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Effect of Wastewater Irrigation on Tagetes Plants

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Abstract. Field and experimental studies were conducted to determine the effect of some contaminants which reached the water stream from a variety of sources near Ras El-Soda area (Alexandria) on some ornamental crops and on marigold plants. The combined industrial and animal wastes lead to large increase in microelement level in nursery surface soils. Roses, carnations and bird of paradise plants suffered from chlorosis and necrosis. Water samples indicated significant increases in BOD, calcium, sodium, bicarbonate, chloride and COD. Soil samples taken from the area irrigated for 3 years with wastewater contained a higher concentration of K, Fe and Cu. The E.C. value of the soil was increased from 1.7 to 7.0 mmhos/cm. Growth of marigold plants was stimulated by irrigation with water mixture consisting of 35% waste-water +65% tap-water but did not tolerate 100% wastewater treatment and with 100% mortality. Leaves of tagetes plants irrigated with wastewater have similar concentrations of heavy metals as did plants irrigated with wastewater. Heavy metal content of the soil irrigated with wastewater was generally close to that of the control (tap water). The E.C. was markedly increased when the soil was irrigated with 100% waste water.

Introduction

Pollutants discharged from chemical industries are considered an important menace to human life. Their drastic damage to agriculture is poorly understood, especially under the Egyptian environment. Each pollutant has a primary effect on various crops either byd killing directly or by changing their physiology that the composition and growth of the crops are drastically changed [1].

Million gallons of wastewater were discharged daily in lakes and streams in Alexandria city. This effluent is usually highly enriched with plant nutrients as well as toxic heavy metals. Use of such water in irrigation can cause a harmful effect on vegetation. The phytotoxicity of industrial effluents has to be determined.

The aim of this work was to study the number of contaminants which reached the water stream from a variety of sources near Ras El-Soda area on some ornamental crops in a commercial nursery. The effect of irrigation with this polluted water on marigold plants was also investigated in two different locations.

Materials and Methods

First experiment

The commercial nursery was located 200 meters south of Siklam Dairy Proccessing Factory in Ras-El-Soda area, Alexandria. This Nursery is the largest commercial nursery in Alexandria with 10 Acre production area and producing cut flowers, pot and container plants as well as greenhouse and foliage crops. For the last 5 years, nearly half of the production was irrigated by water taken from stream canal where Siklam Dairy Proccessing Factory and an animal production station discharge their effluents. The second half of the nursery area is designed to produce container plants and irrigated with tap water.

Dairy plant (Siklam Dairy Factory) discharges the following quantities in the drainage system [2].

Volatile material	= 6.0 ton/day
Oil and lipid	= 1.0 ton/day
BOD	= 1.2 ton/day
COD	= 3.7 ton/day
Suspended matter	= 3.0 ton/day

During and after the experiment, samples of plant tissues samples of the soils of the nursery (from depth of 20 cm) and irrigation water were collected and analyzed for metal and other chemical and physical properties according to the standard methods for water and wastewater analysis [3]. Trace metals were conducted using acid digested wastes aspirated in jarrel ash 750 atomic absorption spectrophotometer.

Second experiment

A pot experiment was run to study the effect of the wastewater effluents on single ornamental crop. Weekly samples were obtained upstream and downstream of the same wastewater stream. This wastewater was mixed with tap water at the followig dilutions (by volume):

1 - 100% wastewater
2 - 70% wastewater + 30% tap water
3 - 35% wastewater + 65% tap water
4 - 100% tap water (control).

Tagetes erecta L. seedling with 10-15 cm height were transplanted in 25 cm diameter pots containing loam/sand media. The seedlings were irrigated every 3 days with the different wastewater treatments.

Two sets of experiments were carried out, the first was located at the commercial nursery, whereas a similar and second set was conducted at Ornamen-

tal Research Station; Faculty of Agriculture, Abis, Alexandria. The average of the two sets of experiments was recorded in the tables as one mean.

Tagetes plants were hand watered and no fertilizer was added. Both sets of the experiments were designed as randomized blocks with 4 replications each. The replicate unit consisted of 4 plants (sub-samples). Flowering dates were determined and were considered as the number of days from seeding to the opening of the first flower. Plant height and fresh weight were recorded at the end of the experiment.

Soil samples for potting were analyzed at the end of the experiment at the International Center for Rural Development (Ameriya, Alexandria).

At the end of the experiment leaf samples were dried and then ground. The ground materials were analyzed for heavy metals using the atomic absorption spectrophotometry. Both leaf samples and chemical analysis of the tested effluents were analyzed at the High Institute of Public Health, Alexandria University.

