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ORIGINAL ARTICLE

Impact of Irrigation by Untreated waste water Effluent upon growth Indicators and Elements Accumulation in Strawberry (*Fragaria ananassa* L.)

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ABSTRACT
Considering the shortage of good quality water, consumption of non-conventional waters such as urban wastewater for use in agriculture is important. Urban waste water can be accounted for a rich source of the elements required by the plant, but incomplete treatment has raised concerns regarding existence of heavy metals in waste water and their entrance to food chain. In order to study the impact of irrigation by non-treated waste water upon chemical properties of the soil, growth indicators and accumulation of heavy metals in strawberry plant, an experiment in the form of factorial based on a fully randomized plan with 2 treatments and 6 repetitions has been executed and normal water as control and waste water were used for plants irrigation. At the end of experiment ,the indicators of strawberry plant as well as the accumulation rate of lead, cadmium and nickel in the plant fruit were evaluated. The results showed that irrigation through urban sewage and waste water has improved the factors relevant to the plant growth significantly, but caused accumulation of unauthorized amount of heavy elements in the plant fruit. The results of the research show that additional amounts of the metals in the soil and water can lead to greater uptake by plants and subsequent entry into the food chain of organisms.
Keywords*: strawberry, waste water effluent, heavy metals, growth indicators*

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INTRODUCTION

Growing populations, expanding agriculture and industry, and successive droughts in recent years have caused that the freshwater resources utilization reaches its peak and man turns to use non-conventional waters such as sewage effluent, especially in agriculture. The use of wastewater in irrigation of agricultural crops has been recommended as a source of nutrients required by plants in different countries, even using the effluent in producing crops causes early flowering and fruit set is larger than the typical water use [1]. But the main cause of concern for agricultural use of sewage is the presence of heavy metals entering the food chain of human beings and animals, because even at low concentrations, these metals are highly toxic to the body's mechanisms [1] Accordingly, Nabulo *et al*., [3] measured the concentrations of heavy metals in vegetable plants grown in nine infected points and according to these results, the concentrations of heavy metallic elements were at a high level that was due to y irrigation with sewage effluent , industrial discharge and waste disposal. Moreover, Khan *et al* ., [4] studied accumulation of heavy metals in the soils and infected foods products due to irrigation by waste water in China and stated that the concentrations of heavy metals in the plants grown in the soils irrigated by waste water were significantly higher than those grown in the normal conditions. Unfortunately, there are still areas where it is use of urban untreated sewage to irrigate their crops and garden and causes that the toxic metals enter the food chain of human beings and animals. In our research, we have decided to study the impact of the use of untreated urban sewage on strawberry plant growth and accumulation of heavy metals lead, cadmium and nickel in this plant.

MATERIALS AND METHODS

This experiment was conducted on strawberry plant salvia figure with 2 treatments and 6 repetitions in a factorial experiment based on completely randomized plan in Kresht village (Tehran) in 2013.Waste water effluent flowing in the region and normal water were used for plants irrigation and before starting experiment, the range of heavy metals existing in sewage effluent and waste water was measured. At the end of experiment, plant growth indicators including number of leaves, leaf area, fruits number, chlorophyll total amount [5], dry weight of aerial organ, number of flowers and the percentage of soluble solid materials were measured. Concentrations of heavy metals lead, cadmium and nickel in strawberry plant were evaluated as well. At the end of the experiment,data analysis was executed using SAS software and Duncan Multi Range Test (DMRT) in the probability levels of 1 and 5.

Results and discussion

1- Particularities of tested waters

According to the table No.1, urban waste water effluent includes a higher range of PH and salinity than normal water; high level of effluent PH can causes rise in the soil pH [1], abundant minerals in urban waste water and sewage and adding them to the soil over time will increase the electrical conductivity of the soil. Accordingly, Singh and Bahati [6] also stated that existence of basic cations including calcium, manganese, potassium and sodium in urban waste water is due to the high level of pH. The above table also shows that the evaluated metal in sewage effluent was in more abundant range than the double-ionized distilled water.

