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Full Length Research Paper

Irrigation influence by treated domestic wastewater instead of agronomical water on essential oil yield of basil (*Ocimum basilicum* L.)

Hossein Hassanpour Darvishi[1]*, Mohammad Manshouri[2], Hossein Sedghi[2] and Sayed Habib Mousavi Jahromi[2]

[1] Ph.D Student of Water Sciences & Engineering, Science & Research Branch, Islamic Azad University (IAU) , Tehran, Iran.
[2]Department of Water Sciences and Engineering, Science and Research Branch, Islamic Azad University, Tehran, Iran.

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In this experiment, we have used the soil profile as a biological filter that can to absorb pollution and microbes in the domestic wastewater at Iran during 2009. In this experiment, we had 15 lysimeters, that were planted canola (*Brassica napus* L.) in 1 to 5 lysimeters and were irrigated by domestic wastewater with BOD_5 about 150 mg/lit and primary drainage water were accumulated. In the 6 to 9 lysimeters was planted alfalfa (*Medicago sativa* L.) and were irrigated by primary drainage water and then, were accumulated secondary drainage water. We have irrigation 10, 11 and 12 lysimeters by secondary drainage water that was planted inside the basil (*Ocimum basilicum* L.). In order to compare plants characteristics, in 13, 14 and 15 lysimeters were planted canola, alfalfa and basil respectively and were irrigated by agronomical water. The results showed that the soil could reduce BOD_5 and COD from 150 and 232 mg/lit to 11 and 18 mg/lit respectively in secondary drainage water. The essential oil yield of basil 17% increased under irrigation by secondary drainage water into irrigation by agronomical water. Therefore, the use of secondary drainage water can be increase the quantity and quality yields in plants and the other hand, protects sweet water resources.

Key words: Domestic wastewater, agronomical water, essential oil yield, basil.

INTRODUCTION

Basil (*Ocimum basilicum* L.) is an annual plant that prefers warm growing weather but nevertheless is tender and killed by sunstroke. Depending on variety and culture, the plants grow 20 - 35 in height and the leaves are violet and typically about 12 (Khalid, 2006). Domestic wastewater treatment is focused generally on treating blackwater. Blackwater 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. Biofilm wastewater treatment systems, which are characterized by their compactness, simple operation, and easy maintenance, can be more stable in treating wastewaters with high flow and substrate variations than suspended-growth activated sludge systems. In addition, biofilm systems can be more suitable for small-scale wastewater or industrial wastewater treatment than activated sludge systems (Rodgers et al., 2008). Federal and state laws require that domestic wastewater be treated through a two- or three-step process with the end products being sewage effluent and biosolids. Domestic wastewater effluent is essentially clear water that contains low concentrations of plant nutrients and traces of organic matter. It is chlorinated to destroy any pathogens (Kidder, 2001). Perennial aromatic plants are cultivated as cash-crops for fresh or dry herb production, or as a source of essential oils and natural antioxidants. These summer crops require substantial amounts of water, up to 7000 to

*Corresponding author. E-mail: aliabadi.farahani@yahoo.com. h.hassanpour87@gmail.com.

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

Parameters	Density	Parameters	Density
Cd (meq/lit)	0.01	HCO_3^- (meq/lit)	4
Cu (meq/lit)	3.51	Cl (meq/lit)	6
Mn (meq/lit)	8.08	P (meq/lit)	38
Zn (meq/lit)	1.83	K (meq/lit)	21
Ni (meq/lit)	0.005	Ca (meq/lit)	29.8
Mg (meq/lit)	27.4	SO_4^{-2} (meq/lit)	2.08
Fe (meq/lit)	11.03	$Ca(OH)_2$ (%)	11
Pb (meq/lit)	1.73	Humus (%)	0.88
CO_3^{-2} (meq/lit)	0	pH	7.9

9000 m^3 ha^{-1} throughout the growing season, to satisfy their potential for intensive biomass production (Dudai, 2005). 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. 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 et al., 2009). 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 treated domestic wastewater instead of agronomical water on essential oil yield of basil (*Ocimum basilicum* L.).

