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Phytocidal Activity of the Treated Municipal Wastewater of Riyadh City, Saudi Arabia*

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Abstract. Four field experiments were conducted in the Agricultural Research and Experimental Station in Dierab, 25 km southwest of Riyadh, to investigate the phytocidal activity of the treated municipal wastewater (SW) on the alfalfa, wheat, tomato and spinach. The experiments included four treatments; two were for the water-type of irrigation (SW) and fresh water (FW); and the remaining two were for the pesticidal (P) and non-pesticidal treatments. Hence the four treatments were SW, FW, SWP, and FWP. Estimates of the phytotoxicity included the measurements of the chlorophylls (CHL) content of the leaves and dehydrogenase activity of the soil (SDA), as well as the phytotoxicity of each of soil extracts (SE) and SW-total soluble solids (LTS).

The results showed that in spite of thge overall growth and production promotion, SW-irrigation decreased the CHL of the alfalfa and spinach, and the SDA as well. SW soil extracts caused a pronounced phytotoxicity, while pesticidal application improved it significantly. Low concentrations of the LTS promoted the seedling growth, but it was severly inhibited by high ones. The inhibition in this case was proportionally correlated with the applied rates of LTS.

Introduction

Secondary treated municipal wastewater (SW) of the city of Riyadh was being used for the agricultural irrigation-purposes in certain crops. Its content of soluble salts can be either beneficial or hazardous to crop plants. Higher levels of Na^+ and (or) Cl^- may induce phytotoxicity, whereas similar levels of N, P and K are considered to be nutrients for crop growth when supplied in proper amounts.

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A study on the use of SW on turf irrigation [1] indicated that SW irrigated soils contained greater concentrations of potentially hazardous Na and soluble salts plus higher concentrations of potentially beneficial plant nutrients when compared to potable irrigated soils. It was found also [2] that leaves of many crops showed leaf burn due to excessive Na^+ or Cl^- contents of SW, especially under conditions of low humidity and high evaporation rates.

Emergence of Bermuda grass was reduced by SW irrigation, relative to potable water, but seedling establishment was improved later on [3]. An inhibitory effect on seed germination and early plant growth was also observed by various treatments containing waste water from olive industry [4]. Plots of Bermuda grass irrigated with SW showed signs of leaf chlorosis, resulted from high P content, which produces insoluble iron phosphates in the soil or plant [3,5]. Heavy metals taken up by vegetable plants grown on SW tend to remain in the roots, while only a fraction of them were translocated to the tops and even a smaller fraction reached the fruits [2].

The aim of this study is to evaluate the phytocidal activity of the SW of Riyadh, on alfalfa, wheat, tomato and spinach germinations and growths. Laboratory tests and field experiments, were conducted for the estimations of the chlorophyll content, soil dehydrogenase activity, and the phytotoxicities of each of SW and soil extracts.

Materials and Methods

1. Phytotoxicity tests

These were carried out according to the modified Naubauer technique [6], in which an aliquot (20 cc) of the tested liquid or solution was added to a Petri- dish (9 cm in diam.) containing a filter ppaer with the same diamter. The dish was covered and left for half an hour. Seeds or grains (10-20) of the tested plant were placed on the filter paper inside the petri-dish, then placed together (without its cover) inside a 0.1mm thick transparent polyethylene bag (30 × 40 cm). The bag was expanded by blowing air inside it, and was then tightly closed with a rubber band, while the inner Petri-dish was maintained in a horizontal level. The bag and its containments was considered as one replicate. Replicates were then placed inside a controlled -environmental grwoth chamber at 24 C°±1 during the light period (12 hr.) and at 18°C ±1 during the dark period (12 hr.) periods of time. The treatments were inspected daily, for 7 to 9 days after the seeding date, then dishes were taken out, and lenghts of the seedling growth were measured.

