October 2010 ISSN : 0974 - 7451 Volume 5 Issue 5

Trade Science Inc.

Environmental Science

An Indian Journal

Current Research Papers

ESAIJ, 5(5), 2010 [306-310]

Effect of irrigation by treated domestic wastewater instead of well water on essential oil content in coriander (*Coriandrum sativum* L.) verities

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Received: 14th August, 2010 ; Accepted: 24th August, 2010

ABSTRACT

In this experiment, we had 15 lysimeters, that were planted coriander (Shahr-e Rey variety) in 1 to 5 lysimeters and were irrigated by domestic wastewater with BOD_5 about 150 mg/lit and primary drainage water were accumulated at 2010. In the 6 to 9 lysimeters was planted coriander (Shahryar variety) 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 coriander (Varamin variety). In order to compare plants characteristics, in 13, 14 and 15 lysimeters were planted Shahryar variety, Shahr-e Rey variety and Varamin variety 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 Shahryar variety 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.

KEYWORDS

Domestic wastewater;
Well water;
Essential oil content;
Coriander varieties.

INTRODUCTION

Coriander (*Coriandrum sativum*) has been used in Chinese cooking and medicine for millennia. It belongs to the parsley family, as does anise, caraway, dill and fennel. The fruits and leaves of coriander possess very different flavors and hence are used in different ways to flavor food. Coriander is an annual herb native to the Mediterranean region and Western Asia. However, commercial supplies now come from Turkey, India, Bulgaria, Russia, and Morocco. Coriander is a very ancient herb. It is mentioned in ancient Egyptian, Sanskrit, Greek and Latin writings. The ancient records reveal that coriander was used for both culinary and medicinal purposes. It was one of the substances utilized by Hippocrates, and other Greek physicians, for medicinal purposes. The Romans made coriander a popular spice, and introduced it to Great Britain. It was later brought to America, and was one of the first spices grown in New England. Coriander grows wild in Palestine. Hence, it's no surprise that it is mentioned in the Bible. The manna that was provided for the Israelites in

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)	5
Cu (meq/lit)	2.45	Cl (meq/lit)	5
Mn (meq/lit)	8.12	P (meq/lit)	35
Zn (meq/lit)	1.45	K (meq/lit)	20
Ni (meq/lit)	0.004	Ca (meq/lit)	28.8
Mg (meq/lit)	25.4	SO_4^{-2} (meq/lit)	2.12
Fe (meq/lit)	10.03	$Ca(OH)_2$ (%)	10
Pb (meq/lit)	1.75	Humus (%)	0.85
CO_3^{-2} (meq/lit)	0	pH	7.8

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
Cd (meq/lit)	0.05	0.02	0
Ni (meq/lit)	1.86	0.99	0.02
Mg (meq/lit)	2.75	1.96	1.7
HCO_3^- (meq/lit)	11.17	9.7	8.7
Cl (meq/lit)	8.7	7.97	6.27
P (mg/lit)	3.47	2.17	1.7
K (mg/lit)	2.77	1.97	1.7
Ca (meq/lit)	3.57	3.07	2.67
SO_4^{-2} (meq/lit)	3.47	3.17	2
Na (meq/lit)	13.87	12.07	11.87
C (mg/lit)	150.48	58.07	30.07
N (mg/lit)	32.17	24.17	20.17
Salinity (ds/m)	1.87	1.68	1.57
pH	7.7	7.71	7.37

the wilderness of the Sinai Peninsula during the Exodus was described as being "like coriander seed" and tasting like wafers made with honey (Exodus 16:31)[4]. 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[10]. 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[8]. 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 9000 m^3 ha^{-1} throughout the growing season, to satisfy their potential for intensive biomass production[5]. 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[9]. In some medicinal plants, water resources induced changes in antioxidants which were suggested to be involved in prevention of plant tissues damage[2]. Shortage of water in arid and semi-arid 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[5]. 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[6].

MATERIALS AND METHODS

This study was conducted on experimental field of Islamic Azad University, Shahr-e-Qods Branch at Iran (27°38′ N, 40°21′ E; 1417 m above sea level) during 2009-2010, with clay loam soil, mean annual temperature (31°C) and rainfall in the study area is distributed with an annual mean of 215 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).

In this experiment, we had 15 lysimeters, that were planted coriander (Shahr-e Rey variety) 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 coriander (Shahryar variety) 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 coriander (Varamin variety). In order to compare plants characteristics, in 13, 14 and 15 lysimeters were planted Shahryar variety, Shahr-e Rey variety and Varamin variety respectively and 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[1].

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 AND DISCUSSION

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 Shahryar variety 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 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 Shahryar variety 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 5).

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 Shahryar variety, 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

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)	1.1×10^{18}	2×10^{5}	1.4×10^{3}
Fecal Coliform (n/100ml)	1.1×10^{18}	2×10^{5}	1.4×10^{3}
Parasite eggs	1.47	0	0
COD (mg/lit)	237	37	17
BOD_5 (mg/lit)	157	17	10

TABLE 4 : Effect of irrigation by secondary drainage water on Shahryar variety characteristics to compare with agronomical water

	Secondary drainage water	Agronomical water
Biological yield	5407 kg/ha	4920 kg/ha
Flowering shoot yield	507 kg/ha	417 kg/ha
Essential oil yield	17 kg/ha	10.7 kg/ha
Essential oil percentage	0.67%	0.47 %

TABLE 5 : Accumulation of different elements in Shahryar variety shoot

	N (%)	P (%)	K (%)	Protein (%)	Ca (mg/kg)	Cd (mg/kg)
Secondary drainage water	7.16	0.16	3.86	18.16	237	0
Agronomical water	6.86	0.16	3.46	14.06	226	0.02

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.[3]. 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 Shahryar variety 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 Shahryar variety 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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