MATERIALS AND METHODS

This study was conducted on experimental lysimeters of Islamic Azad University, Science and Research Branch of Tehran at Iran (35°48' N, 51°01' W; 1320 m above sea level) in 2009, relative humidity (68%), mean annual temperature (16°C) and rainfall in the study area is distributed with an annual mean of 235 mm. The volume of each lysimeter was 150 lit (Height = 100 cm and Radius = 30 cm) filled by clay loam soil consisted of 19.9% clay, 22.09% silt and 58.72% sand 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 and apparent specific weight of soil was 1.52 g/cm^3 (Table 1).

Canola (*Brassica napus* L. cul. Opera), alfalfa (*Medicago sativa* L. cul. Hamedani) and basil (*Ocimum basilicum* L. var. Mianeh) were used in this experiment. In this experiment, we had 15 lysimeters, that were planted canola in 1 - 5 lysimeters and were irrigated by domestic wastewater with BOD_5 about 150 mg/lit and primary drainage water were accumulated. In the 6 - 9 lysimeters was planted alfalfa and were irrigated by primary drainage water and then, were accumulated secondary drainage water. We have irrigation 10, 11 and 12 lysimeters by secondary drainage water that was planted inside the basil. In order to compare plants characteristics, in 13, 14 and 15 lysimeters were planted canola, alfalfa and basil respectively and were irrigated by agronomical water (Figure 1).

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

Also, the chemical quality of domestic wastewater, primary drainage water and secondary drainage water were determined for compare with standards of Iran and FAO. Finally, data were subjected to repeated measure analysis.

RESULTS

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

Also, in the Table 3 is shown amount removed of biological, chemical and microbial pollutants in domestic wastewater by crossing the soil profile in 2 stages.

The final results showed that use the secondary drainage water for basil irrigation increased plat characteristics to 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 10.2 kg/ha, 4900 kg/ha, 410 kg/ha and

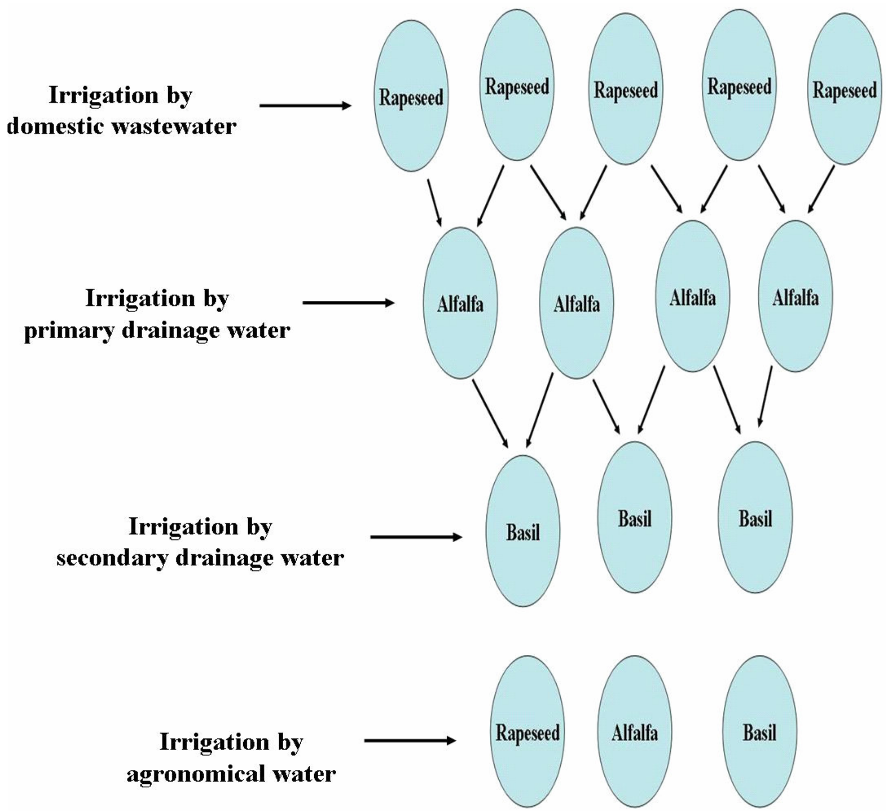

Figure 1. Experimental lysimeters

Table 2. The chemical quality of domestic wastewater, primary drainage water and secondary drainage water and compare them with standards of Iran and FAO.