2. Lyophillized total-solids (LTS)

Aliquots of treated municipal waste water (SW) were freeze-dried using a Labconco Model 77520 Bench-Top Freeze dry system, at -75°C and 50 μHg vacuum for 24 hr. Lyophillized total solids (LTS) were found to be 1.05 + 0.09 mg/ml. Solubility tests including water, acidic, alkaline and organic solvents revealed that LTS was very soluble in HCl solution (5%), soluble in water; sparingly soluble in acetone, and practically non-soluble in acetonitrile, chloroform, ethanol, ether, hexane, methanol or NaOH solution (5%).

Crude LTS was used to study its effects on wheat (*Triticum aestivum*) and cucumber (*Cucumus sativus*) germination and seedling growth. The test was carried-out according to the modified method of Neubauer [6], and included serial concentrations of LTS in distilled water. It also included two check treatments, fresh and filtered SW for comparison. The number of replications were six, with 10 seeds or grains each.

3. Soil extracts (SE)

Four field experiments were conducted in the Agricultural Research and Experimental Station (ARES) on Dierab, for two seasons (1989 and 1990). The experiments were cultivated with alfalfa (*Medicago sativa*), tomato (*Lycopersicon esculentum*); wheat (*T. aestivum*) and spinach (*Spincacia oleraceae*). In each of these experiments, four treatments were included, two of them were for the water type of irrigation without any chemical treatment against pests and diseases, whereas the remaining two were for the use of such chemicals. Hence, the four field treatments were: Secondary treated municipal waste water of Riyadh (SW), fresh water (FW), SW irrigation plus pesticide application (SW) and FW irrigation plus pésticide (FWP). Analysis of SW, FW and soil are presented in Table 1, and the pesticidal treatments of the field experiments are in Table 2.

Table 1. Analysis of secondary treated municipal waste water (SW); fresh water (FW) and soil samples from field of experiments.

Determination	SW	FW	Soil
pH	7.26	7.80	7.67
EC ,dSm^{-1}	1.61	0.70	2.70
COD ,mg/l.	89.00	---	---
NH_3–N ,mg/l.	20.70	---	---
PO_4–P ,mg/l.	6.90	---	8.90
K^+ ,mg/l.	15.10	1.10	1.20
Ca^{++} ,mg/l.	128.00	3.27	12.30
Mg^{++} ,mg/l.	28.00	1.89	8.80
Na^+ ,mg/l.	140.00	1.95	8.50
SO_4^{--} ,mg/l.	326	187	202
Cl^- ,mg/l.	170	66	128
HCO_3^- ,mg/l.	195	67	79
TSS ,mg/l.	1050	450	---
CO_3^{--} , eq	---	---	40.00
Sand , %	---	---	40.00
Silt , %	---	---	38.00
Clay , %	---	---	12.00

Source: [14]

Table 2. Schedule of the pesticide applications and their dates for the control of alfalfa, tomato, wheat and spinach pests

