UTILIZATION OF SEWAGE WATER IN THE PRODUCTION OF INDUSTRIAL OIL AND FIBER FROM FLAX PLAN

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ABESTRACT

Reuse of treated waste water for agriculture enables fresh water to be exchanged for more economically and socially valuable purposes, while providing farmers with reliable and nutrient-rich water. This exchange also has potential environmental benefits, reducing the release of waste water effluent downstream and allowing the assimilation of its nutrients into the soil. If wastewater reuse was rejecting, the option could be costly in such situations. The aim of this study is to identify the suitability of primary treated sewage water alone or mixed with different rates of Nile water and their effects on soil properties and grown plants. So, field experiments with Randomized complete Block design were conducted in winter seasons of 2011/2012 for flax crop, to study the effect of different water irrigation quality on the fiber yield and characters of sakha 2 flax cultivar at Balaks sewage water station,El- Qalioubia Governorate, Egypt. Results revealed that 100% sewage water recorded highest mean values of most flax characters such as total length, technical length, , No. of capsule / plant, No. of seeds / capsule, No. of benches / plant, fiber length and Iodine values, fiber yield per Fadden, fiber length, long fiber percentage and fiber fineness. On contrary, using 100 % swage water caused significant decrease on fiber strength compared with those irrigated with 100% Nile water. The highest values of seeds yield, straw yield, fiber yield, weight of 1000 seeds, oil yield, fiber (%) and seed oil (%) were observed with irrigation 100% sewage water.

Key Words: flax, Kenaf, primary treated sewage water, industrial oils and fibbers.

INTRODUCTION

Currently, Egypt produces an estimated 5.5– 6.5 Billion Cubic meters (BCM^3) of sewage water per year. Of that amount, about 2.97 BCM^3 per year is treated, but only 0.7 BCM^3 per year is utilized for agriculture. Where, 0.26 BCM^3 is undergoing secondary treatment and 0.44 BCM^3 undergoing primary treatment, mainly direct reuse in desert areas or indirect reuse through mixing with agricultural drainage water (Abdel-Shafy and Abdel-Sabour,2006).

Flax (*Linum usitatissium L*) is the second important fiber crop after cotton in Egypt. It is grown for producing fibers only or seeds only, but in Egypt it is grown as dual purpose crop. Flax is the oldest fiber crop in Egypt. Flax is grown during winter season. In Egypt, flax cultivated area was about 35700 fedd. annually. Water is often the primary limiting factor in any crop production. Therefore, irrigation management is very important nowadays in Egypt due to the shortage in water resources as well as the expansion of agriculture in newly reclaimed lands (Hamada *et al*., 2009). The application of sewage water led to increased canola seeds yield but seed oil (%) was decreased. Hussein *et al*., (2004) found that oil (%) in seeds of cotton crop was decreased when irrigated by domestic sewage effluent Also, Oil (%) in seeds was decreased in seeds of Safflower and rapeseed plants irrigated with sewage water more than that irrigated with Nile water (Abo-Rabeh,2011).

Flax is considered one of the most important dual purpose crops for oil and fiber production in Egypt and the world, flax seeds are rich in oil (41%), protein (20%), and dietary fiber (28%) (Ibrahim, 2009).

The current study aims at gaining more information about the effects and suitability of primary treated sewage water alone or mixed with different rates of Nile water on flax plant characteristics, fiber productivity and quality and oil yield.

MATERIALS AND METHODS

Field experiment:

To evaluate the effect of water quality on flax plant characteristics, fiber productivity and quality and oil yield. Field experiments were carried out at the Balaks in Mostored Potable water and Sanitation Company,Cairo, Egypt during winter 2012& summer 2103.seeds of flax (*Linum usitatissium L*) was obtained from Fiber Crops Research Department, Field Crops Research Institute, Agriculture Research Center, Giza Egypt.

Seeds of flax were sown in 15 November 2012. The experimental plot area was 10 m of length X 4 m of width. The distance between rows was 10 cm. Seeds yield at harvest was recorded in 15 May 2013. Each parts of plant samples were washed then dried at 70^0C .The dry materials were finely ground and kept in polyethylene bags for analysis.

