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## The agronomic and economic value of treated wastewater reuse for some field crops in desert soil

Ezzat Momamad Abd El Lateef<sup>1\*</sup>, Mahmoud Alaa Farrag<sup>1</sup>, Mostafa El-Sayed Abd El-Salam<sup>1</sup>,  
Jeremy Hall<sup>2</sup>, Mohamed Negm<sup>3</sup> and Abd elazeem Kottob Mohamed Salem<sup>1</sup>

<sup>1</sup>National Research Centre, Agric. Div., Dokki, Giza, 33 El-Behooth St., Giza, Egypt

<sup>2</sup>Independent sludge and water consultant, Medmenham, Marlow, SL7 2HD, UK

<sup>3</sup>Faculty of Engineering, Ain Shams Univ., Public Works Dept., Ahmad Osman Street, Nasr City, Cairo, Egypt

\*Corresponding author: [ezzlatnrc\\_2nrc@hotmail.com](mailto:ezzlatnrc_2nrc@hotmail.com)

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### Abstract

To evaluate the agronomic and economic value of wastewater reuse in desert soil, demonstration field trials were conducted in desert (virgin) soil to evaluate the effect of irrigation with secondary treated wastewater from El Berka wastewater treatment plant on food and non-food crops. The results showed that considerable amounts of macronutrients (NPK) were applied to the grown crops through the treated wastewater irrigation: N (36–176%), P<sub>2</sub>O<sub>5</sub> (72–360%), and K<sub>2</sub>O (99–357%) of the recommended fertilizer rates according to the crop. Crop yields showed significant differences when treated wastewater was combined with the recommended fertilizer rates for most crops. Maize, cotton, sunflower, and wheat seemed to be better cropped for irrigation with secondary treated wastewater. The calculation of fertilizer value in EGP based on market prices in Egypt showed that nitrogen addition value ranged between 315 and 1178 EGP, P between 194 and 1128 while K ranged between 585 and 2398 EGP according to the crop and the period of wastewater irrigation. The Economic value of fertilizer inputs applied to the field crops indicates that the total NPK value ranged between 1049 and 4303 LE. It could be concluded from this study that treated wastewater has substantial agronomic value for most of the field crops studied. Wastewater irrigation could save partial NPK crop requirements and needs fertilizer compensation. The advantage of field crop irrigation with treated wastewater is evident from the agronomic and economic scene. A crucial conclusion of this work is that it serves in wastewater pricing plans in the new lands in Egypt and similar countries.

**Keywords** Irrigation, Desert soil, Wastewater reuse, Macronutrients, Economic value, Treated wastewater pricing

### Introduction

In Egypt, the annual water demand exceeds the available freshwater by 6 billion m<sup>3</sup>year<sup>-1</sup> (Abu Zeid, (1992). Water reuse is arising because of the water crisis with Nile basin countries, ambitious land reclamation programs, growing populations, increasing rural development, and crop demands. However, there are attendant risks involved with reuse to the plant, soil, groundwater, and health (Oron et al., 1992; Shatanawi & Fayyad, 1996, Aissi et al., 1997, Oron et al., 2007). One of the most recognized benefits of wastewater use in agriculture is the associated decrease in pressure on

freshwater sources (Jaramillo and Restrepo, 2017). Thus, wastewater serves as an alternative irrigation source (Winpenny et al., 2013), specially for agriculture, the greatest global water user, which consumes 70% of available water (Pimentel et al., 1999). Furthermore, wastewater reuse increases agricultural production in regions experiencing water shortages, thus contributing to food safety (Pimentel et al., 1999). WRC (2001) estimated that wastewater could offer about 30% of the crop requirements of N and 100% or more from crop requirements of K in sandy calcareous soil in Alexandria. Additionally, the nutrients naturally present in wastewater allow savings of fertilizer expenses to be realized

(Drechsel et al., 2010; Winpenny et al., 2013; Corcoran 2010 and Moscoso, 2017), thus ensuring a closed and environmentally favorable nutrient cycle that avoids the indirect return of macro-(especially nitrogen and phosphorous) and microelements to water bodies. Depending on the nutrients, wastewater may be a potential source of macro- (N, P, and K Ca, Mg, B, Mg,) and micronutrients (Fe, Mn, or Zn) (Barreto et al., 2013 and Jimenez, 1995). Wastewater reuse has been proven to improve crop yield (Moscoso, 2017; Jimenez, 1995) and result in the reduced use of fertilizers in agriculture (Toze, 2006). Therefore, this work aims to evaluate the effect of treated wastewater on irrigation of field crops yields and the agronomic and economic value of the nutrients applied through wastewater irrigation in sandy soil.

