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Full Length Research Paper

Domestic wastewater (DWW) influence on secondary metabolite in thyme (*Thymus vulgaris* L.) under field conditions

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In order to study domestic wastewater influence on secondary metabolite in thyme (*Thymus vulgaris* L.) under field condition, this experiment was carried out in Iran. In the field, 15 lysimeters having thyme (*T. vulgaris* L.) were used, where 1 to 5 lysimeters were irrigated by domestic wastewater and primary drainage water was accumulated. 6 to 9 lysimeters were irrigated by primary drainage water and then, were accumulated by 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. The secondary metabolite in thyme 3.4% increased under irrigation by secondary drainage water into irrigation by agronomical water. The findings may give applicable advice to medicinal and aromatic plants researchers 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.

Key words: Domestic wastewater, essential oil yield and *Thymus vulgaris*.

INTRODUCTION

Wastewater is any water that has been adversely affected in quality by anthropogenic influence. It comprises liquid waste discharged by domestic residences, commercial properties, industry, and or agriculture and can encompass a wide range of potential contaminants and concentrations. In the most common usage, it refers to the municipal wastewater that contains a broad spectrum of contaminants resulting from the mixing of wastewaters from different sources. Sewage is correctly the subset of wastewater that is contaminated with feces or urine, but is often used to mean any waste water (Mittler, 2002). "Sewage" includes domestic, municipal, or industrial liquid waste products disposed of, usually via a pipe or sewer or similar structure, sometimes in a cesspool emptier. The physical infrastructure, including pipes, pumps, and screens, channels etc. are used to convey sewage from its origin to the point of eventual treatment or disposal is termed sewerage. Any oxidizable material present in a natural waterway or in an industrial wastewater will be oxidized both by biochemical (bacterial) or chemical processes. The result is that the oxygen content of the water will be decreased. Since all natural waterways contain bacteria and nutrients, almost any waste compounds introduced into such waterways will initiate biochemical reactions (such as shown above). Those biochemical reactions create what is measured in the laboratory as the biochemical oxygen demand (BOD). Such chemicals are also liable to be broken down using strong oxidizing agents and these chemical reactions create what is measured in the laboratory as the chemical oxygen demand (COD). Both the BOD and COD tests are a measure of the relative oxygen-depletion effect of a waste contaminant. Both have been widely adopted as a measure of pollution effect. The BOD test measures the oxygen demand of biodegradable pollutants whereas the COD test measures the oxygen demand of oxidizable pollutants. The so-called 5-day BOD measures the amount of oxygen consumed by

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

pH	EC (ds/m)	FC	PWP	Caly (%)	Silt (%)	Sand (%)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	Mn (meq/l)	Pb (meq/l)	Zn (meq/l)	Humus (%)
7.1	6.24	14.47	8.21	39	23	38	13.24	17.28	25.17	6.93	2.14	2.45	1.7

biochemical oxidation of waste contaminants in a 5-day period. The total amount of oxygen consumed when the biochemical reaction is allowed to proceed to completion is called the ultimate BOD. The ultimate BOD is two times consuming, so the 5-day BOD has almost universally been adopted as a measure of relative pollution effect. There are also many different COD tests of which the 4 h COD is probably the most common. There is no generalized correlation between the 5 day BOD and the ultimate BOD. Similarly there is no generalized correlation between BOD and COD. It is possible to develop such correlations for specific waste contaminants in a specific waste water stream but such correlations cannot be generalized for use with any other waste contaminants or waste water streams. This is because the composition of any waste water stream is different. As an example and effluent consisting of a solution of simple sugars that might discharge from a confectionery factory is likely to have organic components that degrade very quickly. In such a case the 5 day BOD and the ultimate BOD would be very similar. That is, there would be very little organic material left after 5 days. However a final effluent of a sewage treatment works serving a large industrialized area might have a discharge where the ultimate BOD was much greater than the 5 day BOD because much of the easily degraded material would have been removed in the sewage treatment process and many industrial processes discharge difficult to degrade organic molecules. There are numerous processes that can be used to clean up waste waters depending on the type and extent of contamination. Most wastewater is treated in industrial-scale wastewater treatment plants (WWTPs) which may include physical, chemical and biological treatment processes. However, the use of septic tanks and other on-site sewage facilities (OSSF) is widespread in rural areas, serving up to one quarter of the homes in the U.S. The most important aerobic treatment system is the activated sludge process, based on the maintenance and recirculation of a complex biomass composed by micro-organisms able to absorb and adsorb the organic matter carried in the wastewater (Tchobanoglous et al., 2003). Anaerobic processes are widely applied in the treatment of industrial wastewaters and biological sludge. Some wastewater may be highly treated and reused as reclaimed water. For some waste waters ecological approaches using reed bed systems such as constructed wetlands may be appropriate. Modern systems include tertiary treatment by micro filtration or synthetic membranes. After membrane filtration, the treated wastewater is indistinguishable from waters of natural origin of drinking quality. Nitrates can be removed from wastewater by microbial denitrification, for which a small amount of methanol is typically added to provide the bacteria with a source of carbon.