Date	Pesticide and formulation	Spray concentration
	Alfalfa	
01.01.1989	Phosphamidone (Dimecron, 50% EC.)	0.10%
28.02.1989	Primicarb (Pirimor, 50% WP.)	0.15%
04.12.1989	Methidathion (Supracid, 40% EC.)	0.15%
12.02.1990	Dimethoate, 40% EC.	0.10%
26.02.1990	Malathion, 57% EC.	0.05%
17.03.1990	Methidathion (Supracid, 40% EC.)	0.15%
19.03.1990	Fenpropathrin, (Danitol, 10 EC.)	0.125%
20.02.1990	Fenpropathrin, (Danitol, 10 EC.)	0.125%
	Tomato	
02.12.1988	Dimethoate, 40% EC.	0.15%
10.12.1988	Diathane M-45	0.25%
13.10.1989	Dimethoate, 40% EC.	0.15%
22.10.1989	Dimethoate, 40% EC.	0.15%
25.10.1989	Fenpropathrin, (Danitol, 10 EC.)	0.15%
30.10.1989	Benomyl, (Benlate, 50% WP.)	0.05%
01.11.1989	Dimethoate, 40% EC.	0.15%
06.11.1989	Fenpropathrin, (Danitol, 10 EC.)	0.15%
13.11.1989	Malathion, 57% EC.	0.15%
26.11.1989	Dimethoate, 40% EC.	0.15%
28.11.1989	Pirimiphos Me (Actellic, 50% EC.)	0.15%
04.12.1989	Pirimiphos Me, (Actellic, 50% EC.)	0.15%
06.12.1989	Methidathion (Supracid, 40% EC.)	0.15%
10.12.1989	Diathane M-45	0.25%
13.12.1989	Fenpropathrin (Danitol. 10 EC.)	0.15%
23.12.1989	Fenpropathrin, (Danitol, 10 EC.)	0.15%
	Spinach	
01.01.1989	(Ridomil, MZ 56% SC)	0.25%
03.01.1990	Metiram, (Polyram combi, 80% WP.)	0.15%
27.02.1990	Metiram, (Polyram combi, 80% WP.)	0.15%
06.03.1990	Metiram, (Polyram combi, 80% WP.)	0.15%
	Wheat	
01.01.1990	Diclofop-Me, (Illoxan, 28% EC.)	3.0L/ha.
14.01.1990	Bromoxynil, (Pardner, 24% EC.)+	3.0L/ha.+
	2,4-D; MCPA, (U-46 fluid combi, 48% EC.	1.5L/ha.

Source [14]

Soil samples were taken from each of the experiments on time of the second season, for extraction processes. Extraction was carried-out [7] on air dried soil samples (100 g) each, in brown colored bottles, using 50 ml of alkaline methanolic solition (95% methanol, pH 11) for 24 hrs. The extracts were evaporated under vacuum to dryness, using a rotary evaporator. The residues were then dissolved in small amounts of acidified (HCl) water and re-extracted five times, each with 25 ml of diethyl ether. The ether was evaporated, and the residue was then re-dissolved in distilled water (40 cc), and used in the phytotoxicity tests, mentioned before.

4. Soil dehydrogenase activity (SDA)

SDA measurements were carried out [8] using 2,3,5-tri--phenyl tetrazolium chloride (TTC) as a substrate. Briefly, soil samples (5g each) were taken from each experiment on the second season, and mixed with calcium carbonate (0.05g) in test tubes, to which TTC solution (3%, 1 ml each) and water (3 ml) were added and thoroughly mixed. The tubes were then covered and incubated at 37°C for 24 hr. The formed formazan was extracted properly by methanol, and filterated on cotton wool. The optical density (D) of the filterates were then measured using a Spectronic 20 Photometer at wave length 485 *nm,* methanol was used as a blank. The formazan concentrations were determined as mg/5g soil/24 hr. using a standard curve.

5. Clorophyll contents (CHL)

Extractions and estimations of the CHL of alfalfa, spinach and wheat leaves were carried-out [9] on three successive dates. The extraction was acheived with acetone (80%), and the estimations were done using a Beckman UV 5240 spectrophotometer, at three wave lengths 645, 652 and 663 *nm,* in a 10 mm cuvette. Concentrations of each of chlorophylls (a), (b) and (Total) were calculated in mg/g of leaves using the equations of ARnon [10]. Results were statistically analyzed [11], and the means were compared according to Duncan's new multiple range test [12].

Results and Discussion

1. Phytotoxicity of lyophillized total solids (LTS)

Results of the LTS phytotoxicity, presented in Table 3, showed that SW and filtered SW (SWF) treatments exhibited a stimulative effect on the growth of wheat roots and shoots, and on the cucumber roots as well. The shoot growth of cucumber was inhibited with the SW and SWF treatments. The improvements in the seedling growth, caused by the SWF treatment was significant in case of wheat-roots, and non-significant for its shoots, as compared to the LTS concentrations and that of the O ug/ml. (distilled water). Suspended solids in SW were from 13 to 62 mg/l (ppm), with a typical value of 25 mg/l [2]; these solids consists of biodegradable organic materials, that are toxic to the seedlings.

