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Use Of Treated Domestic Sewage Effluent For Growing Summer Oil Crops In Arid Lands

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Abstract

Water scarcity is one of the most serious troubles that feature the world outstandingly in arid and semi arid regions. Re-use of water including domestic sewage effluents frames an appreciable and self-controllable resource so far despite many impediments and restrictions should be reclaimed. In the present work two field trials were conducted in a sandy soil in Upper Egypt (Luxor) to explore the use of treated domestic sewage effluents compared to freshwater (groundwater) for growing six summer oil crops *i.e.*, castor bean, sunflower, soybean, sesame, peanut and cotton. The pertinence of reusing biologically treated domestic sewage effluents in farming practices were assessed in terms of both parasitic load and potential toxic elements inside. Results exhibited that all tested growth characters and yield components for tested plants irrigated with biologically treated sewage effluents far exceeded those for plants irrigated with freshwater. Plants irrigated with sewage water produced more oil yield than control by 206.6, 319.4, 28.8, 90.5 and 371.5 Kg/acre for castor bean, sunflower, soybean, sesame and peanut crops, respectively. While oil yield of cotton crop was decreased by 16.2 Kg/acre .The content of potential toxic elements in seeds and oil harvested from plots irrigated exclusively with sole treated domestic sewage effluents were almost more or less the same as those met in harvests irrigated with freshwater. It is worthy to point out that the oil produced from previous crops (in most cases) are used in industrial purposes such as manufacturing of printer ink, nylon, soaps, papers, textile, leather, waxes, varnishes, lacquers, paints, various glues, plastics and a variety of synthetic materials as well. Therefore, treated domestic sewage effluents , particularly when separated away from liquid industrial wastes, might be used in growing oil crops for manufacturing purposes in arid and semi arid lands.

keywords: treated domestic sewage effluents, arid and semi arid lands, oil crops, non conventional water resources, water reuse

Introduction

Water insufficiency is one of the most critical problems that confront the world particularly in the arid and semi arid regions. Re-use of domestic sewage effluents outlines the most substantial and self-controllable resource so far despite many obstacles and limitations to be retrieved. Sewage farming is meditated as one of the most environmentally sound mode for disposing off sewage effluent. Areas irrigated with sewage effluent are extensive all over many parts of the world. On the other hand, it is yet practiced at small scale in most developing countries.

In Egypt, sewage effluent, however, have been used in irrigation since 1941's in a desert sandy area northeast of Cairo. At present, small plots scattered here and there are also irrigated with sewage effluent. A national project for re-using sewage effluent in growing forests are about to arise.

Sewage effluent generated from sewer stations in both lower and Upper Egypt, raw or treated, falls in a good permissible range for most crops according to their salinity and heavy metal contents. In addition, their high nitrogen and other nutrient elements content significantly reduce or even exterminate the exigency for chemical fertilizers.

It is generally recognized that sewage effluent re-use in agriculture is merited on agronomic and economic grounds, but care must be fulfilled to minimizing inauspicious health and environmental impacts.

El –Mergawi(2004) mentioned that some plants (such as sunflower) show the potential for uptake and recovery of metals into above ground biomass(phytoextraction) , or filtering metal from water on to root system (rhizofiltration) or stabilizing waste sites by erosion control and evapotranspiration of large quantities of water (phytostablisation) . moreover, some plants can uptake and degrade organic contaminants (phytotransformation). Raskin and Ensley (2000) mentioned that there are some important consideration when selecting plants for phytostablisation i.e., should be poor translocators of metal contaminants to aboveground plants tissues that could be consumed by humans or animals.. The present work aims at measuring re-use of secondary treated domestic sewage effluent on selected summer oil crops. These crops are suitable, because they need not necessarily to be processed in food chain, but they can be used for production of numerous industrial commodities (Marie *et al* 2002).

Methods Of Approach

Two field experiments were carried out in Upper Egypt (Luxor) during the summer season 2000. The first experiment was irrigated with secondary treated domestic sewage effluent without any chemical fertilizers. However, a commence dose of dried sludge was added to the virgin sandy soil before sowing at the rate of 40 m^3 /acre. The second experiment was irrigated with ground water and received the doses of chemical fertilizers validated for each crop. Phosphate fertilizer was combined with soil previous to sowing, nitrogen fertilizer was added at three equals' interval doses, and potassium fertilizer was added at flowering stage.