Ozone waste water treatment is also growing in popularity, and requires the use of an ozone generator, which decontaminates the water as ozone bubbles percolate through the tank. Disposal of wastewaters from an industrial plant is a difficult and costly problem. Most petroleum refineries, chemical and petrochemical plants have onsite facilities to treat their wastewaters so that the pollutant concentrations in the treated wastewater comply with the local and or national regulations regarding disposal of wastewaters into community treatment plants or into rivers, lakes or oceans (Byrd et al., 1984). Despite the cost of wastewater 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 domestic wastewater influence on secondary metabolite in thyme (*T. vulgaris* L.) under field condition at Iran.

MATERIALS AND METHODS

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 (Table 1) and in order to prevent water influx from field to lysimeters, those placed on metal legs.

In this experiment, we have used the soil as a biological filter that can absorb pollution in the domestic wastewater. In this experiment, we had 15 lysimeters, containing planted thyme (*T. vulgaris* L.), where 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 by 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 (Figure 1).

At maturity, plants were collected from each lysimeter for determination of the flowering shoot yield and total dry matter. Then, 100 g flowering shoot dry matter was selected for determination of the 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 repeat measure analysis.

RESULTS

The chemical quality of domestic wastewater, primary

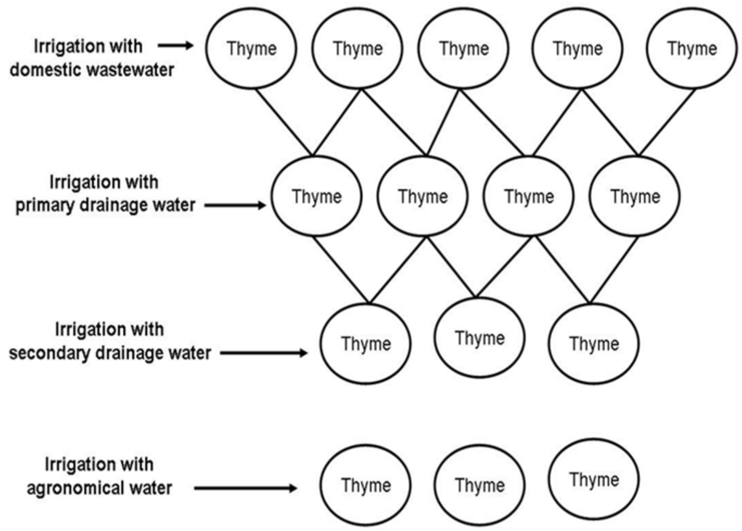

Figure 1. Experimental lysimentals in field.

