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EFFECT OF IRRIGATION WITH TREATED WASTEWATER AND FERTILIZATION ON AVAILABILITY OF SOME NUTRIENTS

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ABSTRACT

A pot experiment was conducted using a sandy loam soil cultivated with sorghum plant. This investigation aimed to study the effect of different treated of municipal wastewater and fertilization on availability of some nutrients after harvesting of sorghum. The experiment consisted of 4 sources of irrigation water namely: 1- well water, 2- primary treated wastewater, 3- secondary treated wastewater and 4- tertiary treated wastewater. In addition, 6 fertilization treatments were applied namely: 1- control, 2- 100% NPK, 3- 50% NPK, 4- 25% NPK 5- 100% PK and 6- 100% NK from the recommended dose of NPK fertilizers for sorghum plant.

The obtained results demonstrated that application of primary treated wastewater resulted in a significant increase in available N at the studied soil depths. The data further indicated that application of 100% NPK treatment gave a significant increase in available N at the various soil depths.

The results also, indicated that the effect of primary treated wastewater was the most conspicuous on available P content of the soil and resulted in a higher available P content as indicated by soil test data. The fertilizer treatments increased the available P at 0-20 cm depth in comparison with the control and 100% NK treatments.

Available K level was increased by applying all water treatments. Application of the secondary wastewater treatment increased significantly available K level at the depth of 0-20 cm, whereas there are no significant differences at the other soil depths. All fertilizer treatments increased slightly available K at various soil depths.

The results indicated that applying well water increased significantly available Cu at 0-20 cm depth in compared with the different treated wastewaters. Nevertheless, the data showed that level of available Zn and Mn was higher under primary and tertiary treated wastewater treatments. Level of available Fe was not affected by using water treatments.

The fertilizer treatments did not result in any significant difference in available Cu, Zn, Mn and Fe.

Keywords: available nutrients, treated wastewater, well water, NPK fertilizers.

INTRODUCTION

The disposal of wastewater to agricultural soils has long been practiced. In many arid and semi-arid regions, using of wastewater as a supplemental source of irrigation is inevitable for increasing agricultural production (El-Nennah, *et al.,* 1982).

Soils of Saudi Arabia are mostly coarse textured, and characterized by high pH values, high amounts of $CaCO_3$ and low organic matter content (Bashour, and Al-Jaloud, 1984). This could result in adequate nutrients supply and could affect the availability of various nutrients.

According to an estimation of Al-Riyadh Region Water and Sewage Authority, approximately 100 million m^3 of wastewater is potentially available annually in Riyadh city alone. Another problem facing agricultural production in the Kingdom is the scarcity of water as a result of aridity, which characterize the whole region. It is suggested that the use of other non-conventional water resources such as treated wastewater could elevate a part of this problem (Al-Tarbaq and El-Dewaih, 1996). In addition to this, the wastewater supplies the plant with some nutrients and enhances the availability of others (Al-Jaloud *et al.*, 1993). Also, wastewater provide additional source of nutrients thereby reducing the need of farmers to invest in chemical fertilizers (Al-Lahham *et al.,* 2003).

The nutrients in wastewater are considered as fertilizers capable of improving crop yield and true growth (Demirjian *et al.,* 1984 and Saenz, 1987). Research also showed that use of some wastewaters for irrigation increased trace metals in soils and plants. El-Nennah *et al.* (1982) observed increases in boron and heavy metals concentrations and considered it as a potential problem for soils and plants.

On the other hand, Modaihsh *et al.* (2002_a) concluded that application of wastewater resulted in a significant increase in available phosphorus even no P fertilizer was applied.

This study aims to investigate the effect of irrigation with different treated wastewaters and fertilization on availability of some nutrients in soil.

MATERIALS AND METHODS

A pot experiment was conducted at the College of Food Science and Agricultural Educational Farm, King Saud University, Saudi Arabia, to study the effect of using different treated wastewaters and nitrogen, phosphorus and potassium fertilizers on availability of N, P, K, Fe, Mn, Zn and Cu nutrients in a calcareous soil. A sandy loam soil sample was collected from the surface soil (0-30 cm) of the Experiment and Research Farm at Dirab area, south Riyadh (25km), Saudi Arabia. Some physical and chemical properties of the studied soil are shown in Table 1.

Table (1): Physical and chemical properties of the investigated soil

Soil property	Values
Sand,%	84.12
Silt,%	04.08
Clay,%	11.80
Soil texture	Loamy sand
$CaCO_3$,%	18.50
Organic matter,%	0.30
pH (soil paste)	7.75
EC_e, dSm^{-1}	5.61
Available N, ppm	17.50
Available P, ppm	2.10
Available K, ppm	61.00
Available Fe, ppm	7.00
Available Mn, ppm	3.42
Available Zn, ppm	10.89
Available Cu, ppm	0.32

The soil was used to fill the pots that were 40 cm in diameter and 80 cm in height with a capacity of 60 Kg soil.

The experiment consisted of 4 sources of irrigation water namely: 1- well water; 2- primary treated wastewater; 3- secondary treated wastewater and 4- tertiary treated wastewater. The wastewater was obtained from Riyadh Wastewater Treatment Plant. The chemical composition of the irrigation water is given in Table 2.

Table 2: Chemical analysis of the irrigation water.