Both experimental quarters were leveled with laser technique and ridged into sufficient numbers of experimental plots, each 42 m^2. The experiments were carried out in a complete randomized block design with four replicates.

Seeds of the six tested summer oil crops were sown just after being inoculated with the biofertilizer " Microbien " (Saber, 1993). Seeds of cotton (Giza 83) were sown on 31 March, peanut (Giza 4), soybean (Giza 22), castor bean (Hindy 12) and sesame (Giza32) on 21 April, while sunflower (Vidok) seeds were sown in 15 May 2000. Whenever essential, flooding irrigation was spread on. The soils of both experimental sites were sandy in texture, very poor in organic matter, nutrient elements, and biomass besides being free from enteric pathogens (Table 1). Soil samples were collected initially and at harvest to estimate chemical and biological changes.

At harvest, ten guarded plants were collected from each experimental plot to measure yield and yield components per plant. The entire yield of each plot was harvested to estimate seed and straw yields per acre, and to calculate harvest index (economic yield\biological yield). The oil yield of each crop was calculated after being extracted with an organic solvent.

Standard methods for soil, water and plant analyses were followed, i.e., those given by Chapman and Pratt (1987) for chemical analyses, and those given by Bridson (1998) for biological analyses.

Results

Chemical and biological analyses of both treated domestic sewage effluent and ground water used in the experiments are given in Tables 1 and 2. It is quit clear from the chemical characters of water that all parameters measured in both types of water are within the permissible limits of irrigation water (FAO, 1993). However, some variations inhered in the chemical properties of both types of tested irrigation waters. Generally, treated domestic sewage effluent contained more nitrogen, phosphorus, and potassium compared to those found in ground water. Both micronutrient and potential toxic elements, however, showed to be more or less the same in both types of tested waters. The total soluble salts in the ground water were almost double those in treated domestic sewage effluent, despite being at a permissible level for irrigating most crops.

Table (1): Chemical analyses of both typed of irrigation waters (ppm)

Parameters	Treated domestic sewage effluent	Ground Water	Permissible limits
N	22.0	2.0	-
P	4.75	0.2	-
K	22.4	5.2	-
Fe	0.036	Traces	5.0
Zn	0.03	Traces	2.0
Mn	0.012	Traces	0.20
Cu	Traces	Traces	0.20
Pb	0.06	0.05	5.0
Cd	0.006	0.008	0.01
B	0.365	0.217	3.0
Cl	64.0	54.0	300.0
TSS	563.0	1375.0	2000.0
Ph	7.8	8.6	-

Table (2): Biological analyses of both types of irrigation waters

Parameters	Unit	Treated domestic sewage effluent	Ground water	Permissible limits
Colonizing fecal coliforms	Viable cell/L	8109	0	1000
Ascaris eggs	Viable cell/L	0	0	600
Ancylostoma larvae	Viable cell/L	0	0	-
Encysted metacercaria of fasciola	Viable cell/L	0	0	-
Coccidia oocyst	Viable cell/L	1	0	3
Nematoda larvae	Viable cell/L	0	0	1
Free amoeba	Viable cell/L	0	0	4500

Table (3): Changes in the properties of soils irrigated with treated domestic sewage effluent or ground water (oven dry basis).

Soil properties	Soil irrigated with treated domestic sewage effluent		Soil irrigated with ground water	
	Initially	At harvest	Initially	At harvest
pH (1:2.5)	8.7	8.0	8.3	8.3
EC (ppm)	462	532	252	226
Organic C %	0.047	0.571	0.290	0.100
Total N %	0.01	0.08	0.02	0.04
Total P%	0.03	0.04	0.07	0.01
Total K%	0.129	0.097	0.049	0.024
Total Zn ppm	22	31	12	14
Total Fe %	1.05	1.01	0.59	0.62
Total Mn ppm	158	143	89	99
Total Cd ppm	2.44	2.56	1.45	1.31
Total Cr ppm	26.18	22.07	23.09	18.11
Total Pb ppm	4.90	2.04	5.76	2.57

From a biological point of view, data introduced in Table (2) authenticated the presence of enteric pathogens in treated domestic sewage effluent, even if being at a permissible for irrigation prospects (WHO, 1989). On the other hand, the biological analyses of the ground water signaled the lack of fecal coliforms. It is worthy to mention that no parasites were detected in both types of irrigation waters.

