dactylon* L.) turf soil (Sonoita gravelly sandy loam: coarse-loamy, mixed, thermic Typic Haplargid) when compared to similarly irrigated potable water plots.

Research plots were irrigated using a 20% leaching fraction. After 3.2 years of use, effluent water increased soil electrical conductivity by 0.2 dsm^{-1}, Na by 155 $mgkg^{-1}$, P by 26 $mgkg^{-1}$, and K by 50 $mgkg^{-1}$ in comparison to potable irrigated plots. Soil pH was not significantly affected by effluent irrigation. The concentrations of Fe, Mn, Cu, and Zn were found to be within the range considered normal for agricultural soil. Effluent irrigation increased soil total organic carbon and nitrogen during the first 1.3 year of irrigation only. Total aerobic bacteria populations were similar in all irrigated plots indicating these microbes were not promoted or inhibited by the use of this waste water. In summary, the irrigation of this turf soil for 3.3 years with the secondarily treated waste water used in this study had no serious detrimental effects on soil quality.

Therefore, the objective of this experiment was to determine the role of soil in filtering of domestic waste water and its effect on soil properties.

MATERIALS AND METHODS

This study was conducted on experimental lysimeters of Islamic Azad University, Shahr-e-Qods Branch at Iran (35°48' N, 51°01' W; 1320 m above sea level) with clay loam soil and the soil consisted of 30% clay, 28% silt and 42% sand (Table 1). The volume of each lysimeter was 150 lit (Height = 100 cm and Radius = 30 cm) filled by soil and in order to prevent water influx from field to lysimeters, those placed on metal legs (height = 40 cm). After filling lysimeters by clay loam soil, plants seeds were planted and were irrigated with agronomical water. In this experiment, we had 15 lysimeters that 1-5 lysimeters were irrigated by domestic waste water and primary drainage water was accumulated from these lysimeters and 6 - 9 lysimeters were irrigated by primary drainage water and secondary drainage water was accumulated and 10, 11 and 12 lysimeters were irrigated by secondary drainage water. In order to compare soil properties, 13, 14 and 15 lysimeters were irrigated by agronomical water. At each stage, soil and water properties were analyzed and compared with agronomical water properties. The analysis of lysimeter soil texture, percentage of sand, silt, clay, amount of K, P, Na, Fc, PWP, pH, SAR, Ca, Mg, EC and analysis of different parameters of water, PO_4^{-3}, HCO_3^- , Na, Ca, Mg, TSS, SAR, Cl, pH, EC, BOD_5 and COD were determined by using standard procedures.

RESULTS AND DISCUSSION

The first of this study, we analyzed lysimeters soil (Table 1) and domestic waste water (Table 2) and then 1 - 5 lysimeters were irrigated by domestic waste water and was accumulated primary drainage water (Table 3).

In the next stage, the 6 - 9 lysimeters were irrigated by primary drainage water and was accumulated, in secondary drainage water and were analyzed in soil after irrigation by primary drainage water (Table 4) and secondary drainage water (Table 5). Then, the 10, 11 and 12 lysimeters were irrigated by secondary drainage water and was analyzed in soil after irrigation by secondary drainage water (Table 6). The results showed that, soil was a biofilter that could reduce a large part of domestic waste water pollutions, for example BOD_5 and COD decreased, but this filtering increased EC, SAR, Na, Ca and Mg of soil. Also, the secondary drainage water was accumulated and analyzed, the data indicated that, primary drainage water pollutions reduced again, but EC, SAR, Na, Ca and Mg of oil increased under this

Table 3. The analysis of primary drainage water.

PO_4^{-3} (mg/l)	HCO_3^- (mg/l)	Na (mg/l)	Ca (mg/l)	Mg (mg/l)	TSS (mg/l)	SAR	Cl (mg/l)	pH	EC (Ds/m)	BOD_5 (ppm)	COD (ppm)
4.42	4.83	18.10	12.20	12.17	190.17	4.82	1.60	6.98	3.81	15	30

Table 4. The analysis of lysimeters soil after irrigation by primary drainage water.

K (mg/l)	P (mg/l)	Na (mg/l)	pH	SAR	Ca (mg/l)	Mg(mg/l)	EC (Ds/m)
208.40	12.14	38.14	7.41	9.92	14.02	16.17	8.71

Table 5. The analysis of secondary drainage water.

PO_4^{-3} (mg/l)	HCO_3^- (mg/l)	Na (mg/l)	Ca (mg/l)	Mg (mg/l)	TSS (mg/l)	SAR	Cl (mg/l)	pH	EC (Ds/m)	BOD_5 (ppm)	COD (ppm)
4.27	4.65	17.92	12.10	11.98	188.14	4.63	1.5	6.94	3.42	5	8

Table 6. The analysis of lysimeters soil after irrigation by secondary drainage water.

K (mg/l)	P (mg/l)	Na (mg/l)	pH	SAR	Ca (mg/l)	Mg (mg/l)	EC (Ds/m)
219.12	18.38	45.17	7.48	11.17	18.52	19.22	8.82

Table 7. Comparison of soil properties before planting with soil properties after irrigation by primary and secondary drainage water.

