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Influence of irrigation with domestic wastewater on different agronomical features in summer savory (*Satureja hortensis* L.)

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Abstract

The main objective of the present study was to evaluate the effects of irrigation with domestic wastewater on different agronomical features of summer savory (*Satureja hortensis* L.). In this experiment, the soil has been used as a biological filter to absorb pollution in the domestic wastewater. 15 lysimeters were used in this work that 1 to 5 lysimeters were irrigated by domestic wastewater and primary drainage water were accumulated. The 6 to 9 lysimeters were irrigated by primary drainage water and then secondary drainage water were accumulated and also 10, 11 and 12 lysimeters were irrigated by secondary drainage water. In order to compare plants characteristics the lysimeters 13 to 15 were irrigated by agronomical water. The results showed that essential oil yield of summer savory significantly increased (14%) under irrigation by secondary drainage water into irrigation by agronomical water. The findings may give applicable advice to commercial farmers and medicinal and also aromatic plants researches for management and concern on water strategy and estimate of irrigation carefully for increase of quantity and quality yields in medicinal and aromatic plants farming.

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Introduction

Domestic wastewater treatment is focused generally on treating black water. Black water 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 (Akpor and Muchie, 2011). 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 (Ahn *et al.*, 2003). Biological nutrient removal methods have advantages over physical and chemical methods, including low waste sludge production and low capital and operational costs. Hundreds of hectares of these crops are required to facilitate an economically viable industrial production system. Therefore, shortage of fresh water for irrigation in arid and semiarid regions restricts utilization of aromatic plants as industrial crops. Replacement of fresh water with treated effluent for irrigation of these plants could promote development of large-scale production systems for biomass, essential oil and natural antioxidants in arid and semiarid zones (Aleksandrowies and Smyk, 1973; Arceivala, 1981). No information is currently available concerning the effect of irrigation with treated municipal effluent on growth and development of crops, essential oil yield or antioxidant production. Salinity and heavy metals contained in treated effluents may increase antioxidant activity and reactive oxygen production in plants. Increased antioxidant content and antioxidant activity were demonstrated in many plants in response to environmental stresses (Mittler, 2002). In some medicinal plants, water resources induced changes in antioxidants which were suggested to be involved in prevention of plant tissues damage (Aliabadi Farahani *et al.*, 2008). Shortage of water in arid and semiarid regions throughout the world dictates utilization of marginal water, of low quality, for irrigation. Treated urban effluents, which may affect yield quantity and quality, are the most common alternative for agricultural irrigation (Dudai, 2005). Despite the cost of waste water treatment and distribution, annual crop costs are lower when irrigating with effluents because the price of effluent water in some areas is lower compared to potable water (Fine *et al.*, 2006). Therefore, the objective of this study was to evaluate the effect of irrigation by treatment of domestic wastewater instead of agronomical water on essential oil yield of summer savory.

Materials and methods

Plant materials and experimental conditions

This study was conducted on experimental lysimeters of Islamic Azad University, Shahr-e-Qods Branch. The volume of each lysimeter was 150 lit filled by clay loam soil and in order to prevent water influx from field to lysimeters, those placed on metal legs (Table 1). In this experiment, we have used the soil as a biological filter that can to absorb pollution in the domestic wastewater. We had 15 lysimeters, that were planted summer savory (*Satureja hortensis* L.) that 1 to 5 lysimeters were irrigated by domestic wastewater and primary drainage water were accumulated. The 6 to 9 lysimeters were irrigated by primary drainage water and then, were accumulated secondary drainage water and we have irrigation 10, 11 and 12 lysimeters by secondary drainage water. In order to compare plants characteristics, in 13, 14 and 15 lysimeters were irrigated by agronomical water. At the maturity, we collected plants from each lysimeters for determination of flowering shoot yield and total dry matter. Then, were selected 100g flowering shoot dry matter for determination of essential oil percentage by Clevenger. Finally, essential oil yield was determined by the following formula (Aliabadi Farahani *et al.*, 2008).

Essential oil yield = Essential oil percentage × Flowering shoot yield.

Finally, data were subjected to repeated measure analysis.