## Materials and methods

This paper is a part of a study entitled the "Cairo East Bank Effluent Re-use Study". The client is the Cairo Wastewater Organization (CWO) and the study is partially funded by the Kuwait Fund for Arab Economic Development (KFAED). The study was implemented by a joint venture consortium of Montgomery, Watson, Gibb International, and some other Arab companies. Demonstration field trials were carried out in winter and summer seasons in the El Berka site located about 20 km northeast of Cairo. As it was intended to use secondary treated wastewater and to be secured the experimental site was located inside the El Berka wastewater treatment plant; the soil is gravelly sand and could be classified as the virgin soil. The experimental area was divided into 32 large experimental units 8 allocated for each crop selected according to the crop and the irrigation method. The design of each trial was Complete Randomized Block Design with 4 replicates were 4 plots received wastewater only and the other 4 received wastewater plus supplementary fertilizer to be adjusted for each crop according to the normal recommended rates. Four crops were planned to grow in each season, crop selection included a range of food, fodder, and industrial (fiber and oil) crops according to WHO (1989). For the summer season, cotton (Giza 85 variety) soybean (Giza82 variety), maize (Single Hybrid 129 variety), and sunflower (local variety) were grown. In the winter season, wheat (Sakha 8 variety), faba bean (Giza 3 variety), lupine (Giza 1 variety), and canola (Pactol variety) were grown. Ddrip and sprinkler irrigation systems were used. Sprinkler irrigation was used for soybean, wheat and canola; drip irrigation for cotton, maize, sunflower, lupin, and fababean. The experimental plot area was 200m<sup>2</sup>(10x20m). Fertilizers were applied according to the normal recommended rates in Egypt for each crop. Nitrogen, phosphorus and potassium were applied as ammonium nitrate(33.5% N), calcium superphosphate (15.5%P<sub>2</sub>O<sub>5</sub>) and potassium sulphate (48%K<sub>2</sub>O), respectively.

## Crop growth and yield assessment

During the two crop cycles, the crops were routinely inspected for diseases, pests, and weed control. At crop maturity, the growth characteristics and yield components were assessed according to the type of the crop. The individual plant measurements included plant height and weight, number of

branches or tillers per plant as well as the number, weight, and dimensions of fruiting organs (pods, capsules, cobs, bolls, spikes, etc.). The conventional assessment practices were followed to provide mean individual plot performance as well as biological, straw, and grain or seed yield /feddan. This research will focus only on the economic yield parameters.

## Treated wastewater analysis

Samples of treated wastewater from El Berka were taken during crop cycles and analyzed for a range of agronomic and environmental parameters. Nutrient and heavy metal loading rates to field trials were calculated according to the irrigation quantities applied to each crop to assess the acceptability of these wastewaters for reuse in the short and long-term. Another objective of these analyses was to determine wastewater compliance with the Egyptian limit values (Decree 44/2000). Treated wastewaters were analyzed according to APHA (1992).

## Wastewater fertilizer inputs to field crops

It was calculated from total water quantity irrigated to each crop and nutrient concentration in wastewater according to WRc (2001).

## The economic value of nutrient addition

It was calculated from nutrient addition to each crop on fertilizer prices basis in Egyptian market.

## Results

### Treated wastewater quality

Final wastewater samples collected from El Berka WWTP throughout the trials were monthly routinely analysed for nutrients and heavy metals (Table 1). The results showed that the pH of the wastewaters was within the acceptable range for reuse, normally 6.5–8.5 according to the Egyptian decree for wastewater reuse (Decree 44, 2000). The nutrient contents of the wastewater were broadly similar in their suitability for reuse. It is worthy to mention that considerable amounts of macronutrients (NPK) were applied to the grown crops through the treated wastewater irrigation: N (36–176%), P<sub>2</sub>O<sub>5</sub> (72–360%), and K<sub>2</sub>O (99–357%) of the recommended fertilizer rates according to the crop.

The heavy metal concentrations were very small in wastewater, and are well below the limit values for secondary wastewater reuse, usually by at least one order of magnitude where the limit values of the heavy metals according to the Egyptian decree for wastewater reuse (Decree 44/2000) are (0.01 for Cd and Cr; 0.2 for Cu, Ni and Mn, 0.05 for Co, and 5 mg kg<sup>-1</sup> for Fe). The numbers of fecal coliforms found in treated wastewater were at 10<sup>6</sup> MPN/L, far more than that permitted by the guidelines of WHO (1989), and *Salmonella* were present in all samples. Nematode ova were found in all samples of treated wastewater over the limit value for reuse (mean 49 ova/L). Table 1 presents the mean concentrations of treated wastewater chemistry and microbiology.