Analyses Technique:

<u>Water analyses:</u>

Sewage water was collected from Balaks drain of Mostored city, Cairo Governorate, and mixed with different rates, 100% Nile water (T_1), 75% Nile water + 25% sewage water (T_2), 50% Nile water + 50% sewage water (T_3),25% Nile water +75% sewage water (T_4) and 100% Sewage water ((T_5).

- pH values of irrigation water samples were determined (USDA, 1969).

- Electrical conductivity (EC) of the irrigation water samples were measured using a conductivity bridge meter (USDA, 1969).
- Determination of Soluble ions (cations and anions) in irrigation water, according to the methods described by Black (1965).
-Determination of soluble heavy metals in irrigation water samples, according to the standard procedures (Greenberg *et al*.,1985).
- Determination of ammonia (NH_4^+) and nitrate(NO_3^-) in irrigation water samples. by Auto Analyzer Instrument according to Tel (1982).

Soil analyses:

The collected soil samples before and after planting at different depths (0–15cm),(15–30cm) and (30–45cm) were air dried, crushed and ground gently by a rod, sieved through a 2 mm sieve to get the fine particles, then kept in plastic bottles for analyses.

Table (1): Mean values of chemical analysis of Nile and primary treated sewage water

Treatments	pH	EC	Cations (meq l^{-1})				Anions (meq l^{-1})			
		(dS/m)	Ca^{++}	Mg^{++}	Na^+	K^+	$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$
Primary treated sewage water	7.99	2.73	8.24	7.95	11.17	0.03	---	2.o	10.5	14.89
Nile water	7.57	0.4	1.55	1.25	1.1	0.30	---	1.0	2.5	1.20

Treatments	Macronutrients (mg/l)			Micronutrients and heavy metals (mg/l)					
	N	P	K	Fe	Mn	Zn	Pb	Ni	Cd
Primary treated sewage water	20.46	4.38	9.33	0.87	0.36	1.18	1.05	0.043	0.40
Nile water	9.86	2.79	7.50	0.23	0.20	0.021	0.06	0.017	0.01

Each value is a mean of three replicates.

A- Soil physical analysis:

-Particle size distribution by the international pipette method according to **Piper (1950). -** Soil texture class was determined using the texture triangle diagram **(Soil Survey Staff, 1962)**.

B- Soil Chemical analyses:

- Saturated soil paste & saturation percentage (SP), (USDA, 1969).
- Soil reaction (pH) of saturated soil paste (Jackson, 1967).
- Electrical conductivity (EC): (USDA, 1969).
- Soluble cations (Ca^{+2}, Mg^{+2}, Na^{+} and K^{+}) and anions (Cl^{-} ,$CO_3^{-2,}$ HCO_3^{-} and SO_4^{-2}) were determined in soil paste extract according to Page and Chang (1981).
- Determination of organic matter contents according to Walkley (1947).
- Determination of calcium carbonate contents: were determined using Collin's calcimeter (Wright, 1939).

Table (2): Physical and chemical properties of studied soil before Flax planting.

pH (1:2:5)	EC (dS/m)	Cations (meq/l)				Anions (meq/l)			SAR
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^-	Cl^-	$SO_4^=$	
7.93	**2.88**	**13.93**	**6.97**	**9.35**	**0.70**	**2.0**	**10.0**	**18.95**	**2.89**

Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Texture	SP %	O.M (%)	$CaCO_3$ (%)
10.39	**65.28**	**10.30**	**14.03**	**Sandy loam**	**22**	**0.44**	**2.19**

Macronutrients (mg/kg)					
N		P		K	
Total	Avai.	Total	Avai.	Total	Avai.
65.94	**34.89**	**12.88**	**3.75**	**482**	**180**

Micronutrients and heavy metal contents mg/kg											
Fe		Mn		Zn		Pb		Ni		Cd	
To.	Avai	To.	Avai	To.	Avai	To.	Avai	To.	Avai	To.	Avai
784	**2.25**	**280**	**1.39**	**23.88**	**4.87**	**19.79**	**2.13**	**17.34**	**1.23**	**4.85**	**0.23**

Each value is a mean of three replicates.