Results and discussion

The chemical quality of domestic wastewater, primary drainage water and secondary drainage water is shown in Table 2. The results showed that use of secondary drainage water for summer savory irrigation increased plat characteristics as compare with agronomical water. In the agronomical water irrigation condition the amount of essential oil yield, biological yield, flowering shoot yield and essential oil percentage were 8.4 kg/ha, 6652 kg/ha, 935 kg/ha and 0.98%, respectively. But highest essential oil yield (9.3 kg/ha), biological yield (7214 kg/ha), flowering shoot yield (658 kg/ha) and essential oil percentage (0.73%) were obtained under irrigation by secondary drainage water. Evaluation of accumulation of different elements in summer savory shoot showed that accumulation of elements such as nitrogen, phosphorus, potassium, calcium and protein were increased under irrigation by secondary drainage water but the cadmium element was reduced under this condition (Table 3).

Table 1. The analysis of lysimeters soil before irrigation by domestic wastewater.

Parameters	Density	Parameters	Density
Cd (meq/lit)	0.02	HCO_3^- (meq/lit)	3.2
Cu (meq/lit)	4.31	Cl (meq/lit)	5.6
Mn (meq/lit)	7.89	P (meq/lit)	37.2
Zn (meq/lit)	2.63	K (meq/lit)	22.2
Pb (meq/lit)	2.63	Humus (%)	1.2
CO_3^{-2} (meq/lit)	0	pH	7.7

Table 2. The chemical quality of domestic wastewater, primary drainage water and secondary drainage water.

Parameters	Domestic wastewater	Primary drainage water	Secondary drainage water
Cd (meq/lit)	0.05	0.01	0
Mg (meq/lit)	2.79	1.95	1.7
Cl (meq/lit)	7.8	6.91	5.26
P (mg/lit)	4.41	3.12	1.3
K (mg/lit)	3.73	1.94	1.7
Ca (meq/lit)	3.55	3.29	2.43
Na (meq/lit)	11.89	11.41	11.67
C (mg/lit)	152.7	56.52	30.25
N (mg/lit)	34.13	23.2	21.25
pH	7.8	6.75	7.5

Table 3. Accumulation of different elements in summer savory shoot.

Treatment	N (%)	P (%)	K (%)	Protein (%)	Cd (mg/kg)
Secondary drainage water	6.12	0.16	2.61	17.22	0
Agronomical water	5.35	0.13	2.32	13.37	0.01

The understanding of how the plants respond to the agronomic growing conditions is a prerequisite for the prediction of essential oil and for controlling oil quality. This is especially important since changes in the chemical composition affect the commercial value of the oil, with consequences to the grower's income (Bernstein *et al.*, 2009). As it was shown in our results, the use of secondary drainage water had a positive effect on most of the emphasized growth compounds. In contrary, secondary drainage water supply in soil achieved a situation for plant to absorb by root growth the nutrients. However, secondary drainage water element isn't in essential oil components, but the our final results indicated that applications secondary drainage water increased essential oil content of summer savory, because the secondary drainage water element (N, P, K, ...) develops leaf area, lateral stem, number of flower and because of increase of the essential oil yield, because elements are the major nutrients that influence plants yield and protein concentration (Arceivala, 1981). When the amount of available soil nutrients limits yield potential, additions of secondary drainage water can substantially increase plants yield. The interaction between the amount of the essential oil percentage and flowering shoot yield is considered important as two components of the essential oil yield. The essential oil percentage increased under the use of secondary drainage water and also, essential oil yield increased under this condition. Therefore, each increaser factor of essential oil percentage and flowering shoot yield, can increases essential oil yield. Our results were similar to the findings of Bernstein *et al.* (2009). They evaluated the effect of irrigation with secondary-treated effluent on plant development, essential oil yield, antioxidant activity and selected antioxidant phenolic compounds in two commercial cultivars of the aromatic species, oregano (*Origanum vulgare* L.) and rosemary (*Rosmarinus officinalis* L.). The applied treated effluent contained higher levels of Na, Cl, $HCO_{3,}^{-1}$ P, K, NH_4^{+1}, NO_3^{-1}, Ca+Mg, B, Mn, and Fe than the local potable water used as control, and were characterized by higher values of electrical conductivity (EC), pH and sodium absorption ratio (SAR). The results demonstrate that both oregano and rosemary are suitable as industrial crops for essential oil and antioxidant production under irrigation with secondary-treated municipal effluent because their yield quantity and quality were not affected. In addition to affects on the irrigated crops, much effort is currently made to study potential effects of irrigation by wastewater on chemical and physical properties of soils. In the present study, the secondary drainage water used were of homely origin, contained only moderate levels of salts, and did not contain elevated levels of heavy metals. Heavy metal accumulation therefore did not appear in the soil or the plant tissues and salinity effects on the plants were moderate (Arceivala, 1981).

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