Irrigating the sandy soil at both experimental sites, with either treated domestic sewage effluent or ground waters led to venerable changes in soil characteristics (Table 3). It is estimable to affirm that in case of irrigation with treated domestic sewage effluent, the upgrading noted in the studied soil characteristics far exceed those measured in case of irrigation with ground water. Data given in (Table 3) show that both soils used in the experiments were very poor in their content of nutrient elements, besides being non-saline and with a ph value over neutrality. Irrigating both soils with either treated domestic sewage effluent or ground water tended to richen the nutrients content in soil. The attended changes within the experimental period, no doubt, are the resultant between nutrients added with treated domestic sewage effluent or chemical fertilizers and those absorbed by growing crops. A positive balance was distinct with treated domestic sewage effluent and a negative one was hold with ground water A noticeable trend of soil amelioration was unconfused throughout irrigation with treated domestic sewage effluent as until now clarified (Saber, 1992). The organic carbon content was magnified from 0.047% initially to 0.571% at crop harvest. Consequently, the most crucial change was the shifting of soil pH from 8.7 to 8.0 within few months. This, however, with no doubt will decidedly affect the availability of nutrient elements for plant absorption. It sounds worthwhile to affirm that at harvest, however, the contents of potential toxic elements in both soils did not surpass so far the permissible limits under irrigation with either treated domestic sewage effluent or ground water.

From a hygienic point of view, treated domestic sewage effluent enriched rhizosphere soil with fecal coliforms, which was absent in the soil irrigated with ground water. An inspiring trend of colonizing fecal coliforms was exceptional in soils irrigated with treated domestic sewage effluent, against that irrigated with ground water.

Prominent variance was recorded in fecal coliforms counts in the rhizosphere of tested oil crops after 30, 60 and 90 60 days of sowing as shown in Table (4) and Fig (1). The varied nature of root exudates in rhizosphere soil gave an impression to put forth an inhibitory or a stimulatory effect on fecal coliforms. The highest viable fecal coliforms were encountered in the rhizosphere of peanut plants, reaching up to 340 viable cell/gm. The root exudates in cotton and sesame rhizosphere exhibited the same effect on fecal coliforms, as more or less the same viable cells were counted therein. On the other hand, the root exudates in castor bean rhizosphere display an inhibitory rather than a stimulatory effect, the viable counts of fecal coliforms were as low as 40 cell/gm.

Table(4) : Number of fecal coliforms counts in the rhizosphere of tested oil summer crops per /gm irrigated by treated domestic sewage effluent

Plant	Number of fecal coliforms per gram		
	After 30 days	After 60 days	After 90 days
Peanut	260	340	330
Soybean	210	250	200
Sesame	150	165	120
Cotton	110	150	130
Sunflower	180	200	200
Castor bean	40	60	46

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The yield characters and components of six oil summer crops after harvest are given in (Table 5 and Figs.2,3 &4). Data for tested plants exhibited appropriate higher values for all measured characters signs for plants irrigated with TDSE compared to those irrigated with ground water. Also, all stately yield components followed the same bias. On the other hand, oil percentages in seeds were decreased when irrigated by domestic sewage effluent, except in the case of peanut plants, which slightly enhanced. However, oil yield per plant and per acre were largest with TDSE compared to those irrigated with GW. These results credited to the highest seed yield (Table 5). Plants irrigated with sewage water produced more oil yield than control by 206.6, 319.4, 28.8, 90.5 and 371.5 Kg/acre for castor bean, sunflower, soybean, sesame and peanut, respectively. While oil yield of cotton crop was decreased by 16.2 kg /acre.

The nutritional value, in premises of macro- (N, P & K) and micro- nutrients (Fe, Zn, Mn & Cu) content in seeds, came into view to be consistently higher in harvests from plots irrigated with treated domestic sewage effluent (Tables 6 and 7), despite the differences were not distinguishably outshine. The same trend of results continued faithfully for all tested oil summer crops.