Growth of wheat roots or shoots was gradually decreased with the increase of LTS-concentrations, up to 10,000 ug/ml., but the root lengths in all treatments of LTS-concentrations were non-significantly different among each other. Shoot growth of seedlings was responding irrigularly as the concentration of LTS increased

(Table 3). However, it was found [4] that, all the wastewater treatments, interfered more markedly with the shoot growth than with the root, and similar effect was also observed as a result of using different salinity levels on germination and growth of pearl millet.

Table 3. Effects of different concentrations of the SW - lyophillized total solide (LTS) on the seedling growths of wheat and cucumber

concentration of LTS (ug/ml.)	Lengths (cm)			
	Wheat		Cucumber	
	Root	Shoots	Root	Shoots
0	11.10 bc	10.85 bcd	4.1 bc	5.9 bc
10	10.440 bc	11.85 ab	6.4 a	9.0 a
100	11.10 bc	11.35 abc	6.2 a	7.0 b
500	--	--	6.0 a	6.8 bc
1000	9.30 c	10.25 cd	4.9 ab	5.1 cd
2500	10.35 bc	11.65 ab	2.7 c	3.6 de
5000	--	--	2.5 cd	3.4 e
10000	9.10 c	9.60 d	1.1 d	1.4 f
SW	11.95 ab	12.00 ab	5.7 ab	3.2 e
SWF	14.10 a	12.35 a	5.0 ab	3.9 de

SWF = filtered SW.

N.B. Means within a column followed by the same letter are not significantly different at the 5% level of probability.

Growth of cucumber roots and shoots was strongly inhibited with concentrations of LTS higher than 1000 ug/ml., and lower concentrations showed gradual decrease in their growths, similar to, but to a lesser extent, than that of wheat (Table 3). Certain degree of promotion in the root and shoot growth of cucumber was observed with LTS-concentrations of 10,100 and 500 ug/ml. Such stimulative effect was not observed in the case of wheat seedlings.

Since LTS content of SW was found to be 1.05 + 0.09 mg/ml., the treatments of 1000 ug LTS/ml. and SW were nearly similar in their contents. However, SW exhibited greater values for wheat seedling growth than those of the 1000 ug LTS /ml. one.

2. Phytotoxicity of soil extracts (SE)

Results of the phytotoxic effects of the SE, presented in Table 4 showed that soil extracts of the SW irrigated plots (SE-SW) had nonsignificant inhibitory effects on the growth of either wheat rootlets orshootlets, as compared with either distilled water (DW) or fresh water (FW) treatments. A significant inhibition in their growths was observed, when SE-SW was compared with the SW. However, SW caused a significant improvement in growths, as compared to the DW treatment. FW caused a similar effect, in the rootlets growth, however, it was not significant.

Table 4. Effects of the soil extracts (SE) of the field treatments on the root and shoot lengths of wheat seedlings.

Treatments	Lengths (cm) of the wheat	
	Rootlets	Shootlets
	Control treatments	
SW	15.70 a	14.76 a
FW	12.92 b	14.08 ab
DW	12.36 b	12.96 c
	Soil extracts of the treatments	
SE-SW	11.56 b	13.26 bc
SE-FW	8.60 c	12.84 c
SE-SWP	9.84 c	13.60 bc
SE-FWP	6.60 d	12.74 c

* Each value is a mean of 5 replication with 20 measures each.

** DW = Distilled water.

N.B. Means within a column followed by the same letter are not significantly different at the 5% level of probability.

Growth of wheat rootlets was significantly inhibited when it was irrigated with SE-FW. Each of SE-FW and SE-FWP treatments exhibited a pronounced inhibition in the shootlets growth, and such inhibition was significant when compared to either SW or FW treatments. SE-SWP and SE-FWP two separate treatments inhibited significantly the rootlet growth of wheat when compared to any of control treatments (DW, FW and SW), or to the respective ones (SE-SW and SE-FW). A similar effect on the shootlets growth was also observed, but without significancy in most cases. However, SW irrigated soils was found [1] to contain greater concentrations of Na^+ and hazardous soluble salts in addition to higher concentrations of potentially beneficial plant nutrients than potable irrigated ones, therefore SW-irrigated soils significantly reduced seedling emergence for both Bermuda grass and rye grass.