**Table (1) Mean concentrations of treated wastewater chemistry and microbiology from El Berka WWTPs.**

Parameters	Mean	Min.	Max.	N	CV%
pH	7.78	7.65	7.86	9	0.8
Total N	12.8	7.4	18.7	25	23.9
Total P	3.4	1.2	5.3	26	29.3
K	13.8	8.3	24.1	27	23.3
Fe	0.577	0.064	0.980	13	54.8
Mn	0.115	0.010	0.320	11	67.4
Cr	0.027	0.006	0.087	11	120.0
Ni	0.039	0.007	0.082	11	68.7
Zn	0.094	0.011	0.180	11	67.7
Cu	0.049	0.014	0.093	11	56.2
Cd	<0.005	<0.005	<0.005	13	-
Pb	0.079	0.031	0.130	13	31.7
Mo	<0.01	<0.01	<0.01	11	-
Co	<0.005	<0.005	<0.005	11	-
<i>Salmonella</i>	1.8	1	2	26	26.1
<i>F. coliforms</i>	35	3	82	24	71.7
<i>Helminth</i>	49	5	202	25	103.1

Units: All determinants in mg/L except EC (dS/m); *salmonella* qualitative range 0 = absent, 1 = low, 3 = high; faecal coliform bacteria 10<sup>5</sup> MPN/100 ml; *helianthus ova*/L.

### Statistical analysis

The obtained results were subjected to the proper statistical analysis using the MSTAT-C package, program according to MSTAT-C. For means comparison LSD at 5% was used.

### Wastewater fertilizer inputs to field crops

Irrigation quantities were accurately recorded for each plot at both sites during the summer and winter seasons. Table (2) summarises the amounts of wastewater irrigated to each crop and fertilizer treatment, as a means of four replicate plots of each treatment. Although a fixed irrigation schedule was envisaged, this had to be adapted according to crop water requirements as observed in the field. The quantities of wastewater applied are broadly in line with normal practice, with exceptions, and these are related to the basic water requirement which varies between crops and the length of the growing season. For instance, cotton requires a long season to mature and consequently, this had the largest amount of wastewater applied. Conversely, lupin has a small water requirement, as indicated by the quantities irrigated.

Table (3) lists the normally recommended application rates of inorganic fertilizer to the range of crops tested in these trials. The recommendations for some crops are different according to the fertility level of the soil and recommended for each crop.

Nevertheless, the wastewaters provide a significant proportion of the normal recommended fertilizer rates. Cotton received 176% of its recommended N rate, but this was due to the high irrigation demand of this crop on desert soil and would not normally be grown under these conditions (Fig 1). These observations are important because one of the problems encountered by wastewater reuse in other countries has been the over-supply of nitrogen at normal crop irrigation duties due

to the high concentrations in the wastewater. This can lead to luxurious growth at the expense of economic yield and give rise to nitrate leaching and pollution of groundwater. This is not likely to occur in Egypt as wastewaters generally have relatively low nitrogen contents.

**Table 2: Mean quantities of wastewater irrigated according to crop type and treatment (m<sup>3</sup>/fd\*)**

Crop	Irrigation method	Fertilizer	
		None	Applied
Lupin	Drip	2171	1565
Maize	Drip	3554	3591
Cotton	Drip	10053	10564
Soya bean	Drip	2197	2831
Sunflower	Drip	2829	2884
Wheat	Sprinkler	3157	2679
Canola	Sprinkler	3051	2609
Faba bean	Drip	3041	2693

fd = feddan = 4200m<sup>2</sup>

The addition of phosphorus by the wastewater was closer to the recommended rates for the crops at both sites, with the excess being applied only to cotton and maize. However, surplus P addition is not a significant environmental concern since this element is readily fixed in the soil where it forms insoluble calcium phosphate.

The potassium contents of the wastewaters were large relative to crop requirements, compared with those for N and P. Consequently, crop requirements for potassium (as K<sub>2</sub>O) were generally exceeded by large margins for most crops. However, potassium is held strongly by soils, particularly those with high cation exchange capacities, and even where this is exceeded and leaching occurs, this will be adsorbed further down the soil profile. In the long-term, groundwater

quality could be affected but not adversely as there are no environmental problems associated with this, other than its contribution to salinity level. The data of chemical additions through treated wastewater varies according to crop water requirements at the duration of cropping. The data show that El Berka soils received small additions of heavy metals; moreover, some elements as Cd, Mo, and Co were below the detection limit as shown in Table (1). These results reflect minimum pollution in the short and long terms and indicate the suitability of Cairo wastewater for reuse on the agricultural land. Similar results were obtained by Mahmoud et al (1998) in Jordan and (WRC,2001) in Egypt. Barreto et al., 2013 and Liu et al., 2011 indicated that depending on the nutrients, wastewater may be a potential source of (N, P, and K) and micronutrients (Ca, Mg, B, Mg, Fe, Mn or Zn). Also, Abd El Lateef et al (2020 a and b) came to similar results.

The general chemistry of the treated wastewater does not impose any constraints on the types of crops that may be grown or the types of soil to which it may be applied. Beneficial additions of NPK to the grown crops were evident and by the results of WRC (2001); they showed that these treated wastewaters would generally provide approximately 50% of N and about 70% of P requirements but about 200% of K requirement, although this varied widely according to the specific crop and whether this was calculated for fertile or infertile soil.