The consumption appropriateness of crop harvests grown under irrigation with treated domestic sewage effluent was judged in both chemical and biological approach. The content of potential toxic elements (Cr, Cd, Pb , Ni & B) were more or less the same in organs irrigated with either with treated domestic sewage effluent or ground water, although being hardly higher in the formers (Table 8). No visible sign of intensifying potential toxic elements was noticed in plant harvests grown under irrigation with sole with treated domestic sewage effluent.

In some cases, plant organs grown under irrigation with ground water accommodated more potential toxic elements than those receiving treated domestic sewage effluent, e.g., lead content in soybean and sunflower crops. Also, Ni content in soybean seeds and Cr in sunflower seeds were lower in the presence of domestic sewage effluent As recorded in Table. (7), oil percent was lower in seeds of sesame, cotton, castor bean, soybean and cotton plants farmed in plots exclusively irrigated with treated domestic sewage effluent. While, the procured oil yield per acre consequently was furthermore higher because of the higher dry weight of harvests.

It is worthy to state that all oils extracted from seeds harvested under irrigation with treated domestic sewage effluent were free from potential toxic elements. The recorded disparity in potential toxic elements content between the different tested plants is accredited to the different nature of absorbing nutrient from soils.

Concerning the contents of macro- and micro-nutrient as well as potential toxic elements in oil of sex tested crops, Data in Table (9) pointed out that most oils extracted nearly free from macro-nutrients, except the oil of sunflower plant under two water sources, but no obvious differences in micronutrient were noticed. Regarding the potential toxic elements in oil of crops under study, the results in Table (9) revealed that, more or less the same in oil produced from organs irrigated with either with treated domestic sewage effluent or ground water. No detectable hint of intensifying potential toxic elements was noticed in plant harvests grown under irrigation with sole with treated domestic sewage effluent. In some instances, the oil under irrigation with ground water accommodated more potential toxic elements than those receiving treated domestic sewage effluent, e.g., lead content in oil of sunflower and soybean crops. Also, Ni content in peanut and sunflower oils were lower in the presence of domestic sewage effluent. It worthy to mentioned that the results of elements content in oil of six crops take the same direction as in the seeds.

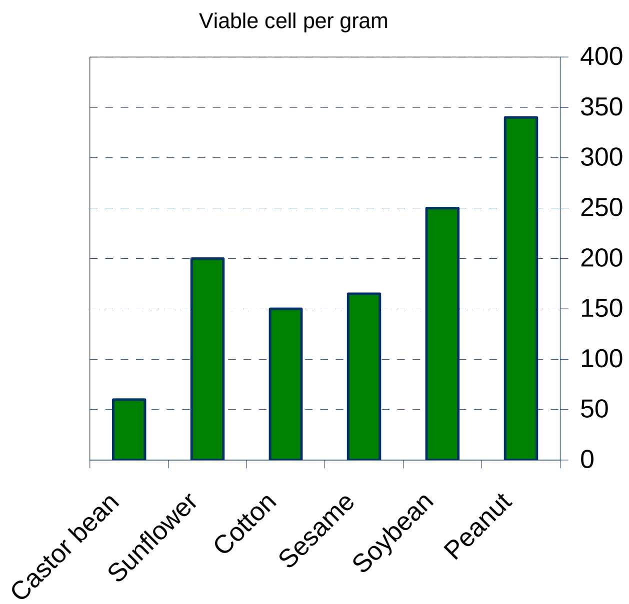
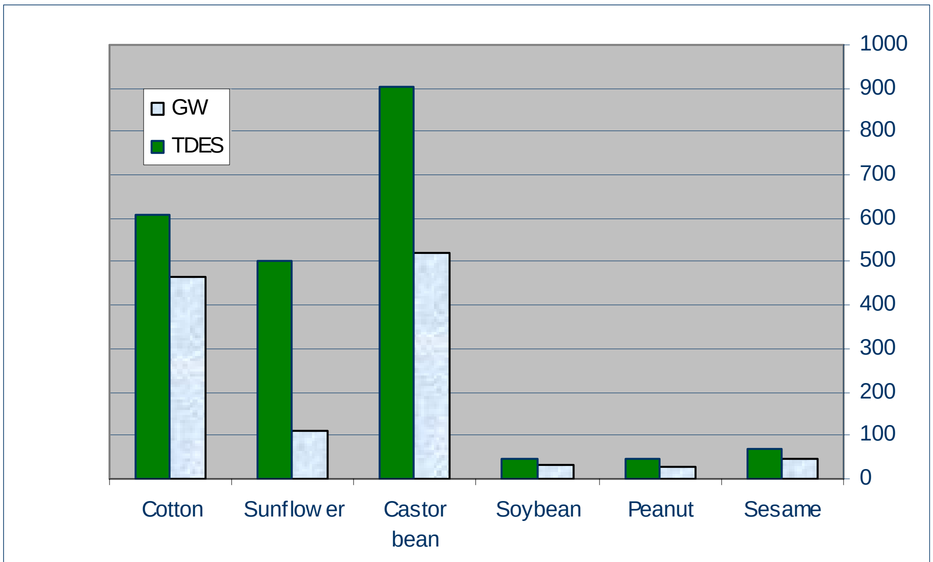