- Available nitrogen was extracted from soil using 2N KCl solution and was measured according to the modified Kjeldahal method **(Page *et al*., 1982).**

C- Total and available heavy metals in the studied soils:

- Total content of Fe, Mn, Zn, Cu, Pb, Ni, Co and Cd in soils were measured according to Jackson (1967).
- Available contents of Fe, Mn, Zn, Cu, Pb, Ni, and Cd in soils samples were extracted by ammonium bicarbonate diethylene triamine penta acetic acid

(AB- DTPA).(1 N NH_4HCO_3 + 0.005 M DTPA) buffered at pH 7.6 and 1: 2 soil : extracting solution ratio according to Soltanpour and Schwab (1977).

Plant analysis:

Seeds and straw Parts of the dry flax plant samples were wet digested using H_2SO_4 and HClO4 Jackson (1967).

- Contents of (N, P, K, Fe, Mn, Zn, Pb, Ni and Cd) were determined using the methods described by Jackson (1973) and Page *et al*. (1982).
- Protein percentage of seeds was calculated by multiplying the nitrogen percentage by the factor 6.25 (Hymowitz *et al*.,1972).

-Nitrogen was determined by Kjedahl method (Chapman and Partt, 1961).

- Phosphorus and microelements were determined by Page *et al.* (1982).
- Potassium was determined using Flame Photometer.
- Seed oil % was determined by using Soxhlet apparatus and petroleum ether (40-60°C) as a solvent according to A.O.A.C. (1990).
- Oil yield (ton/fed) was calculated by seed yield (t/ha) x seed oil (%).
- Total plant length (cm) was measured from soil surface to the highest point of plant.
- Technical length (cm) was determined from soil surface to the first branch.

- Retting process

To separate fiber bundles from flax straw stem must be submerged in water at the ratio of 1: 13 (straw: water). This process takes about 10-12 days, where the fiber becomes easy separate from its stem.

- Fiber percentage was calculated by (weight of total fiber (g) /weight of straw after retting (g)) x 100.

-Fiber yield (ton/fed) was calculated by straw yield (ton/fed) x fiber (%).

- Fiber fineness (Nm) was calculated by = NxL / G . Where N= number of fibers (20 fibers each 10 cm), L= length of fibers in mm, G= weight of fibers in mgs (Radwan and A. Momtaz, 1966)

Oil analysis:

- Oil percent (%) = (oil weight) ⁄ (weight of seeds) x 100)
- Oil was analyzed according to **American Oil Chemists' Society methods** and the results ware compared with Standards of the EU "EN 14214",U.S."ASTM D6751" standard, and specifications for the German "DIN 51606" production of biodiesel.
- Iodine value (IV) for crude oil according to A.O.C.S. (1998).
- The obtained results were subjected to statistical analysis of variance according to method described by Snedecor and Cochran (1982).

RESULTS AND DISCUSSION

1-Water analysis: Data present in Table (3) showed that, the salinity (EC) ware 0.4, 0.98, 1.78, 2.11 and 2.73 dS/m for T_1, T_2, T_3, T_4 and T_5, respectively.

Table (3): Mean values of Macronutrients, Micronutrients and heavy metals (mg/l) for the different irrigation water during Flax cultivation.

Water Quality	EC dSm^{-1}	pH	Macronutrients (mg/l)			Micronutrients and heavy metals (mg/l)					
			N	P	K	Fe	Mn	Zn	Pb	Ni	Cd
(T_1)	0.4	7.67	14.34	4.35	7.22	0.23	0.15	0.08	0.11	0.057	0.005
(T_2)	0.98	7.61	15.98	4.77	7.63	0.34	0.21	0.21	0.35	0.093	0.020
(T_3)	1.78	7.79	17.67	5.13	8.21	0.49	0.27	0.33	0.68	0.160	0.035
(T4)	2.11	7.84	19.12	5.61	8.89	0.61	0.31	0.85	0.82	0.222	0.042
(T5)	2.73	8.09	23.58	6.36	10.04	0.86	0.39	1.26	1.11	0.265	0.059

Each value is a mean of three replicates.

% The highest values of N, P and K concentrations in 100 % sewage water (T_5) were 23.58, 6.36 and 10.04 mg/l**.,**respectively. While, these concentrations were 14.34, 4.35 and 7.22 mg/l in100freshwater(T_1), respectively. Also, sewage water had the highest values of Fe, Mn, Zn Pb, Ni and Cd compared with freshwater.