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

Parameter	Domestic wastewater	Primary drainage water	Secondary drainage water	Agronomical water
BOD5 (PPM)	176	27	7.9	3.3
COD (PPM)	214	41	17.3	7.8
EC (ds/m)	5.52	4.61	3.75	1.03
pH	7.35	7.15	6.63	7.14
N (mg/lit)	36	21	19	9.8
P (mg/lit)	4.32	3.21	1.65	0.51
K (mg/lit)	3.48	1.73	1.62	0.58
Ca (meq/lit)	3.3	3.01	2.5	1.52
Mg (meq/lit)	2.56	1.69	1.14	0.86
Na (meq/lit)	11.82	11.25	11.14	8.05

BOD_5 = Biochemical oxygen demand. COD = chemical oxygen demand.

Table 3. Thyme features under irrigation by secondary drainage water and agronomical water.

	Essential oil yield (kg/ha)	Biological yield (kg/ha)	Flowering shoot yield (kg/ha)	Essential oil (%)
Secondary drainage water	8.7	8536	823	0.68
Agronomical water	7.9	5689	835	0.83
Variation percentage	+9.19	+33.35	-1.45	-22.05

drainage water and secondary drainage water is shown in Table 2.

The final results showed that use the secondary drainage water for thyme irrigation increased plat characteristics to compare with agronomical water. In the agronomical water irrigation condition the highest essential oil percentage (0.83%) and flowering shoot yield (835 kg/ha) were achieved. But highest essential oil yield (8.7 kg/ha), biological yield (8536 kg/ha), were obtained under irrigation by secondary drainage water (Table 3 and Figures 2 to 5).

Evaluation of accumulation of different elements in thyme 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

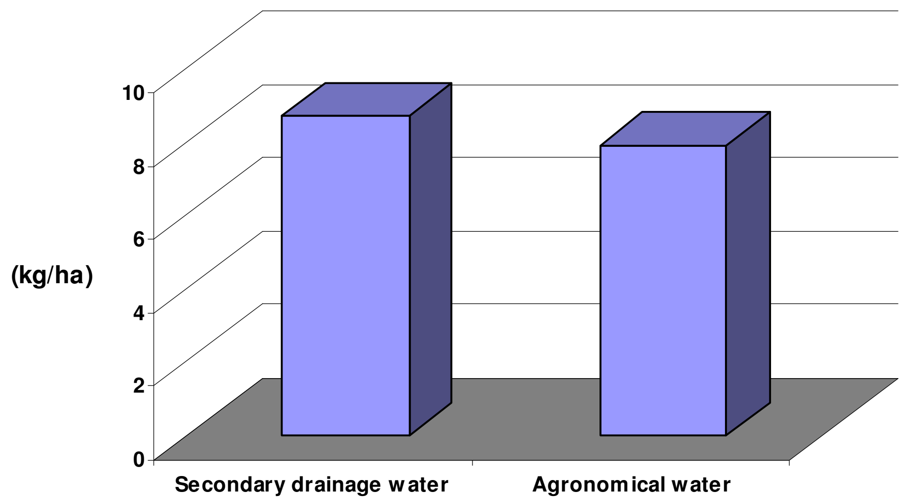

Figure 2. Essential oil yield variation in thyme.

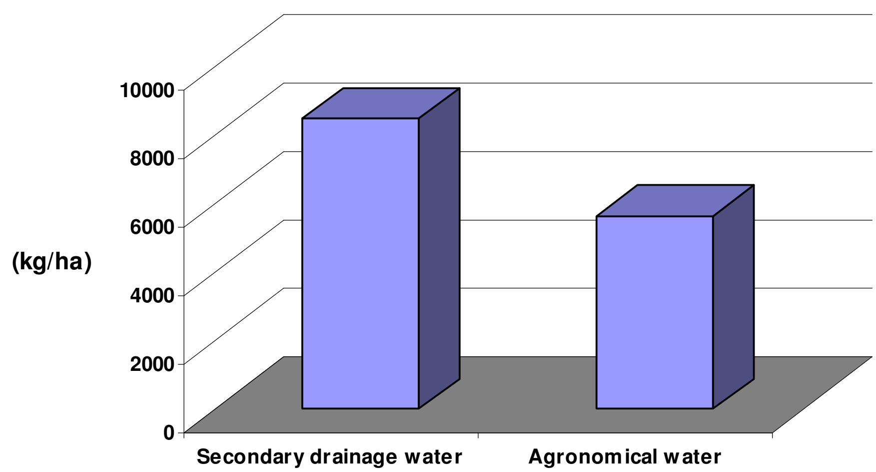

Figure 3. Biological yield variation in thyme.