Fig (1) Counts of fecal coliforms in the rhizosphere of the tested plants after 60 days of sowing (oven dry basis)

Discussion

Potentiality of sewage farming is mainly established by its bearings on agro-environment and public health. As far as the few guidelines that have been written are often limited in reach, a multidisciplinary approach to planning such farming is obligatory (Pescod, 1992). Expedient planned use of treated domestic sewage effluent not only set aside valuable water resource but also takes superiority of nutrient elements common in sewage effluent to grow plants.



Fig(2): Straw dry w eight(g/plant) after harvest of summer oil crops irrigated w ith TDSE or GW

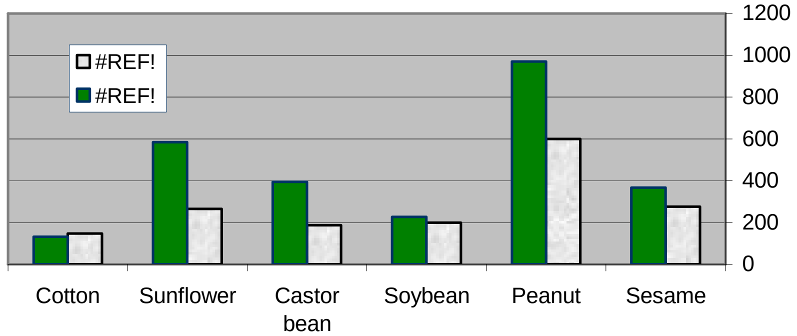


Fig (3): Oil yield (kg/acre)of oil crops irrigated with either treated domestic sewage effluent (TDES) or ground water(GW)

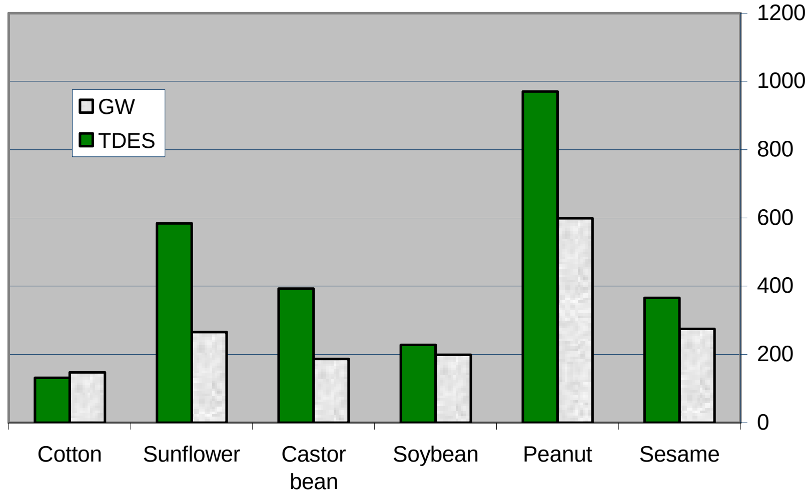


Fig (4): Oil yield (kg/acre)of oil crops irrigated with either treated domestic sewage effluent (TDES) or ground water(GW)

Table (5): Yield characters at harvest of oil crops irrigated with either treated domestic sewage effluent or ground water

