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Full Length Research Paper

Studies on variations of domestic wastewater pollution indexes after being treated by agronomical soil

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The objective of this study was to study the pollution indexes [biochemical oxygen demand (BOD_5) and chemical oxygen demand (COD)] variations in domestic wastewater after treatment with agronomical soil. In this experiment, 15 lysimeters were used, 1 to 5 lysimeters were irrigated by domestic wastewater and primary drainage water was accumulated from these lysimeters, 6 to 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. Finally, soil and water properties were measured at the end of irrigation. The results showed that soil could filter the domestic wastewater and reduce pollution indexes of domestic wastewater. Also, irrigation with domestic wastewater increased electrical conductivity (EC), potassium (K), phosphorus (P), calcium (Ca) and magnesium (Mg) of soil. The findings may give applicable advice to commercial farmers and agricultural researchers for management and proper use of water.

Key words: Biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), domestic wastewater, agronomical soil.

INTRODUCTION

Domestic wastewater treatment is focused generally on treating backwater. Backwater is the perfect medium for the growth of pathogenic bacteria. Therefore, it is extremely necessary to treat it before reuse or to be discharged into rivers and lakes. Discharge of untreated or partially treated wastewaters containing carbon (C), nitrogen (N) and phosphorus (P) into receiving waters can lead to eutrophication. As a result, it is necessary to develop treatment systems that efficiently and economically remove nutrients from these wastewaters. Biological nutrient removal methods have advantages over physical and chemical methods, including low waste sludge production and low capital and operational costs. 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 that 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 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, experiment was carried out on a sandy soil in Agadir region where two types of water were used: the rainfall supplemented with treated wastewater irrigation of which five treatments were tested. Leaf, root content of N, P, potassium (K), calcium (Ca) and magnesium (Mg) was increased proportionally to the irrigation doses. The electrical conductivity (EC) of the soil increased from the beginning 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

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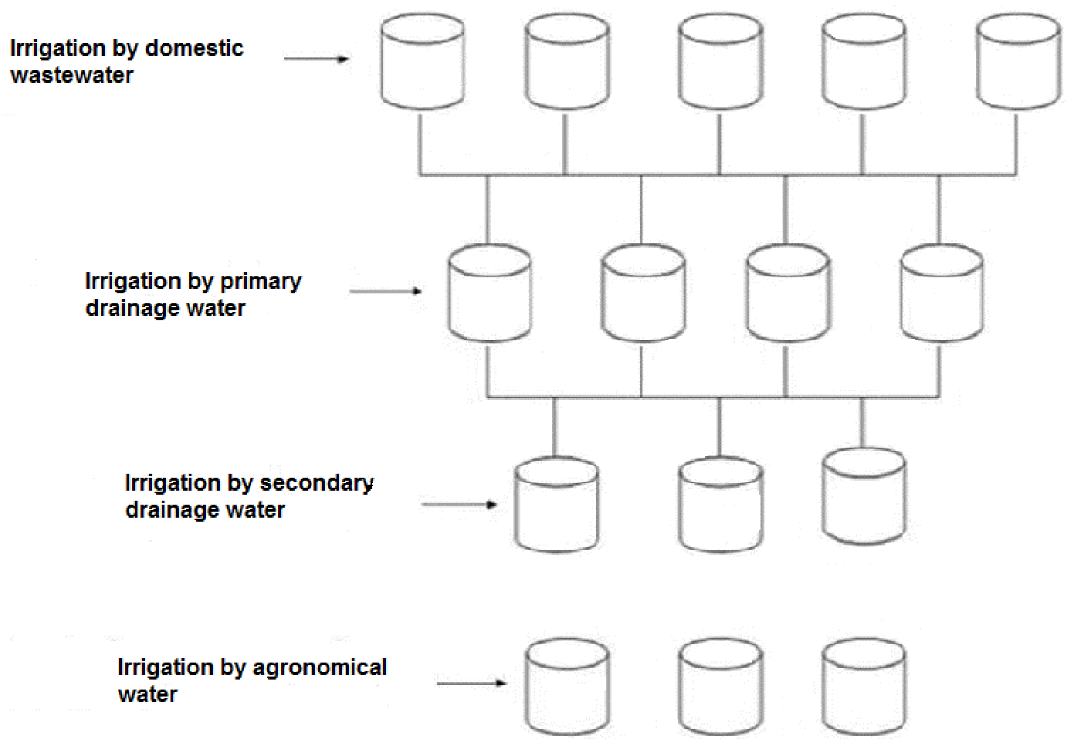