Results

Field study (nursery observations)

Heavy application of wastewater and animal wastes enriched in metals lead to large increase in micro-element levels in nursery surface soils (Table 1). Their accumulation represents a long range potential for phytotoxicity.

Analysis of irrigation water: Water samples obtained upstream and downstream indicated significant increases in BOD, calcium, sodium bicarbonate chloride, COD and total suspended solids. This large increase of nutrients was formed when excessive amounts of animal wastes and milk processing wastes are disposed with watering on the nursery soil (Table 1).

Soil analysis: Soil samples taken at random from different areas and irrigated with wastewater contained a higher concentration in potassium, Fe and Cu. However, the E.C. was increased from 1.7 to 7.0 mmhos/cm. Concentrations of phosphorus, Mg, Zn, calcium carbonate, showed little or no increase in polluted soil compared with soil irrigated with tap water (Table 2).

Apparently some physical, chemical, and biological problems were associated with irrigation by wastewater to ornamental crops in the nursery. Our observations indicated that roses, carnations and bird of paradise (sterlitzia) plants suffered much when grown on polluted water showing chlorotic leaf tips, necrosis and leaf absces-

Table 1. Analysis of wastewater effluent produced by dairy processing factory and animal produc" station.

Constituents		Tap water	Wastewater
E.C.$^{-1}$	mmhos/cm	0.11	6.25
Ph		7.1	7.6
Calcium	mg/l	0.50	5.0
Sodium	mg/l	0.26	4.74
Potassium	mg/l	0.04	0.66
Bicarbonate	mg/l	0.69	3.87
Nitrate + Ammonia – N	mg/l	1.0	40.0
Total dissolved solids	mg/l	0.43	1.4
B.O.D^{-2}	mg/l	32.2	356.0
C.O.D ^{3}	mg/l	872.0	1567.0

1 – E.C = Electrical Conductivity
2 – BOD = Biological Oxygen Demand
3 – COD = Chemical Oxygen Demand

Table 2. Chemical analysis of soil taken from the nursery and irrigated by wastewater or tap water.

Constituents		Soil irrigated with tap water	Soil irrigated with wastewater
Ph		7.60	7.30
E.C. mmhos/CM^{-1}		1.7	7.0
Potassium (mg/100 gm)		29.2	136.0
Phosphorus (mg/100 mg)		20.8	20.0
Fe	ppm	14.3	33.0
Cu		16.7	69.0
Mg		200.4	216.1
Zn		19.9	26.0
Calcium carbonate		19.8	27.0
Silt (%)		28.0	29.0
Sand (%)		62.0	64.0
Clay (%)		8.0	7.0

1 – E.C = Electrical conductivity.

Table 3. Influence of wastewater irrigation of different concentrations on growth parameters of tagetes.

Wastewater % in the mixture	Height (cm)	Fresh weight (g)	Days to flowering
Zero	35.6a*	46.8b	66a
35	44.7a	58.7a	71a
70	20.4b	25.4c	63a
100	died	died	died

* Mean separation within column by Duncan's Multiple range test (0.05)

Table 4. Concentration of heavy metals in tagetes leaves.

% Wastewater in the mixture	Zn mg/g	Fe mg/g	Cu mg/g
Zero	0.038	0.037	0.002
35	0.036	0.028	0.001
70	0.051	0.033	N.D.[1]
100	0.078	0.026	N.D.

1 – N.D. = Non Detectable

Table 5. Chemical analysis of the soil after 90 days of irrigation with wastewater.

Soil irrigated with	PH	E.C Mmohs/Cm	Zn mg/g	Fe mg/g	Cu mg/g	P mg/g	NO3 mg/g
Tap water	7.2	1.7	0.067	0.48	0.06	1.4	1.7
100 % Wastewater	7.4	7.0	0.108	0.53	0.06	1.1	7.7

sion especially in the lower parts. Dieback symptoms on some of these plants, especially roses were common. Instance of salt injury to roses and dahlia plants grown in soil irrigated by wastewater have been reported. On the other hand, plants irrigated with tap water did not produce any symptoms. A permeability problem occurred in the surface layer of the soil and may be related to the comparatively high sodium concentration of the waste water.

A - Morphological symptoms: Plants irrigated with water having, 70% wastewater showed chlorotic leaf tips, necrosis and leaf abscission in the lower parts. Whereas those irrigated with 35% of tap water showed no signs of abnormality.

B - Plant growth and flowering: The highest growth was obtained from zero and 35% waste water treatments, while height of plants irrigated with 70% waste water was significantly less than that of the control (Table 3). Marigold plants did not tolerate 100% wastewater treatment. Those plants had 100% mortality.

On the other hand, mixing tap water with 35% wastewater stimulated fresh weight which was nevertheless, significantly reduced when irrigated with 70% wastewater. Flowering date was not affected significantly by any treatment in this experiment (Table 3).