The potential long-term consequences to soil quality of irrigating these treated wastewaters were modeled in other studies (WRC, 2001) which showed that it would take several hundred years to reach precautionary soil limit concentrations, but if crop off-take is taken into account, then heavy metal input and output would be more-or-less in balance and there would be the minimal net impact on soil

quality. Similar results were obtained by Mahmoud et al. (1998). WRC (2001) in Egypt reported that the concentrations were variable and reflect minimum pollution in the short and long terms and indicate the suitability of Cairo wastewater for reuse on the agricultural land. In another study (Abd El Lateef et al., 2010; Derfasi, 2014; Abd El Lateef et al., 2020 and Abd El Monsef and Abd El Lateef 2020) came to a similar conclusion

### Crop Yields

#### Summer Crops

Data presented in Table 4 and Fig 2 show the overall yield criteria of summer crops showed statistically significant increases due to the addition of fertilizer. The coefficients of variation of the means of data derived from individual plant measurements were quite small, but the CVs of the yields derived from area assessments were relatively large due to crop variability.

Application of recommended fertilizer rate to maize significantly increased all yield characters. Maize grain yields were large for this soil type, and the addition of fertilizer increased yields by 52%, approaching the national average yield of 2.3 t/fd. The grain to straw ratio was 1:3.5, indicating that a greater proportion of the nutrients were supporting grain production, rather than straw. These ratios were the same whether fertilizer was applied or not, which suggests that maximum potential grain yields for these sites may not have been achieved, as an increased straw production may be expected relative to grain if excessive levels of nutrients are applied.

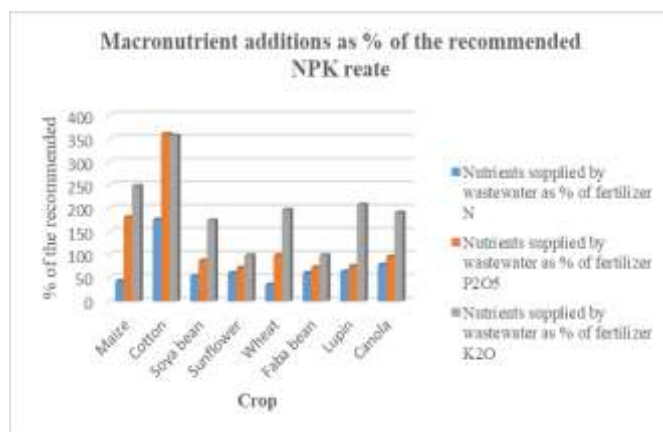
**Table 3: Proportion of nutrients supplied by wastewaters to the field trials compared with generally recommended rates of fertilizer for summer and winter crops in desert soils in Egypt**

Crop	Fertilizer recommended (kg/fd)			Addition in wastewater (kg/fd)			Nutrients supplied by wastewater as % of fertilizer		
	N	P2O5	K2O	N	P2O5	K2O	N	P2O5	K2O
<b>Summer crops</b>									
Maize	105	15.5	24	45.8	28.0	59.4	44	181	248
Cotton	75	22.5	48	132.3	80.9	171.3	176	360	357
Soya bean	60	22.5	24	32.3	19.7	41.8	54	88	174
Sunflower	60	31	48	36.7	22.4	47.5	61	72	99
<b>Winter crops</b>									
Wheat	100	22.5	24	36.5	22.3	47.2	36	99	197
Faba bean	60	31	48	36.8	22.5	47.7	61	73	99
Lupin	60	31	24	38.5	23.5	49.8	64	76	208
Canola	45	22.5	24	35.4	21.6	45.8	79	96	191

Cotton responded well to irrigation with treated wastewater (Table 4 and Fig 2). Seed cotton yield per plant (total of two picks), as measured on an individual plant basis, was increased significantly by the addition of fertilizer (P<0.0001), with yields of fertilizer treatments being three times that from the treated wastewater only, however, the large CV indicates the high variability of these data. When

yields were measured on an area basis, there were no significant effects on seed cotton yield at either pick. The straw yield was significantly increased by fertilizer application to wastewater, the increase was similar to that observed for seed cotton (19% vs 13%). The first pick accounted for 75% of the total yield on both treatments. Highly significant increases in all of the yield parameters of

soybean characters were achieved by the addition of fertilizer over those achieved by the treated wastewater on its own (Table 4 and Fig 2). The treated wastewater alone provided insufficient nutrients since fertilizer increased the measured parameters by about 150%. Seed yield increased from 0.35 t/fd to 0.88 t/fd, and the latter compares favorably with the national average yield of 1.1 t/fd, considering the poor quality of this soil. Straw yield also increased substantially with the addition of fertilizer but the seed: straw ratio was slightly smaller, indicating that optimum yield had not been reached.



**Fig 1: Macronutrient additions of treated wastewater to field crops as a percentage of the recommended NPK rate for each crop in desert land**

Data presented in table 4 and Fig 2 indicate that there were highly significant effects of fertilizers on all of the yield parameters of sunflower, with substantial increases in seed and straw yields, compared with those achieved with only treated wastewater. The addition of fertilizer increased seed yield by 67%, but increased straw yield by 141%. This may be attributed in part to the nutrient supply from El Berka effluent which closely met with recommended amounts of fertilizer for this crop. Similar results were reported by Mahmoud (1998) and Abd El Lateef et al (2014) on maize, cotton and mungbean. They added that crops irrigated with secondary treated wastewater perform equally as well as, or significantly better than, with canal water.