Parameters	Domestic wastewater	Primary drainage water	Secondary drainage water	Standard of Iran	Standard of FAO
Cd (meq/lit)	0.04	0.01	0	0.1	0.01
Ni (meq/lit)	1.83	0.98	0.01	2	0.06
Mg (meq/lit)	2.71	1.93	1.8	4.1	---
HCO_3^- (meq/lit)	11.18	9.4	8.8	---	0.14
Cl (meq/lit)	8.2	7.92	6.21	16.9	4-10
P (mg/lit)	3.41	2.12	1.8	---	---
K (mg/lit)	2.71	1.93	1.8	4.1	---
Ca (meq/lit)	3.51	3.02	2.64	---	---
SO_4^{-2} (meq/lit)	3.42	3.12	3	4.16	---
Na (meq/lit)	13.82	12.01	11.85	---	3-9
C (mg/lit)	150.47	58.02	30.02	---	---
N (mg/lit)	32.11	24.14	20.11	10	5-30
Salinity (ds/m)	1.83	1.62	1.52	---	< 3
pH	7.9	7.75	7.34	6.5-8.5	6.3-8.4

0.48% respectively. But highest essential oil yield (12 kg/ha), biological yield (5400 kg/ha), flowering shoot yield (500 kg/ha) and essential oil percentage (0.66%) were obtained under irrigation by secondary drainage water (Table 4).

Evaluation of accumulation of different elements in basil 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

Table 3. The amount of biological, chemical and microbial pollutants in domestic wastewater, primary drainage water and secondary drainage water.

	Domestic wastewater	Primary drainage water	Secondary drainage water
Coliform (n/100ml)	1.2×10^{18}	3×10^{5}	1.5×10^{3}
Fecal Coliform (n/100ml)	1.2×10^{18}	3×10^{5}	1.5×10^{3}
Parasite eggs	1.42	0	0
COD (mg/lit)	232	30	18
BOD_5 (mg/lit)	150	15	11

BOD_5 = Biological oxygen demand
COD = Chemical oxygen demand.

Table 4. Effect of irrigation by secondary drainage water on basil characteristics to compare with agronomical water.

	Secondary drainage water	Agronomical water	Percent of increasing (%)
Biological yield	5400 kg/ha	4900 kg/ha	+ 10
Flowering shoot yield	500 kg/ha	410 kg/ha	+ 21
Essential oil yield	12 kg/ha	10.2 kg/ha	+ 17
Essential oil percentage	0.66 %	0.48 %	+ 37

Table 5. Accumulation of different elements in basil shoots.

	N (%)	P (%)	K (%)	Protein (%)	Ca (mg/kg)	Cd (mg/kg)
Secondary drainage water	7.14	0.18	3.81	18.12	236	0
Agronomical water	6.84	0.14	3.42	14.07	228	0.01

condition (Table 5).

DISCUSSION

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. 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 basil, 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. 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 to evaluate 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.

Conclusion

Our results demonstrate that secondary drainage water is suitable for growth and quality production of basil essential oil production in areas where water supply is limited. In addition, for large-scale production not otherwise possible due to lack of water, cultivation with effluents has an additive economical benefit to the farmers. Therefore, irrigation of basil with the secondary drainage water can reduce stress on the plants, increase essential oil production, and may lead to an economic advantage over regular water irrigation. Practically, our findings may suggest farmers and agricultural researchers to consider carefully on limiting or control the huge water resources by the use of secondary drainage water.

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