2. Effect of different water quality irrigation on soil properties fter flax harvest.

Soil pH:

The effect of the sewage water and its different qualities due to dilution with different rates of fresh water after the period of flax cultivation on soil pH is shown in table (4). These values of surface soil layers (0-15 cm) after flax harvest were 8.03, 8.01, 7.95, 7.83 and 7.79 for (T_1),(T_2),(T_3), (T_4) and (T_5), respectively. The results of study indicated that the application of sewage water to soil had decreased soil pH than initial soil. These results are in agreement with Mohammed *et al.* (2014) who indicated that the reason for decreasing of soil pH may be due to decomposition of organic matter and production of organic acids in soils irrigated with wastewater.

The soils of all the experimental treatments are characterized by slightly to moderately alkaline conditions, where the soil pH values is always around between 7.79 and 8.03 after flax harvest, according to Ayers & Westcot, (1985) and Shaban (2005).

Soil salinity (Electrical conductivity):

Irrigation with sewage water led to increase soil salinity (E.C) as compared to the soil irrigated with freshwater. The obtained data in Table (4) show that (EC) values of the surface soil (0-15 cm) were 2.75, 2.92, 3.14, 3.22 and 3.35 dS/m for (T_1), (T_2), (T_3), (T_4) and (T_5), respectively. El- Gazzar (1996) came to the same conclusion.

Soil organic matter %:

Organic matter in soil is the most important indicator of soil quality playing a major role in nutrient cycling; it increased as the proportion of primary sewage water increased in irrigation water. This is most likely to the higher organic matter content of waste water. Organic matter contents tend to be high in the surface layers than in the lower ones. Organic matter contents of soils in this study are still low due to their quick decomposition; this is a natural characteristic feature of semi-arid regions.

Soil calcium carbonate%:

Date presented in Table (4) reported that, irrigation with waste water led to increase $CaCO_3$%. These results were reported also by Tabari and Salehi (2009).

Macronutrients contents in the studied soil after flax harvest:

Data in Table (4) showed that the irrigation with sewage water led to increase total and available N, P and K (mg kg^{-1}) compared with fresh water, especially in surface layer (0-15 cm). This is a true; the sewage water had more enrichment in organic materials as well as N, P and K.

The highest increasing % of total and available soil nitrogen by using 100% sewage water (T_5) compared with those irrigated with (T_1) were 24.68 and 35.33 % While, the highest increasing % of total and available phosphorus were 24.22 and 36.32 %. In the same context, the highest increasing % of total and available potassium were12.35 and 18.97 % for the surface layers respectively, during the periods of flax cultivation.

Table (4): Effect of different irrigation water quality on some surface soil properties:

Waterquality	pH 1:2.5	EC dS/m	O.M (%)	$CaCO_3$ (%)	Macronutrients mg/kg					
					N		P		K	
					Total	Avai	Total	Avai	Total	Avai
T_1	8.03	2.75	0.42	2.05	65.71	38.55	12.88	3.80	486	195
T_2	8.01	2.92	0.68	2.22	68.86	47.39	14.36	3.89	513	198
T_3	7.95	3.14	1.02	2.31	74.98	49.52	14.76	4.01	528	204
T_4	7.83	3.22	1.54	2.43	76.99	50.17	15.72	4.13	539	209
T_5	7.79	3.35	1.87	2.65	81.93	52.17	16.00	5.18	546	232

Each value is a mean of three replicates.

These results are in agreement with Kholdabakhsh *et al*., (2013) and Amin (2011) who indicated that the soil irrigated with waste water caused an increase of total and available N, P and K of soil treated with waste water and this can be attributed to N, P and K content in the wastewater.

Micronutrients and heavy metals contents in the studied soil after flax harvest:

The obtained data in Table (5) show that the soil content ($mgkg^{-1}$) of the tested micronutrients and heavy metals i.e. (Fe, Mn, Zn Pb, Ni and Cd) irrigated with 100% sewage water (T_5) or mixed with different rates of fresh water (T_4, T_3 and T_2) after flax planting led to increase these heavy metals in soil surface in comparison with the soil irrigated with 100% fresh water (T_1).

Table (5): Effect of different water quality on micronutrients and heavy metal contents in surface soil after Flax harvest.