3. Effect on Chlorophyll Content

Chlorophyll contents (CHL) of alfalfa leaves were estimated three times; two in the winter season (on the 18th and 30th of December, 1989); and the third was in summer (on the 27th of May, 1989). Two estimations of CHL for spinach were in winter (during January and February, 1990); and one only for wheat was in winter also (on 16 January, 1990).

Results of the effects of the field treatments on the CHL of alfalfa are presented in Table 5, and those of spinach and wheat are in Table 6. Values of general means (GM) of the total CHL (CHL-t) in the three estimations of alfalfa were nearly equal, and they were 2.47 and 2.55 mg/g fresh weight for the winter two estimations, and 2.55 mg/g for the summer one (Table 5). Corresponding values for spinach were 1.45 and 1.62 mg/g, and that of wheat was 1.82 mg/g (Table 6).

Table 5. Effects of the field treatments on chlorophyll contents of the alfalfa leaves, on different dates

Treatments	Mean values of chlorophyll-contents (in mg/g fresh weight)								
	ON 18.12.1989			ON 30.12.1989			ON 27.5.1990		
	a-CHL	b-CHL	t-CHL	a-CHL	b-CHL	t-CHL	a-CHL	b-CHL	t-CHL
SW	1.33 f	0.41 d	1.74 e	1.48 b	0.42 d	1.81 d	1.81 abc	0.71 a	2.55 ab
FW	2.03 cd	0.59 abc	2.62 bc	2.59 a	0.73 a	3.18 a	1.65 c	0.61 a	2.30 c
SWP	1.95 d	0.63 a	2.58 c	2.19 a	0.57 bc	2.68 bc	1.95 a	0.71 a	2.77 a
FWP	2.30 a	0.62 ab	2.91 a	2.04 a	0.55 c	2.51 bc	1.82 ab	0.72 a	2.52 ab
SW's	1.64 e	0.52 bc	2.16 d	2.17 a	0.50 cd	2.25 c	1.88 ab	0.71 a	2.66 a
FW's	2.17 ab	0.60 abc	2.77 ab	2.32 a	0.64 ab	2.85 ab	1.77 bc	0.67 a	2.44 bc
NP's	1.68 e	0.50 c	2.18 d	2.04 a	0.58 bc	2.50 bc	1.73 bc	0.66 a	2.42 bc
P's	2.12 bc	0.63 a	2.75 b	2.12 a	0.56 c	2.60 bc	1.89 ab	0.72 a	2.67 a
GM	1.90 d	0.56 abc	2.47 c	2.25 a	0.57 bc	2.55 bc	1.81 abc	0.69 a	2.55 ab

N.B. Values within a column followed by the same letter are not significantly different at the 5% level of probability.

Table 6. Effects of the field treatments on chlorophyll contents of the spinach and wheat leaves, on different dates