C - Leaf content of heavy metals: The analysis of marigold leaves which has received wastewater treatment showed little but insignificant increase in heavey metals uptake (Table 4).

D - Soil content of heavy metals: The soil used for seedlings growth was analyzed at the end of the experiment (Table 5). Heavy metal content of the soil irrigated with wastewater was generally close to that of the control (tap water). Concentration of No. 3 was slightly increased compared with tap water treatment. However, E.C. was also markedly increased when the soil was irrigated with 100% wastewater.

Discussion

The nutrients in wastewater (e.g. nitrogen, phosphorus..) provide fertilizer value to crops but excessive contents may delay maturity and may reduce water quality. For example, heavy applications of farm manures to land may, in addition to elevating the nitrate contents of soil and water, produce ammonium toxicity of plants [4]. The height and fresh weight of plants irrigated with 35% wastewater was stimulated. There were many reports of stimulatory effects upon enzymes caused by low concentration of heavy metals in irrigation water [5,6].

In these experiments, instances of salt injury to tagetes plants following irrigation by wastewater have been reported. Leaves of tagetes plants showed leaf burn and chlorosis. This may be due to excessive sodium or other cations in wastewater which can substitute for other cations in the soil [1] and which tends to disperse caly particles in the soil, leading to decreased permeability. Marigold plants under 100% wastewater irrigation regime had 100% mortality. Salinity might be the most important factor in killing plants when it exceeded the normal rate (above 7 mmhos/cm) [1].

This study indicates that irrigation by wastewater did not produce difference in leaves content of heavy metals. Because the analysis was carried out in the leaves, heavy metals taken up by plants tend to remain in the roots [1].

The BOD and COD were high in the wastewater. Manning [7] demonstrated that sewage and paper industries add considerable wastes to waters. Rapid decomposition of the materials by aerobic bacteria greatly depletes the water's oxygen content which increases BOD and COD.

Recycling wastewater might be available option for increasing horticultural crop yield and production. Some additional treatments can be made before such water can be used for agricultural and landscape irrigation.

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تأثير الري بمياه مخلوطة بمخلفات المصانع على نبات القطيفة

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ملخص البحث. أجريت هذه الدراسة على مرحلتين، الأولى في مشتل تجاري في منطقة الرأس السوداء ويعتبر من أكبر مشاتل محافظة الاسكندرية. ويصب في مصدر مياه الري لهذا المشتل مخلفات مصنع سيكلام لمنتجات الألبان كذلك تخلط معه مخلفات الماشية الموجودة في عنابر تربية الماشية الواقعة على مجرى المياه نفسه وفي المنطقة نفسها.

وكان الهدف من هذه الدراسة بحث تأثير هذه المخلفات المخلوطة بمياه الري على صلاحية التربة في المشتل التجاري وبالتالي على بعض محاصيل الزينة التجارية والتي تروى من هذا المصدر خلال السنوات الثلاث السابقة. وقد تم تحليل مياه الري الملوثة ووجدت زيادة جوهرية في BOD وأيونات الكالسيوم والصوديوم والبايكربونات والكلورايد و COD. وقد احتوت عينة التربة التي أخذت للتحليل على نسبة عالية من البوتاسيوم والحديد والنحاس. وقد ازدادت درجة تركيز الأملاح E.C) (والتوصيل الكهربائي) من ١,٧ إلى ٧,٠ mmhos/cm. وكانت محاصيل الورد والقرنفل وعصفور الجنة هي أكثر نباتات الزينة تأثرًا من المياه الملوثة.

وقد أجريت المرحلة الثانية من الدراسة في مشتل الزهور والزينة بالكلية وتم استخدام هذه المياه نفسها في ري نبات الماريجولد (القطيفة) Tagetes المزروع في قصارى. وكانت هناك تجربة مماثلة تمامًا ومقارنة في المشتل التجاري. وقد وجد أن خلط ٣٥٪ من المياه الملوثة بـ ٦٥٪ من مياه الشرب قد شجعت النمو الخضري لنبات القطيفة. ولذلك ثبط النمو جوهريًّا عندما تم خلط ٧٠٪ من المياه الملوثة بمياه نقية واحترقت النباتات تمامًا عند استخدام مياه الري بدون أي تخفيف. أما محتوى الأوراق من العناصر الثقيلة فلم يتغير نتيجة الري بالمياه الملوثة. كذلك لم تتأثر التربة نظرًا لقصر مدة الري التي لم تتعدى ٤ شهور باستثناء زيادة جوهرية في تركيز الملوحة (E.C) والتي ارتفعت نتيجة للري بالمياه الملوثة.