Water quality	Micronutrients and heavy metal contents mg/kg											
	Fe		Mn		Zn		Pb		Ni		Cd	
	To.	Avai	To.	Avai	To.	Avai	To.	Avai	To.	Avai	To.	Avai
T_1	785	2.27	289	1.42	23.82	4.90	19.79	2.12	17.36	1.22	4.84	0.21
T_2	791	2.35	293	1.48	24.54	5.10	20.13	2.19	17.55	1.26	4.97	0.22
T_3	807	2.41	298	1.50	25.89	5.17	20.98	2.28	17.86	1.29	5.10	0.23
T_4	812	2.68	314	1.52	26.11	5.54	21.57	2.43	17.94	1.37	5.32	0.24
T_5	837	2.74	322	1.57	27.65	5.83	22.02	2.52	18.03	1.41	5.56	0.26

Each value is a mean of three replicates**.**

Total Fe values ranged from 785,791,807, 812and 837 mg kg^{-1} by using (T_1), (T_2), (T_3), (T_4) and (T_5), respectively. The corresponding relative increases % of available Fe values compared with the same soil layer before the experiment were 0.13, 0.89, 2.93, 3.57 and 6.76 % by using (T_1), (T_2), (T_3), (T_4) and (T_5), respectively.

Mean values of total and available Mn in the surface soils (0-15cm) were 322 mg/kg and 1.57 mg/kg respectively due to irrigation with 100%waste water (T_5), while with the same soil irrigated by 100% fresh water (T_1) it were 289 mg/kg and 1.42 mg/kg, with corresponding relative increases 14.42 and 10.56 % respectively

Concerning the effect of irrigation of soils with waste water on total and available Zn, data in Table (5) showed that values of Zn concentration were 23.82, 24.54, 25.89, 26.11 and 27.65 mg kg by using (T_1), (T_2), (T_3), (T_4) and (T_5). The corresponding relative increases % of available Zn values in surface soil (0-15cm) compared with the same soil layers before the experiment were 0.62, 4.72, 6.16, 13.76 and 19.71 % by using (T_1), (T_2), (T_3), (T_4) and (T_5), respectively.

Data presented in Table (5) showed that values of total Pb at soil irrigated with waste water through flax cultivation varied from 19.79, 20.13, 20.98, 21.57 and 22.02 mg kg^{-1} in the upper soil layers (0-15 cm depth), by irrigating with (T_1), (T_2), (T_3), (T_4) and (T_5), respectively. The corresponding relative increases % of total Pb was 11.27 % due to irrigated surface soil with 100% sewage water (T_5) compared with the same soil layers irrigated with (T_1). The relative increases % of available soil Pb were 3.30, 7.75, 14.62 and 18.87 % as a result of irrigated with (T_2), (T_3), (T_4) and (T_5), respectively and compared with (T_1)

Concerning the effect of irrigation of soils with waste water on total and available Ni, the relative increases % were 3.87 and 15.57 %, respectively. Due to irrigation with 100%waste water (T_5) and compared with (T_1).

As regard to total and available soil Cd contents as a result of irrigation with sewage water (T_5) were 5.56 and 0.26 mg kg^{-1} with relative increases % 14.88 and 23.81 % respectively, compared with the same soil irrigated by (T_1).

It is worthy to mention that the contents of all values of total and available heavy metals in the studied soil presented within safe or permissible limits and possible using these water sources for irrigation (FAO, 1992).

These results are in agreement with those reported by Rashad *et al.,* (1995) for uncontaminated sandy soils of Egypt,

3- Effect of different irrigation water quality on flax plant:

Morphological characters:

Data presented in Table (6) showed that increasing rates of sewage water led to increasing in all morphological characters than fresh water used for irrigation. The maximum values of total length (cm), active plant length (cm), fiber length (cm), No. of capsule/plant, No. of seeds/capsule, No. of branches/plant and Iodine values (IV) were 96.59, 72.48, 79.51, 8.02, 5.82, 15.28 and 157.18 respectively, for soil irrigated with 100% sewage water (T_5). Also, the relative increases % of most morphological characters' values of flax plant in soil irrigated with 100 sewage water (T_5) compared with the same soil irrigated with 100% fresh water (T_1) were 28.56 % for Total length; 31. 04 % for Technical length, 25.65 % for fiber length 16.74% for No. of capsule/plant; 28.76% for No. of seeds/capsule; 32.98% for No. of Branches/plant and 13.77 % for Iodine values respectively

Table (6): Some characters of flax plant as affected by different water quality irrigation.