Figure 1. The location and number of experimental lysimeters.

and Pepper (1992) was to determine the influence of secondarily treated municipal wastewater irrigation on the chemical quality of bermudagrass (*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 EC by 0.2 dSm^{-1}, sodium (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. Therefore, the objective of this experiment was to determine the biochemical oxygen demand (BOD_5) and chemical oxygen demand (COD) variations in domestic wastewater after treatment with agronomical soil.

MATERIALS AND METHODS

This study was conducted on experimental lysimeters of Islamic Azad University, Shahr-e-Qods branch at Iran with clay loam soil. The volume of each lysimeter was 150 l (diameter = 50 cm and height = 80 cm) filled by soil and in order to prevent water influx from field to lysimeters, those placed on metal legs. Figure 1 shows the location and number of experimental lysimeters. At the end of the lysimeters was a pore draining (diameter = 5 cm) that wastewater accumulated in the gradated tubs. In this experiment, 15 lysimeters were used, 1 to 5 lysimeters were irrigated by domestic wastewater (volume of wastewater was 40 l for each lysimeter) and primary drainage water was accumulated from these lysimeters, 6 to 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. Due to the irrigation water in the second row lysimeters supplied from the drainage water of the first row lysimeters, the number of lysimerers in the second row decreased (1 lysimeter). Also, the number of lysimerers in third row decreased in relation to number of second row lysimerers (1 lysimetre). In order to compare soil properties, 13, 14 and 15 lysimeters were irrigated by agronomical water and lysimeters irrigated each 15 days regularly for 3 months. At the end of experiment, soil and water properties were measured and compared with agronomical soil and water properties. The analysis of lysimeter soil, texture, percentage of sand, silt, clay, amount of K, P, Na, field capacity (FC), permanent wilting point (PWP), pH, sodium adsorption ratio (SAR), Ca, Mg, EC and analysis of different parameters of water, total soluble salts (TSS), SAR, pH, EC, BOD_5 and COD were determined.

RESULTS AND DISCUSSION

Firstly in this study, we analyzed lysimeters soil (Table 1), domestic wastewater (Table 2) and agronomical (normal) water (Table 3) and then 1 to 5 lysimeters were irrigated by domestic wastewater. The soil was analyzed after irrigation by domestic wastewater (Table 4) and then the primary drainage water was accumulated (Table 5).

In the next stage, the 6 to 9 lysimeters were irrigated by primary drainage water and was accumulated by secondary drainage water. Later, the soil was analyzed after irrigation by primary drainage water (Table 6) and secondary drainage water (Table 7).

Then, the 10, 11 and 12 lysimeters were irrigated by secondary drainage water and was analyzed soil after

Table 1. The physical and chemical characteristics 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)
Clay loam	42	28	30	201.41	5.12	30.21	31.7	16.1	7.2	8.72	12.01	14.12	5.68

Table 2. The characteristics of domestic wastewater.

TSS (mg/l)	SAR	pH	EC (dS/m)	BOD_5 (ppm)	COD (ppm)
208.81	5.81	7.2	4.8	150	232

Table 3. The characteristics of agronomical (normal) water.

TSS (mg/l)	SAR	pH	EC (dS/m)	BOD_5 (ppm)	COD (ppm)
150.25	3.86	7.01	1.40	2.42	7.01

Table 4. The physical and chemical characteristics of lysimeters soil after irrigation by domestic wastewater.