Treatments	Mean values of chlorophyll-contents (in mg/g fresh weight)								
	Spinach						Wheat		
	ON 10.01.1990			ON 24.02.1990			ON 16.01.1990		
	a-CHL	b-CHL	1-CHL	a-CHL	b-CHL	t-CHL	a-CHL	b-CHL	t-CHL
SW	0.99 e	0.32 b	1.27 f	1.16 bc	0.38 bc	1.53 bcd	1.99 a	0.56 a	2.49 a
FW	1.23 ab	0.37 a	1.55 abc	1.52 a	0.56 a	2.02 a	1.41 d	0.38 d	1.73 a
SWP	1.09 cde	0.33 ab	1.36 def	1.18 bc	0.38 bc	1.55 bcd	1.53 bcd	1.53 bcd	1.86 a
FWP	1.30 a	0.37 a	1.63 a	1.04 c	0.34 c	1.37 d	1.52 bcd	0.41 cd	1.86 a
SW's	1.04 de	0.32 b	1.31 ef	1.17 bc	0.38 bc	1.54 bcd	1.76 abc	0.49 ab	1.84 a
FW's	1.27 ab	0.37 a	1.59 ab	1.28 ab	0.45 bc	1.70 abc	1.46 d	0.40 cd	1.80 a
NP's	1.11 cd	0.35 ab	1.41 cde	1.34 ab	0.47 ab	1.78 ab	1.76 ab	0.47 bc	2.11 a
P's	1.20 abc	0.35 ab	1.49 abcd	1.11 bc	0.36 c	1.46 cd	1.52 bcd	0.42 bcd	1.86 a
GM	1.15 bc	0.35 ab	1.45 bcde	1.23 bc	0.42 bc	1.62 bcd	1.61 bcd	0.44 bcd	1.82 a

N.B. Values within a column followed by the same letter are not significantly different at the 5% level of probability.

Alfalfa contents of CHL-a, CHL-b and CHL-t in winter estimations, depended upon the field treatment and the season. Values of CHL-a, CHL-b and CHL-t contents of SW treatments were the lowest in winter, whereas those of FW were the lowest in summer (Table 5). Such result was also observed by the naked eye during the growing seasons of alfalfa, as it was observed that the green color of the alfalfa leaves in winter was more dense in the FW treated plots than in the SW-treated ones, but in summer season, the situation was reversed. Fainting of the green color of alfalfa leaves in SW-treated plots during the winter may be due to certain degree of phytotoxicity of the SW, whereas, in summer such effect was minimized. However, it was reported [3] that SW-treated plots or those treated with higher rates of N fertilizer in the summer, showed signs of chlorosis which may resulted from high soil P, producing insoluble iron phosphates in the soil or plant. Higher N levels found in SW irrigated soil, may have further contribution to the chlorosis by inducing a growth rate that exceeded the ability of the plant to utilize soil Fe, since the foliar application of ferrous sulphate alleviated the chlorosis, and the fertilized FW plots did not show signs of severe chlorosis.

FW-irrigated alfalfa (Table 5) exhibited values of CHL-a and CHL-t significantly greater than those of SW. A similar trend was also observed with FWP and SWP treatments. However, the treatments of FW's were greater in this respect than the SW's. Non pesticidal treated plots (NP's) of alfalfa exhibited values of CHL-a; CHL-b and CHL-t, significantly less than those of the pesticidal treated ones (P's). A similar behavior was also observed in the estimations of latter date, as it was found that SW showed the least values of CHL-a, CHL-b and CHL-t; FW the greatest and each of SWP and FWP were not significantly different in this respect. FW was greater than FWP, but SW was smaller than SWP, and SW's was smaller than FW's, and the corresponding values of each of NP's and P's were non-significantly different. However, alfalfa-P's treatment was sprayed with each of methidathion (on 4.12.1989) and dimethoate (on 12.12.1989) for insect control, i.e, two and one week before the first estimation of CHL respectively (Table 2). Generally, on the 30.12.1989, the SW values of CHL-a, CHL-b and CHL-t of alfalfa were significantly less than the GM respective values.

The alfalfa SWP treatment exhibited the greatest CHL-a, and CHL-t values on 27.5.1990, whereas those of FW were the least, and values of CHL-a in each of SW, FWP, SW's, FW's NP's, P's and GM were non-significantly different among each other. Values of CHL-t in each of SWP, SW's and P's were significantly greater than those of the FW, FW's and NP's (Table 5).

Spinach contents of CHL-a, CHL-b and CHL-t, in each of its two estimations were nearly similar to that of the alfalfa first one. In the two estimations of spinach, SW and SW's exhibited values of CHL-a, CHL-b and CHL-t significantly smaller than those of FW and FW's, but the NP's and P's were non-significantly different in this respect (Table 6). The greatest values of CHL-a, CHL-b, and CHL-t were those of the FWP in the first estimation and those of the FW in the second. Polyram-combi was sprayed (on 3.1.1990), one and three weeks before the first and the second estimations respectively (Table 2).