Water Quality	Characters						
	Total length (cm)	**Technical length (cm)**	**Fiber length (cm)**	**No. of capsules /plant**	**No. of seeds/ capsule**	**No. of branches /plant**	**Iodine value**
T_1	75.13	55.31	63.28	6.87	4.52	11.49	138.15
T_2	85.81	57.73	69.45	7.03	4.86	12.69	143.27
T_3	89.83	64.02	73.04	7.40	5.11	14.00	148.97
T_4	92.48	69.33	75.73	7.88	5.19	14.62	152.26
T_5	96.59	72.48	79.51	8.02	5.82	15.28	157.18

Each value is a mean of three replicates.

Yield components of flax plant:

Data obtained in Table (7). Showed that all the values of yield components of flax plants increased with increasing sewage water rates except for fiber fineness(Nm)

The highest values of seeds yield (ton/fed,) straw yield (ton/fed.) and fiber yield (ton/fed.) due to irrigation with 100% sewage water (T_5) were 0.65, 2.43 and 0.322 (ton/fed.) respectively, with increasing 18.18 %, 10.96 % and 23.85 % respectively, comparing with those irrigated with fresh water (T_1). The height increases value of weight of 1000 seeds (g) of flax plant was 7.16 (g), with irrigated (T_5), while this value was 5.69 (g) with the same plant irrigated by fresh water (T_1), with increase of 25.83 %.

Table (7): Yield of flax plant as affected of different water quality irrigation.

Water quality	Characters							
	Seeds yield ton/fed.	Straw yield ton/fed.	fiber yield ton/fed.	1000 seeds Weight (g)	Oil yield ton/fed.	Fiber (%)	Fiber fineness (Nm)	Seed Oil (%)
T_1	0.550	2.190	0.260	5.69	0.178	11.48	190.4	32.39
T_2	0.590	2.200	0.265	5.96	0.196	12.19	183.1	33.42
T_3	0.620	2.260	0.280	6.05	0.222	12.56	180.6	35.78
T_4	0.630	2.310	0.311	6.78	0.231	12.99	174.2	36.65
T_5	0.650	2.430	0.322	7.16	0.253	13.26	170.3	38.87

Each value is a mean of three replicates.

On the other hand, the maximum values of oil yield (ton/fed.), fiber %, and seed oil % were 0.253 ton/ fed., 13.26 %, and 38.87 %, respectively due to the effect of irrigation with 100 %waste water (T_5), which increased by 26.94 %, 15.50 % and 20.0 % respectively, comparing with those irrigated with fresh water (T_1).

Regarding fiber fineness (Nm), it decreased from 190.4 to 170.3 due to irrigation with100 %waste water (T_5) comparing with those irrigated with fresh water (T_1), the decrease % was 11.8 %.

Concentration and uptake of nutrients by flax plant:

Nutrient contents in flax seeds were affected by irrigation of different water quality.

Data presented in Table (8) show that the highest concentration values (%) of flax seeds were 3.91for N, 0.35 for P and 2.59 for K and the uptake values (kg/fed) were 214.0 for N, 24.0 for P and 152.0 for K when irrigated with 100% sewage water (T_5).

The relative increasing % of N concentration in seeds of flax were 4.81, 13.4, 22.68 and 34.36 % as a result of irrigation with T_2, T_3, T_4 and T_5, respectively, compared with those irrigated with 100% fresh water (T_1).

The highest increasing % of P and K concentration in seeds of flax when irrigated with (T_5) was 20.69 and 17.73% respectively, compared with those irrigated with (T_1).

N, P and K uptake in seeds of flax were 214.0, 24.0 and 152.0 kg/ fed., respectively, when irrigated with (T_5), with relative increasing % 18.89, 26.32 and 21.6 %, respectively comparing with those irrigated with (T_1).