Character	Sesame		Peanut		Soybean		Castor bean		Sunflower		Cotton	
	GW	TDES	GW	TDES	GW	TDES	GW	TDES	GW	TDES	GW	TDES
No. of capsules , fruits or bolls/plant	118.4	148.0	-	-	-	-	105.7	209.0			14	22
No. of pods/plant	--	--	38.8	53.6	53.9	75.0	-	-	-	-	-	-
No. of seeds/plant	3433	5180	43.9	71.2	149	237	297	627				
No.of branches / plant	-	-	9	15	4.6	5.0	5.8	9.0-	-	-	10.0	31.6
Weight of seeds/plant (gm)	130.2	241.2	48.9	86.8	23.4	39.1	96.0	221.0	57.9	143.6	26.0	54.9
Straw yield/acre (ton)	1.140	1.621	2.978	4.675	1.497	2.660	-	-	2.99	5.681	2.116	2.66
Harvest index (%)	0.32	32.0	23.7	24.4	63.0	65.0	-	-	21.0	25.0	24.6	22.9
Seed yield/acre (ton)	0.53	0.76	1.15	1.83	0.89	1.46	0.52	1.26	0.79	1.93	0.69	0.79
Seed oil %	52.0	48.1	52.2	53.1	22.4	15.6	35.3	31.1	33.4	30.3	21.4	16.6

Table (6): Macronutrient content (%) of seeds grown under irrigation with either treated domestic sewage effluent or ground water (oven dry basis)

Plant	N		P		K	
	TDSE	GW	TDSE	GW	TDSE	GW
Sesame	3.26	2.47	0.721	0.581	0.860	0.720
Peanut	2.56	2.92	0.459	0.371.	0.860	0.860
Soybean	4.74	3.61	0.681	0.621	1.640	1.250
Sunflower	2.14	1.98	0.485	0.411	0.900	0.680
Cotton	2.50	1.68	0.637	0.833	1.120	1.080

Table (7) Micronutrient content (ppm) of seeds grown under irrigation with either treated domestic sewage effluent or ground water (oven dry basis)

Plant	Fe		Zn		Mn		Cu	
	TDSE	GW	TDSE	GW	TDSE	GW	TDSE	GW
Sesame	175.2	162.1	46.11	31.18	19.40	15.13	13.18	11.60
Peanut	64.35	36.35	34.85	28.85	8.28	13.18	8.50	8.00
Soybean	68.75	58.12	53.95	52.51	42.43	40.19	9.60	7.91
Sunflower	98.95	53.15	35.10	28.00	18.93	16.18	11.59	15.25
Cotton	55.10	30.60	38.10	21.15	13.48	13.33	7.15	5.95

(TDSE): Treated domestic sewage effluent
(GW): Ground water (-): Not determined

Table(8): Potential toxic elements content of seeds grown under irrigation with either treated domestic sewage effluent or ground water(oven dry basis)

Plant	Cr		Cd		Pb		Ni		Br	
	TDSE	GW	TDSE	GW	TDSE	GW	TDSE	GW	TDSE	GW
Sesame	3.42	1.21	0.62	0.53	4.19	1.17	25.13	11.06	18.11	12.09
Peanut	Traces	Traces	0.25	0.25	1.23	0.32	7.65	5.15	19.38	20.58
Soybean	7.15	4.13	2.53	1.92	Traces	0.21	1.15	1.47	26.15	20.91
Sunflower	0.76	1.55	0.29	0.15	1.67	3.91	16.00	24.55	25.93	24.58
Cotton	0.45	Traces	Traces	Traces	0.43	Traces	1.25	0.25	11.78	10.98

Table (9): Macronutrients (%), micronutrients and potential toxic elements content (ppm) of oil crops grown under irrigation with either treated domestic sewage effluent or ground water .