### Winter Crops

Yield parameters of lupine are summarised in Table 5. The addition of fertilizer increased crop performance and the results showed that the performance of individual plants under drip irrigation was superior due to the few plant densities (26,000 plants per feddan) due to the wider row spacing under the drip irrigation system. Data in Table 5 and Fig. 3 show that under either irrigation system, fertilizer increased crop performance. Data presented in Table 5 show that all of wheat yield parameters were increased although straw and biological yields were not significantly increased. The harvest index was greater with fertilizer application where relatively more grain was produced relative to straw yield.

These results emphasize that the recommended amounts of fertilizer are necessary to achieve adequate yields of wheat on this type of soil, even when irrigated by treated wastewater. This is maybe due to them that the addition of nutrients by treated wastewater irrigation is cumulative over the growing period of the crop, whilst fertilizer is applied in several doses, planned according to the growth of the crop to ensure appropriate nutrition throughout. This is demonstrated by the improved harvest indexes where fertilizer was applied.

All of the yield parameters of canola under surface irrigation were greater than under sprinkler irrigation (Table), even though a larger quantity of treated wastewater was irrigated by sprinkler (mean of 2830 m<sup>3</sup>/fd compared with 2682 m<sup>3</sup>/fd). This indicates greater water efficiency under surface irrigation and may be due to larger evaporative losses from sprinkler irrigation. However, statistically, significant differences were only detected for the number of seeds per pod, straw, and biological yields. The harvest index was greater under surface irrigation, without significant differences.

From the same table, significant increases in yield response due to the addition of fertilizer were observed for seed, straw, and biological yields. There were small but significant interactions between irrigation method and fertilizer treatments for straw and biological yields. Yields under sprinkler irrigation with fertilizer added were poor.

Data presented in Table (5 and Fig 3)) show that as expected, the lower plant density under drip irrigation produced larger individual plants with more pods, but seed weight was smaller. The increase in plant yield did not compensate for the low plant density under drip irrigation. Consequently, the harvest index was better under surface irrigation (the normal method of irrigation) and had the largest seed and straw yields on an area basis. The addition of fertilizer increased all yield parameters insignificantly except for seed yield (P= 0.0409).

These results derived from all crops clearly show that some field crops respond well to irrigation with treated wastewater i.e.; maize, cotton, wheat, and fababeans. However, other crops like lupin, canola, and soybean showed less response for irrigation with treated wastewater under the poor desert conditions. Several investigators obtained yield increases due to wastewater application (Vazquez-Montiel et al., 1996; WRc, 2000 and 2001 Abd El Lateef et al., 2014, 2020 and Abd El Monsef and Abd El Lateef 2020). Such an increase in crop yields due to wastewater irrigation could be attributed to the nutrient content about specific crop requirements. In this respect, Campbell, et al, (1983) stated that weekly application of 25 mm wastewater was enough to supply 40-80% of corn requirements and all of the P requirements while other researchers pointed out that the increase in corn yield was due to the enhancement of nutrient uptake and the improvement of the physical properties of the soil. Indeed, wastewater reuse has been proven to improve crop yield (Moscoso, 2017 and Jimenez, 1995) and result in the reduced use of fertilizers in agriculture (Toze 2006).

**Table 4: Effect of treated wastewater irrigation and fertilizer application on yield and yield components of summer field crops**

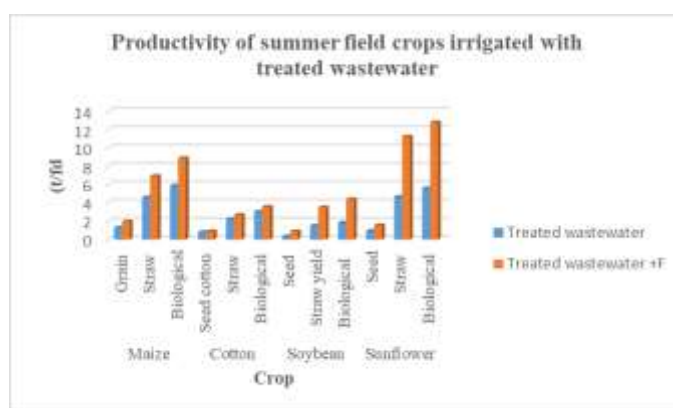
Crop	Maize			Cotton					Soybean			Sunflower		
	Grain yield (t/fd)	Straw yield (t/fd)	Biological yield (t/fd)	Yield 1st pick (t/fd)	Yield 2nd pick (t/fd)	Seed cotton yield (t/fd)	Straw yield (t/fd)	Biological yield (t/fd)	Seed yield (t/fd)	Straw yield (t/fd)	Biological yield (t/fd)	Seed yield (t/fd)	Straw yield (t/fd)	Biological yield (t/fd)
Treated wastewater	1.290	4.585	5.876	0.602	0.193	0.794	2.245	3.040	0.347	1.495	1.841	0.941	4.661	5.602
Treated wastewater +F	1.956	6.940	8.897	0.674	0.221	0.895	2.684	3.579	0.884	3.508	4.393	1.573	11.241	12.814
Significance	**	***	***	Ns	ns	ns	**	***	***	***	***	***	***	***
Probability	0.0012	<0.0001	<0.0001	0.0715	0.1802	0.0876	0.0015	0.0008	<0.0001	<0.0001	<0.0001	0.0003	<0.0001	<0.0001
CV%	38.2	24.3	25.3	10.8	24.4	12.7	13.2	11.2	49.6	44.4	45.3	40.1	46.7	43.4
LSD0.05	0.037	0.491	0.708	-	-	-	0.22	0.25	0.117	0.297	0.389	0.257	1.281	1.465