Wheat seemed to be more tolerant to the SW effect than alfalfa or spinach. Differences between the means of CHL-t in the treatments of wheat were non-significant; but for the CHL-a and CHL-b, SW exhibited the greatest values, which were significantly greater than those of FW, SWP, FWP or GM. However, wheat CHL-a and CHL-b values of SW's were significantly greater than those of FW's, but those of NP's and P's were not significantly different among each other (Table 6).

In general, alfalfa CHL was found to be greater in its amount than it was in spinach or wheat. The treatment of SW exhibited smaller values of CHL than any of other treatments, in almost all estimations of alfalfa and spinach; but in wheat, this treatment showed the greatest CHL values. FW showed the greatest CHL values in almost all estimations of alfalfa and spinach, but in wheat, it showed the least ones. The treatments of SW's and NP's were smaller in this respect than the respective FW's and P's treatments, in almost all estimations of alfalfa, and spinach, but in wheat the opposite situation was observed. Hence, wheat was considered a tolerant crop to SW, and each of alfalfa and spinach were less in this respect.

4. Effects on soil dehydrogenase activity (SDA)

SDA values of all treatments were generally low, which reflected poor biological activity of the soil. This may be due to the low content of the soil from organic matter (see Table 1).

Soil sample of alfalfa plots showed the highest SDA values and those of spinach were the least; and wheat SDA values were slightly greater than those of tomato's. However, SDA values of alfalfa tomato or wheat conducted during February or March were greater than those of May (Table 7). Greater SDA values of alfalfa, may be the result of the regular irrigation, all over the year, of that perennial crop. In arid climates, SW irrigation would generally be beneficial to the soil by increasing the soil organic content [13], and the soil temperatures during February and March were not too high, compared to May; hence SDA values during athe former two months were greater than those of the latter one. However it was reported [3] that excessive rates of soil N in the SW-irrigated plot lead to lower heat tolerance of the growth plant (rye grass) plus earlier and more rapid stand loss during high summer temperatures, hence SDA also may suffer from the combination of high temperatures and high N treatments during the summer months. It seems that the application of pesticides, to plant or soil adversely affected the biological activity of the soil, since in almost all estimations, SW, FW and NP's exhibited SDA values greater than the respective pesticidally treated ones (SWP, FWP and P's respectively). Similarly each of FW and FWP

Table 7. Effects of the field treatments on activity of soil dehydrogenase (SDA), of alfalfa, tomato, wheat and spinach experiments, on different dates

Treatments	Mean values of Formazan (mg/g soil/24hrs.)						
	Alfalfa		Tomato		Wheat		Spinach
	6.3.1990	14.5.1990	6.3.1990	6.5.1990	27.2.1990	6.5.1990	6.3.1990
SW	0.160 a	0.118 de	0.075 bc	0.048 d	0.111 ab	0.072 a	0.043 d
FW	0.170 a	0.218 a	0.097 a	0.051 cd	0.123 a	0.065 a	0.051 bcd
SWP	0.092 c	0.099 e	0.070 c	0.064 abc	0.071 de	0.028 c	0.062 abc
FWP	0.063 d	0.190 abc	0.078 bc	0.076 a	0.062 e	0.036 bc	0.072 a
SW's	0.127 b	0.109 de	0.073 bc	0.056 bcd	0.091 bcd	0.051 ab	0.053 bcd
FW's	0.117 b	0.204 ab	0.088 ab	0.064 abc	0.093 bc	0.051 ab	0.062 abc
NP's	0.166 a	0.169 abc	0.086 ab	0.050 cd	0.118 a	0.069 a	0.048 cd
P's	0.067 c	0.145 cde	0.074 bc	0.070 ab	0.067 cde	0.033 bc	0.067 ab
GM	0.122 b	0.157 bcd	0.081 bc	0.060 bcd	0.092 bcd	0.051 ab	0.058 abcd