Crop	GW	TDES	GW	TDES	GW	TDES	GW	TDES
	N		P		K			
Peanut	0.21	0.65	0.008	0.007	Traces	Traces		
Soybean	0.251	0.382	Traces	0.049	Traces	Traces		
Sesame	Traces	Traces	Traces	Traces	Traces	Traces		
Cotton	Traces	Traces	Traces	Traces	Traces	Traces		
Sunflower	0.258	0.351	0.011	0.005	Traces	Traces		
Crop	GW	TDES	GW	TDES	GW	TDES	GW	TDES
Castor bean	-	Traces	-	Traces	Traces	Traces		
	Fe		Zn		Mn		Cu	
Peanut	4.90	3.00	9.50	6.00	Traces	Traces	Traces	Traces
Soybean	4.80	11.0	6.35	11.50	0.05	0.95	0.45	Traces
Sesame	6.15	8.85	2.30	2.85	0.19	0.28	Traces	0.15
Cotton	2.51	2.90	9.12	11.00	0.21	0.25	Traces	Traces
Sunflower	2.60	2.80	7.50	32.50	0.15	0.10	0.10	0.10
Castor bean	-	2.10	-	0.55	-	0.80	-	0.60
	Ni		Pb		Cd		Br	
Peanut	2.51	2.37	Traces	0.76	0.50	0.65	Traces	Traces
Soybean	1.55	2.31	1.14	0.93	0.45	0.60	Traces	Traces
Sesame	1.17	1.28	0.42	0.64	0.18	0.25	0.19	0.34
Cotton	1.62	1.78	1.58	1.75	0.43	0.55	Traces	Traces
Sunflower	4.48	4.07	0.92	0.31	0.65	0.60	Traces	Traces
Castor bean	-	0.84	-	0.09	-	0.45	-	0.27

(TDSE): Treated domestic sewage effluent
(GW) : Ground water (-) : Not determined

Whenever good quality water is meager, water of marginal quality would have to be carefully though about for use in agriculture. Treated domestic sewage effluent is marginal quality water because of the linked health and agriculture jeopardize. The use. of such water ought to more complex management tool as well as more strict monitoring formats.In addition to the economic donations of the water, the fertilizer value of treated domestic sewage effluent is of high distinction. With typical concentrations of nutrient elements in treated domestic sewage effluent form conventional sewer pant, the concentration of N, P & K are 22, 4.75 & 22.4 ppm
respectively. Regarding application rate of 15000 m^3/acre/year, the fertilizing contribution of treated domestic sewage effluent is 330 kg N, 71 kg P and 34 kg K annually per acre. Thus all the nitrogen, phosphorus, and most of the potassium commonly necessary for agricultural crop production would be endowed by treated domestic sewage effluent. In addition other pragmatic micronutrients and organic matter contained in treated domestic sewage effluent will meet the expenses of extra benefits.

Growth criteria trait that the physiological act of plants allied to sole irrigation with treated domestic sewage effluent far exceeded those irrigated with ground water. Both harvests index and seed index were higher in the prior plants. The physiological preference in plants was more purposeful towards the formation of economic yield (seeds or oil) rather than to straw. Similar finding were reported by Simon et al 1998 and Saber et al 2001.These findings are instantly associated to the better ecosystem that was provide in soil, with treated domestic sewage effluent, as far as plant nutrient adequacy is given due consideration. To an inferior extent the hormonal action of treated domestic sewage effluent might had a slight stimulatory role on plant growth (Krishnamoorthy, 1981)

Safety measures about human consumption of harvests from a sewage farm are bounded with the content of potential toxic elements and pathogens load (FAO, 1993 and WHO, 1989). Current results implicit at no sign of accumulation of potential toxic elements in yields cultivated under irrigation with treated domestic sewage effluent for one season. The potential toxic elements contents in sewaged plants were, more or less the same, as with plants irrigated with ground water. These results may be attributed to that sewage water in Luxor is not mixed with industrial waste water. Hovak *et al* 1998 stated that there was a linear relation between Cd content in plants and NH-4 extractable Cd in soils from two sites. Although at one sites Pb levels were high, Pb content in leaves and seeds did not exceeded 20 and 0.1 mg/kg, respectively
Obtained results showed signs that root exudates in rhizosphere soil put forth either an inhibitory or a stimulatory function towards fecal coliforms. Such phenomena might be used, as an fortunate implement, in denying soil impurity with enteric pathogens through sensible crop selection in sewage farms. From a hygienic point of view, no edible crops eaten raw should be grown in sewage farm. Present results, however, proofed the complete removal of enteric pathogens during food processing. It is

optional to attach an agro-industrial complex to sewage farms for the sake of producing safe products. However, the presence of endo-microbial toxins in the products is still questionable.

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