**Table 5: Effect of treated wastewater irrigation and fertilizer application on yield and yield components of winter field crops**

Crop	Lupin				Wheat				Canola				Faba bean			
	Seed yield (kg/fd)	Straw yield (t/fd)	Biological yield (t/fd)	Harvest index	Grain yield (t/fd)	Straw yield (t/fd)	Biological yield (t/fd)	Harvest index	Seed yield (kg/fd)	Straw yield (t/fd)	Biological yield (t/fd)	Harvest index	Seed yield (t/fd)	Straw yield (t/fd)	Biological yield (t/fd)	Harvest index
Treated wastewater	0.189	0.476	0.664	0.318	0.912b	3.413b	4.324	0.218	206.2b	2.104b	2.311b	0.276	0.701b	1.221	1.922	0.378
Treated wastewater +F	0.227	0.793	1.020	0.336	1.208a	4.207a	5.415	0.235	271.5a	2.577a	2.849a	0.317	0.878a	1.507	2.392	0.395
Probability	-	-	-	-	0.0109	-	-	-	0.0206	0.0416	0.031	-	0.0409	-	-	-
Significance	Ns	ns	ns	ns	*	ns	ns	ns	*	*	*	ns	*	ns	ns	ns
LSD0.05	-	-	-	-	0.2	-	-	-	51.2	0.448	0.47	-	0.167	-	-	-

**The economic value of treated wastewater**

Considerable amounts of macronutrients (NPK) were applied to the grown crops through the treated wastewater irrigation. Table 6 shows the calculation of fertilizer value in EGP based on market prices in Egypt. Nitrogen addition ranged between 315 and 1178 EGP, P between 194, and 1128 while K ranged between 585 and 2398 EGP (LE) according to the crop and the period of wastewater irrigation. The most beneficial value of N,P, and K was reported by cotton (Fig 4). This could be attributed to the longer period of cotton irrigation with treated wastewater than other crops. The Economic input of fertilizer applied to the field crops indicate that the total NPK value ranged between 1049 and 4303 LE according to the crop NPK requirements and the duration of irrigation. These results emphasize that the nutrients naturally present in wastewater allow savings on fertilizer expenses to be realized (Drechsel et al., 2010; Winpeny et al., 2013; Corcoran, 2010; Moscoso, 2017; Abd El Lateef et al., 2014 and 2020).



**Fig. 2 Productivity of summer field crops irrigated with treated wastewater**

The advantage of field crop irrigation with treated wastewater is evident from the agronomic and economic scene. Several investigators assured that the nutrients naturally present in wastewater allow savings on fertilizer



expenses to be realized (Drechsel et al., 2010; Winpeny et al., 2013; Corcoran, 2010 and Moscoso, 2017)

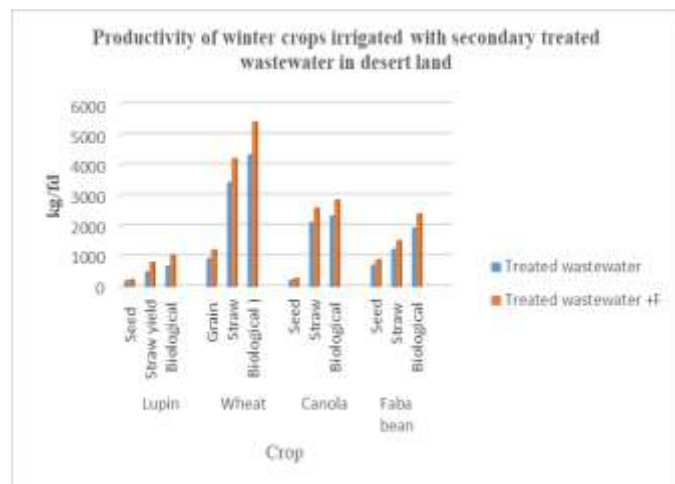


Fig. 3 Productivity of winter crops irrigated with secondary treated wastewater in a desert land