	K (mg/l)	P (mg/l)	Na (mg/l)	pH	SAR	Ca (mg/l)	Mg (mg/l)	EC (Ds/m)
Before planting	201.41	5.12	30.21	7.2	8.72	12.01	14.12	5.68
Irrigation by primary drainage water	208.40	12.14	38.14	7.41	9.92	14.02	16.17	8.71
Irrigation by secondary drainage water	219.12	18.38	45.17	7.48	11.17	18.52	19.22	8.82

condition. In Tables 7 and 8 we compared in each stage of soils and water of lysimeters with soil before planting and agronomical water is introduced.

Both opportunities and problems exist in using sewage water for landscape irrigation. Recycled sewage water irrigation in urban landscapes is a powerful means of water conservation and nutrient recycling, thereby reducing the demands of freshwater and mitigating pollution of surface and ground water.

However, potential problems associated with recycled sewage water irrigation do exist. These problems include salinity build up and relatively high Na and B accumulation in the soil. Especially, the significantly higher soil SAR in sewage water irrigated sites compared with surface water irrigated sites provided reason for concern about possible long term reductions in soil hydraulic conductivity and infiltration rate in soil with high clay content, although these levels were not high enough to result in short term soil deterioration. Salt leaching would become less effective when soil hydraulic conductivity and infiltration rate were reduced.

These chemical changes may in part and contribute to the stress symptoms and die off and it observed in some ornamental trees. As more landscape facilities and development areas plan to switch to recycled sewage water for irrigation, landscape managers must be prepared to face new challenges associated with the use of recycled sewage water. Persistent management practices, such as applications of soil amendments that provide Ca to replace Na; periodic leaching to reduce salt accumulation; frequent verifications to maintain infiltration, percolation, and drainage; regular soil and plant monitoring, selection and the use of salt tolerant turf grass and landscape plants will be helpful in mitigating

Table 8. Comparison of domestic waste water properties with primary and secondary drainage water properties.

	PO_4^{-3} (mg/l)	HCO_3^- (mg/l)	Na (mg/l)	Ca (mg/ l)	Mg (mg/l)	TSS (mg/l)	SAR	Cl (mg/l)	pH	EC (Ds/m)	BOD_5 (ppm)	COD (ppm)
Domestic wastewater	5.07	5.10	24	14.7	15.01	208.81	5.81	1.82	7.2	4.8	150	232
Primary drainage water	4.42	4.83	18.10	12.20	12.17	190.17	4.82	1.60	6.98	3.81	15	30
Secondary drainage water	4.27	4.65	17.92	12.10	11.98	188.14	4.63	1.5	6.94	3.42	5	8

the negative impact and ensuring continued success in using sewage water for landscape irrigation. Many sewage water irrigators are not landowning farmers, but landless people that rent small plots to produce income-generating crops such as vegetables that thrive when watered with nutrient-rich sewage. Across Asia, Africa and Latin America these waste water micro-economies support countless poor people. Stopping or over-regulating these practices could remove the only income many landless people have.

Conclusion

Most treated sewage water are not very saline, salinity levels usually ranging between 500 - 200 mg/l (EC_w = 0.7 to 3.0 dS/m). However, there may be instances, where the salinity concentration exceeds the 2000 mg/l level. In any case, appropriate water management practices will have to be followed to prevent salinization, irrespective of whether the salt content in the sewage water is high or low. It is interesting to note that, even the application of non-saline sewage water, such as one containing 200 - 500 mg/l, when applied at a rate of 20,000 m^3 per ha, a fairly typical irrigation rate, will add between 2 - 5 tonnes of salt annually to the soil. If this is not flushed out of the root zone by leaching and removed from the soil by effective drainage, salinity problems can build up rapidly. Leaching and drainage are thus two important water management practices suggested to avoid salinization of soils.

ACKNOWLEDGEMENTS

The authors are indebted to Dr. Sayed Alireza Valadabadi and Dr. Payam Moaveni for providing financial assistance and continuous encouragement to carry out the paper.

REFERENCES

Bouwer H, Idelovitch E (1987). Quality requirements for irrigation with sewage water. J. Irrig. Drain. Engrg. 113(4): 516-535.
Mancino CF, Pepper IL (1992). Irrigation of turf grass with secondary sewage effluent: Soil quality. Agron. J. 84: 650-654.
Mosab T (2000). The use of treated wastewater as supplementary irrigation for bread wheat (*Triticum aestivum*) production. Msc Thesis. University of IAV Hassan II, Agadir, Morocco.
Oron G, Demalach J, Bearman JE (1986). Trickle irrigation of wheat applying renovated wastewater. Water resources bulletin. 22(2): 439-446.
Scott C, Faruqui NI, Raschid L (2004). Wastewater use in irrigated agriculture: Confronting the livelihood and environmental realities, (eds).
USEPA (1992). Manual: Guidelines for water reuse. USEPA Rep. 625/R-92/004. USEPA, Washington, DC.