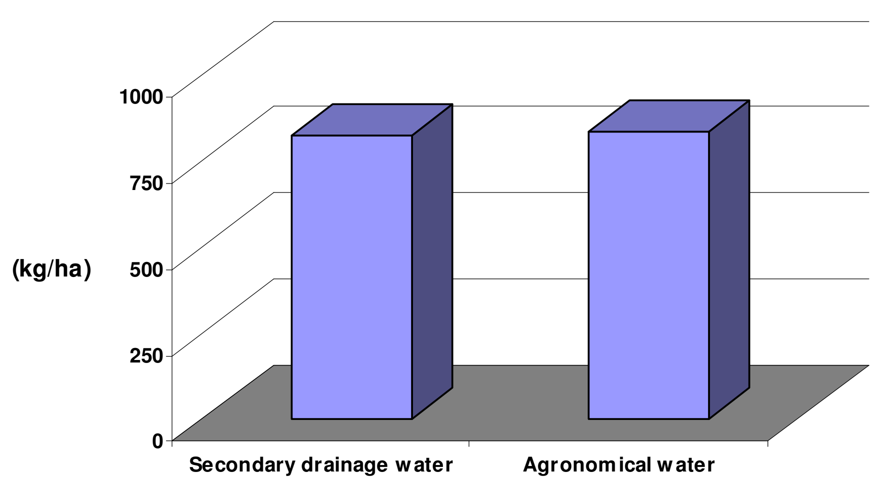

Figure 4. Flowering shoot yield variation in thyme.

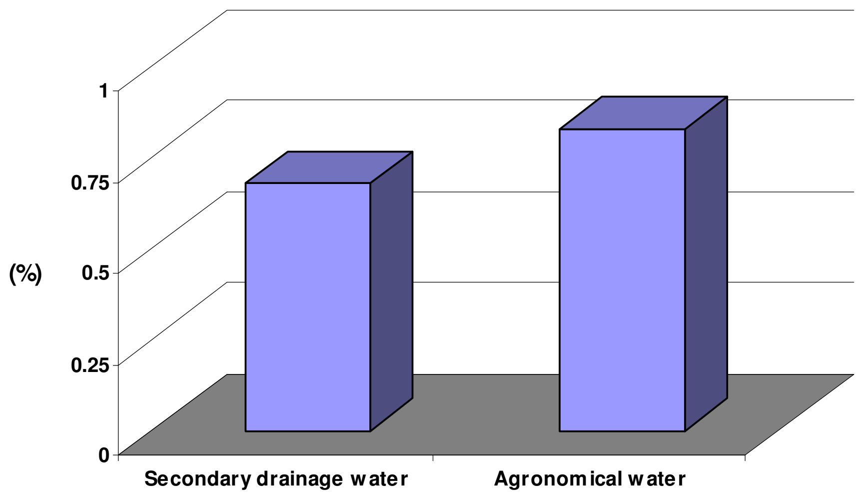

Figure 5. Essential oil percentage variation in thyme.

Table 4. Accumulation of different elements in thyme shoot.

Parameter		P (%)	K (%)	Protein (%)	Cd (mg/kg)
Secondary drainage water	7.35	0.19	2.46	14.23	0
Agronomical water	4.21	0.07	1.78	10.36	0
Variation percentage	+42	+63	+27	+27	---

condition (Table 4).

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 very 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. On the contrary, secondary drainage water supply in soil, created a situation where plant had to absorb nutrients by root growth. However, secondary drainage water element is not in essential oil components, but the final results indicated that application of secondary drainage water increased essential oil content of thyme, 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 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.

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