N.B. Values within a column followed by the same letter are not significantly different at the 5% level of probability.

treatments exhibited greater SDA values, significant in most cases, than those of the SW and FWP ones. Hence, SDA values of FW's were greater than those of SW's, except that of alfalfa on the first date, in which the SDA values of FW's and SW's were non-significantly different (Table 7). Such result was contrary to what was expected. The treatment of SW, with its contents of organic and inorganic residues, would assist in flourishing the biological activity of the soil, representing by the SDA.

Alfalfa was sprayed with insecticides, five days before the first date of SDA estimation (Table 1), and this may be the cause of the significant decrease in the SDA values of FWP, compared with the respective treatments FW and, SW. Tomato experiment was heavily treated with pesticides (Table 1), hence, FW showed SDA values significantly greater than each of the SW, SWP and FWP, but it was non-significantly greater than the SW's or SWP's. Each pair of the treatments: SW and FW; SWP and FWP or SW's and FW's, on the two dates of SDA estimations of wheat, were non-significantly different among each other (Table 7). However, the pesticide application strongly reduced the SDA, since the values of SW, FW and NP's were significantly greater than SWP, FWP and P's. The first SDA estimation in each of tomato and wheat, showed values of SDA, greater than those of the second.

SDA of spinach was estimated once, in which the SDA values of each pair of treatments: SW and FW; SWP and FWP or SW's and FW's were non-significantly different, whereas those of each of FWP, SWP and P's were significantly greater than the respective treatments FW, SW and NP's (Table 7). Spinach experiment was sprayed with the fungicide polyram combi 80% wp, one week before the SDA estimation date (Table 1), and it was not certain if the fungicide improved the SDA values or not. However, FW treatments (FW, FWP and FW's) exhibited values of SDA non-significantly greater than those of the corresponding SW ones (SW, SWP and SW's).

In general, FW treatments showed SDA values greater than those of SW ones, in almost all tested crops. The pesticide application decreased SDA values in alfalfa, tomato and spinach, but increased them in wheat.

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التأثير السام على النباتات لمياه الصرف الصحي المعالجة لمدينة الرياض

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ملخص البحث. تم تنفيذ مجموعة من التجارب بمحطة الأبحاث والتجارب الزراعية بديراب بهدف قياس السمية النباتية لمياه الصرف الصحي المعالجة لمدينة الرياض على البرسيم والقمح والطماطم والسبانخ وشملت معاملتين للري بمياه صرف صحي، ومياه عادية مع إجراء (أو بدون إجراء) مكافحة للآفات بالمبيدات. وقد تم قياس تأثير المعاملات على المحتوى النباتي من الكلوروفيل وعلى النشاط الانزيمي لديهيدروجينيزات التربة، وكذلك قياس السمية النباتية للمستخلصات من التربة، وللجوامد الكلية الذائبة في مياه الصرف المتحصل عليها بالتجفيف.

وقد أظهرت النتائج أنه بالرغم من تشجيع النمو النباتي وإنتاجيته، فإن محتوى أوراق البرسيم والسبانخ من الكلوروفيلات في معاملات الري بمياه الصرف أقل منها في معاملات الري بالمياه العادية وأن النشاط الاختزالي لأنزيمات التربة في معاملات الري بالمياه العادية أعلى منه في الري بمياه الصرف. كما أظهرت النتائج كذلك أن مستخلصات التربة في معاملات الري في مياه الصرف قد أحدثت سمية نباتية واضحة على البادرات وأن استعمال المبيدات معها أدى إلى إحداث المزيد منها. كما عملت التركيزات المنخفضة من الجوامد الكلية لمياه الصرف على تنشيط نمو البادرات بينما عملت تركيزاتها العالية على تثبيطه، وتناسب مقدار التثبيط مع تزايد تركيز الجوامد.