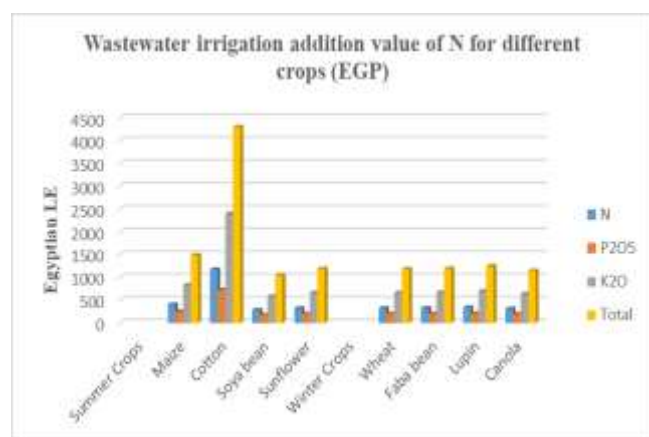


Fig. 4 Wastewater irrigation addition value of Total NPK for different crops (EGP)

**Conclusions**

It could be concluded from this study that treated wastewater has substantial agronomic value for most of the field crops. Wastewater irrigation could save partial NPK crop requirements and needs fertilizer compensation. The results emphasize that the recommended amounts of fertilizer are necessary to achieve adequate yields of wheat on this type of soil, even when irrigated by treated wastewater. This is maybe due to that the addition of nutrients by treated wastewater irrigation is cumulative over the growing period of the crop, whilst fertilizer is applied in several doses, planned according to the growth of the crop to ensure appropriate nutrition. The importance of this work is that it serves in wastewater pricing plans in the new lands in Egypt and similar countries.

Table (6) Wastewater irrigation addition value of N for different crops (EGP)

Crop	N	P2O5	K2O	Total
Summer Crops				
Maize	407.62	252	831.6	1491.22
Cotton	1177.47	728.1	2398.2	4303.77
Soya bean	287.47	177.3	585.2	1049.97
Sunflower	326.63	201.6	665	1193.23
Winter Crops				
Wheat	324.85	200.7	660.8	1186.35
Faba bean	327.52	202.5	667.8	1197.82
Lupin	342.65	211.5	697.2	1251.35
Canola	315.06	194.4	641.2	1150.66

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**Authors' contributions**

All authors (Ezzat Momamad Abd El Lateef, Mahmoud Alaa Farrag, Mostafa El-Sayed Abd El-Salam, Jeremy Hall, Mohamed Negm and Abd elazeem Kottob Mohamed Salem ) have contributed significantly to the conception and design of the study, the interpretation of data, and the drafting and revision of the manuscript. All authors read and approved the final manuscript.

**Ethics approval and consent to participate**

The authors declare that the work is ethically approved and consent to participate.

**Consent for publication**

The authors declare that the work has consent for publication.

**Conflict of interest**

The authors hereby declare no conflict of interest.

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**References**

Abd El-Lateef, E.M., Abd-Elmonsef, A.A. & Abd El-Salam, M.S.(2020). Effect of oil crops irrigation with treated wastewater and different irrigation systems on seed yield, quality and water productivity in sandy and clay soils. *American-Eurasian Journal of Scientific Research* 15 (1),14-27 DOI: 10.5829/idosi.ajejr.2020.14.27.

Abd El Lateef, E.M., Hall, J.E., Farrag, M.A.A. & Farrag A. A. (2010). Agro-economic studies on wastewater reuse in developing marginal areas in West Delta, Egypt. *International journal of water resources and arid environments*, 1(2), 110-115.

Abd-Elmonsef, A.A. & Abd El-Lateef, E.M.(2020). Effect of drip Irrigation with Treated Wastewater on Some Field Crops in Sandy Soil. *Agricultural Engineering Research Journal* 10 (1), 17-27. DOI: 10.5829/idosi.aerj.2020.17.27.