Micronutrients concentration and uptake in seeds of flax plant:

The relative increase % of Fe concentration and uptake in seeds of flax irrigated with (T_5) compared with the same seeds irrigated with (T_1), were 22.28 and 26.07%, respectively, as shown in (Table 9). While, the highest increase % of Mn concentrations and uptake values were 22.26 and 33.32% respectively, due to irrigation with (T_5).

Table (8): Macronutrients concentration and uptake in flax seeds as affected by different water quality irrigation.

Water Quality	Macronutrients in seeds flax plant					
	N		P		K	
	Conc. (%)	Uptake (kg/fed)	Conc. (%)	Uptake (kg/fed)	Conc. (%)	Uptake (kg/fed)
T_1	2.91	180.0	0.29	19.0	2.20	125.0
T_2	3.05	189.0	0.30	20.0	2.30	133.0
T_3	3.30	200.0	0.31	21.0	2.45	142.0
T_4	3.57	209.0	0.33	22.0	2.53	147.0
T_5	3.91	214.0	0.35	24.0	2.59	152.0

Each value is a mean of three replicates.

In the same context, the highest values of Zn concentration and uptake in seeds irrigated with (T_5) were 37.53 mg /kg and 22.54 g/fed., respectively in seeds of flax plants with the relative increases 13.66 % for Zn concentration and 24.12 % for uptake respectively, compared with the same seeds irrigated with (T_1),

Heavy metals concentration and uptake in seeds of flax plant:

The highest values of Pb concentration and uptake in flax seeds were 0.83 mg/kg and 21.90 g/fed respectively, when irrigated with (T_5). The corresponding relative increasing % of Pb concentration and uptake in seeds of flax plants comparing the highest values and lower ones due to irrigation with fresh water (T_5) were 20.29 and 29.59 %. These results are in agreement with Bjelkova *et al.,* (2011) who found that the application of sewage sludge on absorption of Pb in seeds of flax increased with increasing the same metals in sewage sludge applied.

Table (9): Micronutrients and heavy metals concentration and uptake in flax seeds plant as affected by different water quality irrigation.

Water quality	Micronutrients and heavy metals in flax plant seeds											
	Fe		Mn		Zn		Pb		Ni		Cd	
	Conc. mg/kg	Uptake g/fed	Conc. mg/kg	Uptake g/fed	Conc. mg/kg	Uptake g/fed	Conc. mg/kg	Uptake g/fed	Conc. mg/kg	Uptake g/fed	Conc. mg/kg	Uptake g/fed
T_1	140.83	74.15	43.30	25.81	33.02	18.16	0.69	16.90	0.94	3.20	0.69	2.21
T_2	142.99	77.34	44.32	26.15	33.90	19.20	0.70	17.50	0.97	3.40	0.72	2.39
T_3	156.82	79.83	46.52	28.84	34.98	20.91	0.73	18.20	1.10	3.68	0.76	2.64
T_4	163.75	82.06	50.73	31.96	36.02	21.62	0.79	19.60	1.15	3.909	0.81	2.82
T_5	172.21	93.48	52.94	34.41	37.53	22.54	0.83	21.90	1.24	4.05	0.83	2.84

Each value is a mean of three replicates.

Regarding data presented in Table (9) show that, applying sewage water in irrigation caused markedly increases in the concentration and uptake of Ni, the relative increase % of Ni concentration and uptake in seeds of flax plant under irrigation with different rates of sewage water were 22.34 and 15.0% respectively, in plot irrigated with (T_3) and were 31.91and 26.56% respectively in plot irrigated with (T_5), compared with (T_1).

Kabata-Pendias and Pendias (1992) showed that Ni toxic limits ranged from 10 -100 ug Ni / g plant. The highest increase % of Cd concentration for flax seeds was 20.29%. While the relative increase % of Cd uptake were 28.51, due to irrigation with 100% waste water (T_5). Compared with the same seeds irrigated with 100% fresh water (T_1).