K (mg/l)	P (mg/l)	Na (mg/l)	pH	SAR	Ca (mg/l)	Mg (mg/l)	EC (dS/m)
228.72	28.45	53.12	7.55	12.91	29.19	24.80	10.64

Table 5. The characteristics of primary drainage water.

TSS (mg/l)	SAR	pH	EC (dS/m)	BOD_5 (ppm)	COD (ppm)
190.17	4.82	6.98	3.81	15	30

Table 6. The physical and chemical characteristics 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)
219.12	18.38	45.17	7.48	11.17	18.52	19.22	8.82

Table 7. The characteristics of secondary drainage water.

TSS (mg/l)	SAR	pH	EC (dS/m)	BOD_5 (ppm)	COD (ppm)
188.14	4.63	6.94	3.42	5	8

irrigation by secondary drainage water (Table 8).

The results showed that soil could reduce a large part of domestic wastewater pollutions, for example BOD_5 and COD decreased, but this filtering increased EC, K, P, Ca and Mg of soil related to soil of before planting (due to had nutritive elements in domestic wastewater). Also, the secondary drainage water was accumulated and analyzed, that our data indicated that primary drainage water pollutions reduced again. Figure 2 compared the indexes of water pollution (BOD_5 and COD) in the irrigation treatment. It shows that the indexes of water pollution in the primary and secondary drainage water are lower than indexes of water pollution in the domestic wastewater.

Table 8. The physical and chemical characteristics 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)
208.40	12.14	38.14	7.41	9.92	14.02	16.17	8.71

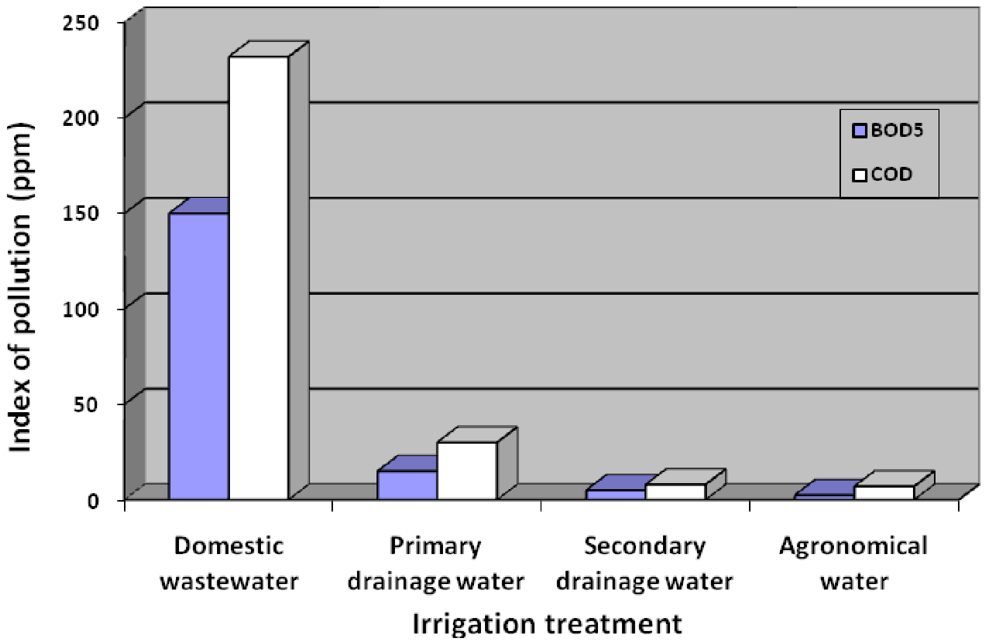

Figure 2. Comparison of pollution indexes in the irrigation treatment.

Therefore, soil could filter the wastewater and reduced the pollution indexes of wastewater sorely. Also, irrigation with wastewater increased nutritive elements in soil that can be source of nutrition for plants. Our findings can give applicable advice to commercial farmers and agricultural researchers for management and proper use of water.

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