- Abu zeid, M. (1992). Water resources assessment in Egypt. *Water Resources Development*, 8(2), 76-86.
- Aissi, A., Chouker-Allah, R., Elmomari, H., Hamdi, A. & Soudi, B. 1997. Impact of irrigation with treated wastewater on infiltration, seepage and uptake on growth of melon (*Cucumis melo* L.). In: *CIHEAN International Conference, Valenzano, Bari, 22-26 Sept., 151-170*.
- APHA (American Public Health Association) 1992. *Standard methods for the examination of water and wastewater. 18th ed., Washington D.C.*
- Barreto, A., Do Nascimento, J., Medeiros, E., Nóbrega, J. & Bezerra, J.(2013). Changes in chemical attributes of a fluvial cultivated with castor bean and irrigated with wastewater. *Revista Brasileira de Engenharia Agrícola e Ambiental* 2013, 17, 480-486. <https://doi.org/10.1590/S1415-43662013000500003>
- Campbell, W. F. ; Miller, R. W. ; Reynolds, J. H. & Schreeg, T. M. (1983). Alfalfa, sweetcorn and wheat response to long term applications of municipal wastewater to cropland. *J. Environ. Qual.*, 12, 243-249. <https://doi.org/10.2134/jeq1983.00472425001200020019x>.
- Corcoran, E., Nellemann C., Baker E., Bos R., Osborn D. and Savelli J.H. (eds). (2010). Sick Water? The central role of wastewater management in sustainable development. A Rapid Response Assessment. United Nations Environment Programme, *UN-HABITAT, GRID-Arendal. www.grida.no ISBN: 978-82-7701-075-5*.
- Decree 44, (2000). Egyptian Standards for Effluent Quality and the Conditions for Reuse. *Ministry of Housing, Egypt; Article 15*
- Drechsel, P., Scott, C. A., Raschid S. L., Redwood, M. & Bahri, A. (Eds.) (2010). Wastewater irrigation and health: assessing and mitigating risk in low-income countries. Colombo, Sri Lanka: International Water Management Institute (IWMI); London, UK: Earthscan; Ottawa, Canada: International Development Research Centre (IDRC). 404p.
- Abd El Lateef, E.M., Hall J E., Farrag M.A.A. & Farrag A. A. (2014). Socio-Economic Studies on Treated Wastewater Reuse in Western Desert, Egypt: An Integrated Approach. *6 International Conference on Water Resources and Arid Environments (ICWRAE 6): 132-137 16-17 December, 2014, Riyadh, Saudi Arabia*.
- Jaramillo, M. F. & Restrepo, I. T. (2017). Wastewater Reuse in Agriculture: A Review about Its Limitations and Benefits. *Sustainability* 9(10) DOI: 10.3390/su9101734.
- Jimenez, B. (1995). Wastewater reuse to increase soil productivity. *Water Sci. Technol.*, 32, 173-180. [https://doi.org/10.1016/0273-1223\(96\)00152-7](https://doi.org/10.1016/0273-1223(96)00152-7).
- Liu, Y. & Haynes, R. (2011). Origin, nature, and treatment of effluents from dairy and meat processing factories and the effects of their irrigation on the quality of agricultural soils. *Crit. Rev. Environ. Sci. Technol.* 41, 1531-1599. <https://doi.org/10.1080/10643381003608359>.
- Mahmoud, M. J., Mazahreh, N. & Ayadi, M. (1998). Reuse of treated wastewater for irrigation of forage crops under dry land conditions. Yield nutrient uptake and soil quality. *Proceedings of the Intern. Conf. of Advanced Wastewater Treatment, Recycling and Reuse, Milano, 14-16 Sept., 2, 733-740*.
- Moscoso, J. (2017). Aspectos Técnicos de la Agricultura con Aguas Residuales. Available online: <http://bvssper.paho.org/bvssacd/scan/019502.pdf> (accessed on 25 September 2017).
- MSTAT-C, 1988. MSTAT-C, a microcomputer for the design, arrangement and analysis Michigan State University, East Lansing
- Oron, G., Demalach, Y., Hoffman, Z. & Manor, Y. (1992). Effect of treated wastewater quality and application method on agriculture productivity and environment of control. *Water Science and Technology* 26(7-8), 1593-1601. <https://doi.org/10.2166/wst.1992.0603>
- Oron, G., DeMalach, Y., Hoffman, Z. & Manor, Y. (2007). Recycling of poor quality urban wastewater by drip irrigation systems. *Journal of Cleaner Production* 15(16), 1529-1534. DOI: 10.1016/j.jclepro.2006.07.032.
- Pimentel, D., Bailey, O. & Kim, P. (1999). Will Limits of the Earth's Resources Control Human Numbers?. *Environment, Development and Sustainability* 1, 19-39 <https://doi.org/10.1023/A:1010008112119>.
- Shatanawi, M. & Fayyad, M. (1996). Effect of Khirbet As-Samra treated wastewater on the quality of irrigation water in central Jordan valley. *Water Research* 30(12), 2915-2920.
- Toze, S. (2006). Reuse of Effluent Water-Benefits and Risks. *Agricultural Water Management* 80(1) 147-159. DOI: 10.1016/j.agwat.2005.07.01.
- WHO (1989). Health guidelines for the use of wastewater in agriculture. *Report 778 of World Health Organization (WHO) Scientific Group, Geneva, Switzerland*. [https://doi.org/10.1016/S0043-1354\(96\)00176-5](https://doi.org/10.1016/S0043-1354(96)00176-5).
- Winpenny, J., Heinz, I., Koo-Oshima, S., Salgot, M., Collado, J., Hernández, F. & Torricelli, R. *Reutilización del Agua en Agricultura: Beneficios para Todos; FAO: Rome, Italy, 2013; Volume 124. ISBN 978-92-5-306578-3*.
- WRC (2000). A strategic appraisal of the potential for treated wastewater reuse in Alexandria region. *Alexandria Effluent and Sludge Reuse Study, WRC Report No. AESRS 15*. WRC report No. AESRS 002.
- WRC (2001). Treated wastewater reuse demonstration trials. *Alexandria Effluent and Sludge Reuse Study, WRC Report No. AESRS 15*

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