Finally, the use of primary treated sewage water in this study achieved high environmental values, enables freshwater to be exchanged for more economically and socially valuable purposes. The morphological study characters of flax plant included plant length, Active plant length, fiber length, No. of capsule/plant, No. of seeds/capsule, No. of benches/plant and Iodine values (IV) were increased by irrigating with treated sewage water in all morphological characters than fresh water, weight of plant yields and straw yield ,weight of fiber yield were increased by irrigating with sewage water comparing with those irrigated with fresh water. The height increases value of weight of 1000 seeds, maximum values of oil yield, fiber % and seed oil % were increased by irrigating with treated sewage water. The highest values of N, P and K concentration and uptake were found with waste water irrigation. From the distribution of micronutrients and heavy metals concentrations in flax plant, there is no doubt that irrigation with waste water was within safe and permissible limits and it is possible to using these water sources for irrigation in the studied soils according to FAO (1992) for waste water treatments and use in agriculture.

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الاستفادة من مياه الصرف الصحى فى انتاج الزيوت الصناعية والألياف من نبات الكتان

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المستخلص

تهدف هذه الدراسة لتقييم صلاحية مياه الصرف الصحى المعالجة أوليا فى إنتاج محاصيل زيتية وألياف ومن هنا يمكن ايجاد قيمة مضافة من استخدام مياه الصرف الصحى وتوفير مياه الرى فى انتاج المحاصيل الغذائية. أجريت هذه الدراسة لاستخدام عينات مياه الصرف الصحى المعالجة أوليا والمقارنة مع عينات من المياه العذبة في زراعة نبات الكتان (Linum usitatissium L.) لاستخدام زيوتها كزيوت صناعية والاستفادة من اليافها.

اختبرت عينات مياه الصرف الصحي والتى كان لها تركيزات عالية الأملاح الذائبة ونسبة الصوديوم الممتص (SAR) وكذلك المحتويات الكلية من المغذيات الصغرى والكبرى وأيضا المعادن الثقيلة بمقارنتها بالمياة العذبة. تتوافق مياه الصرف الصحى المعالجة أولياً مع معايير استخدام مياه الصرف الصحى فى الزراعة لمنظمة الفاو. تم ستخدام مياه الصرف الصحي المعالج فى رى اراضى الدراسة، الآمرالذي أدى إلى زيادة طفيفة فى ملوحة التربة (EC) ، المادة العضوية% وكربونات الكالسيوم %. ومن ناحية أخرى انخفاض الاس الهيدروجينى للتربة. كما نتج عن استخدام مياه الصرف الصحي في ري التربة في زيادة المحتويات الكلية من المغذيات الصغرى والكبرى وأيضا المعادن الثقيلة فى كل من التربة ونباتات الدراسة. وكان تراكم هذه المكونات على سطح التربة . ومن الجدير بالذكر أن هذة المحتوياتات ضمن الحدود الآمنة أو المسموح بها والتي يمكن استخدام مصادر هذه المياه لأغراض الري في التربة. وتضمنت الدراسة بعض الصفات المورفولوجية للنباتات مثل طول النبات (سم)، طول النبات النشط (سم)، طول الألياف (سم)، عدد الكبسولات / نبات، عدد البذور / كبسولة، عدد التفرعات / نبات ورقم اليود .(IV) حيث لوحظ زيادة فى كل هذا الصفات مع استخدام رى بمياه الصرف الصحي ١٠٠.%

وأوضحت النتائج زيادة قيم مكونات المحصول مثل وزن المحصول (طن / فدان) وزن محصول القش (طن / فدان) ووزن المحصول الألياف (طن / فدان) مع زيادة معدلات الرى بمياه الصرف الصحي وفي نفس السياق من الزيادات فى وزن ١٠٠٠حبة (طن / فدان) ومحصول الزيت(طن / فدان) وكذلك النسبة المئوية للالياف وايضا النسبة المئوية لزيت البذورمع زيادة معدلات الرى بمياه الصرف الصحي .كذلك زيادة تركيز المحتويات الغذائية من النيتروجين والفسفور والبوتاسيوم

لبذورالكتان مع نوعية مياه الري وكذلك امتصاص النبات لهذه العناصر والتى زادت مع تزايد معدل مياه الصرف الصحي، تركيزات المعادن الثقيلة والممتص في بذورالكتان والمروية مع مياه الصرف الصحي١٠٠ % ضمن الحدود الآمنة أو المسموح بها وبالتالى توصى الدراسة بأمكانية استخدام مثل هذة المصادر من المياة لأغراض الري فى الاراضى المصرية لانتاج بعض النباتات المستخدمة لانتاج الزيوت الصناعية والالياف بمعايير وتحت دراسات مقننة.