Table 1- Concentration of heavy metals in tested water

Treatment	pH	EC (dS/m)	Pb (mg/L)	Cd (mg/L)	Ni (mg/L)
Normal water	7.2	1.45	0.03	0.01	**0.01**
Waste water	8.95	4.7	0.38	0.12	**0.12**

According to the standards of FAO (1995) the authorized range of lead, cadmium and nickel is 0.1, 0.01 and 0.6 gram per liter respectively. Therefore, the accumulation of these elements in the soil and plant is evident due to high concentrations of heavy metals [7].

2-Plant growth indicators

The table No.2 shows that in all measured growth factors ,the plants irrigated by waste water effluent indicate a far better situation than the control, because irrigation by waster water causes the rise in the soil nutrients quantities [8] and easier access to high concentrations of macro and micro nutrients in urban wastewater causes an increased rate of growth [9].

Table 2- Plant growth indicators

Treatment	Leaf area (cm2)	Number of leaf	fruits number	Chlorophyll mgg-) (1.f.w.	dry weight of leaf (g)	number of flower	soluble solid materials (%)
Normal water	1037 b	15.15 b	4.56 b	42.39 b	4.33 b	5.91 b	**9.12 b**
Waste water	1285 a	19.4 a	6.55 a	49.8 a	6.54 a	7.26 a	**9.44 a**

In addition, organic materials in sewage cause the improvement of the soil physical conditions and as a consequent the rise in plants' efficiency [10]. Until now, effluent and waste water significance as supplier of plants needs to water and nutrients have been proved in numerous researches. Accordingly, Myers *et al*., [11] stated in their experiments that application and use of urban waste water by affecting upon plant physiological process facilitate growing of leaves to grow and as a consequent increases the number of plant leaves and rise in biomass. Therefore, the rise in indicators relevant to plant growth including number and area of leaves, dry weight of leaves ,chlorophyll content and …in irrigated plants is not unexpected.

3- Concentrations of heavy elements in strawberry fruit

According to the table No.3, the amount of lead absorption by strawberry plant in the treated plants through waste water effluent is several times more than plants treated by normal water.

Table 3- Concentrations of heavy elements in strawberry fruit

Treatment	Pb (mg/Kg)	Cd (mg/Kg)	Ni (mg/Kg)
Normal water	1.5 b	0.5 b	0.67 b
Waste water	8.9 a	3 a	6.6 a

Maximum authorized amount of lead in the plant is 5 mg/kg [12]. Therefore, concentration of this element in plant tissue is more over than authorized level. The rate of lead absorption in different plants include different limits and the adverse impact of heavy metals such as lead upon human health has been proved [13].

Cadmium element had also a higher level of concentration and density than that measured in the plants irrigated by normal water and also had an authorized level, because cadmium amount in plant for human consumption should not be exceed 0/1mg/kg [12]. Cadmium range in plants changed according to plant species ,root environment and cultivation time [14]. Rather high levels of cadmium concentrations can be accumulated in nutritive parts of plant without any obvious sign of the disease affecting the plant [12].

Nickel like the above mentioned elements had also higher concentration than authorized level in the treated plants by waste water effluent. The average amount of nickel entering human organism through daily nutrition is about 400 to 500 microgram [12]. Rise in nutritive concentration in plant(leaves and fruits) is due to the increase of these elements in irrigation source or soil [10]. Therefore, it is not unexpected that high range of these heavy metals (and even other unmeasured metals) in plant tissue would be seen. Of course, it should be noted that waste water flowing in this region is raw and so far nothing has been done for treating and refining it.

CONCLUSION

The findings of the research showed that sewage effluent can be applied as a resource rich of nutrients for plants growth and increase of products, but the main problem with this issue is high concentration of heavy metals in effluent which causes accumulation of these elements in the soil and the plant and consequently, entrance of toxic elements to human and animal life cycle. Therefore, used waste water effluent must be treated, filtered and processed so that these elements would not damage the environment and fauna.

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