Water treatments	pH	EC dS/m	OM %	mgL^{-1}					
				N	P	K	Zn	Fe	Mn
Primary	7.72	1.59	0.04	50.55	6.28	19.75	0.02	0.07	0.02
Secondary	7.59	1.46	0.03	14.45	4.37	15.50	0.05	0.03	0.02
Tertiary	7.56	1.45	0.02	6.30	3.85	14.00	0.05	0.04	0.02
Well water	6.81	1.35	N.D*	4.90	0.12	10.00	0.44	0.07	0.00

*** N.D is not determined**

The experiment included also 6 fertilizer treatments namely: 1- control 2- 100% NPK; 3- 50% NPK; 4- 25% NPK; 5- 100%PK and 6- 100% NK from the recommended dose of NPK fertilizers for sorghum plant. The recommended doses of N, P and K fertilizers are: 150 Kg N/ha, 60 Kg P/ha and 50 Kg K/ha, respectively. Nitrogen was added as urea, while phosphorus and potassium were applied as KH_2PO_4.

Twenty seeds of sorghum (Sorghum bicolor L.) were planted in each pot. The treatments were replicated three times. The experiment was conducted in a Randomized Complete Block Design. Plants were harvested 60 days after planting. After harvesting, representative soil samples were collected from three soil depths at 0-20, 20-40 and 40-60 cm from each pot. The soil samples were air-dried, passed through 2 mm sieve and stored for analysis.

Available nitrogen was extracted from the soil samples by using KCl solution as described by Keeney and Nelson (1982). Available P, K, Fe, Zn, Mn and Cu were extracted by using NH_4HCO_3-DTPA (AB-DTPA) solution according to the method described by Soltanpour and Schwab (1977). N was determined using microkjldahl method according to the method described by Jackson (1967). P was determined by a colorimetric method using a spectrophotometer and K was determined by using the flame photometry method (Jackson, 1967).

Available trace elements (Fe, Zn, Mn and Cu) were determined in the AB-DTPA extract by Inductively Coupled Plasma Spectrometer (ICP), (Optima 4300DV).

Data were subjected to statistical analysis using Statistical Analysis System- Analysis of Variance (SAS, 1982) with least significant difference (LSD) for the mean separation.

RESULTS AND DISCUSSION

Effect of wastewater and fertilization on availability of N, P and K nutrients:

The effect of treated wastewater and fertilization on availability of nitrogen at various depths of the studied soil is shown in Table 3(a, b, c).

Table 3a:Effect of irrigation water and fertilization on available N (ppm) at 0-20 cm

Fertilizer(F) treatments	Water treatments (W*)				
	W.W	**P.W**	**S.W**	**T.W**	**Mean**
Control	19.60	49.47	28.19	24.27	30.27a
NPK 100%	35.60	38.27	24.27	29.17	31.83a
NPK 50%	30.40	38.27	25.20	21.73	28.90a
NPK 25%	34.00	39.73	26.27	24.56	31.14a
PK 100%	23.20	37.33	25.20	28.19	28.48a
NK100%	40.66	28.93	25.20	28.00	30.70a
Mean	30.58b	38.67a	25.72b	25.99b	

LSD (0.05) for W means = 5.2
LSD (0.05) for F means is N.S
***P.W = Primary treatment**
***S.W = Secondary treatment**
***T.W = Tertiary treatment**
***W.W = Well water**

Table 3b:Effect of irrigation water and fertilization on available N (ppm) at 20-40 cm

Fertilizer(F) treatments	Water treatments (W)				
	W.W	**P.W**	**S.W**	**T.W**	**Mean**
Control	27.07	35.47	36.40	25.20	31.04ab
NPK 100%	30.80	48.53	39.73	20.53	34.90a
NPK 50%	35.49	27.07	24.27	25.60	28.11ab
NPK 25%	26.13	42.13	28.60	28.93	31.45ab
PK 100%	29.73	38.27	22.40	37.00	31.85ab
NK100%	28.93	25.99	22.00	25.20	25.53b
Mean	29.69ab	36.24a	28.90ab	27.08b	

LSD (0.05) for W means = 8.85 **LSD (0.05) for F means is N.S**

Table 3c: Effect of irrigation water and fertilization on available N (ppm) at 40-60 cm

Fertilizer(F) treatments	Water treatments (W)				
	W.W	**P.W**	**S.W**	**T.W**	**Mean**
Control	23.33	64.37	28.00	23.33	34.67ab
NPK 100%	41.93	43.87	38.27	31.73	38.95a
NPK 50%	38.67	30.80	23.33	24.66	29.37b
NPK 25%	31.73	36.00	41.07	26.00	33.7ab
PK 100%	24.27	32.66	20.53	28.00	26.37b
NK100%	38.40	40.13	21.47	33.20	33.30ab
Mean	33.06a	41.31a	28.78a	27.82a	

LSD (0.05) for W means is N.S **LSD (0.05) for F means is N.S**

Data reveal that primary treated wastewater showed a significant increase in available N at all soil depths in compared to the secondary and tertiary treated wastewaters. On the other hand, there is no significant difference in available N between the secondary, tertiary treated wastewaters and well water, respectively. This result may be due to the high content of N presented in the primary treated wastewater as indicated in Table 2.

These results are comparable to the results obtained by Al-Jaloud (1994). He observed an increasing in N content in soil irrigated with treated wastewater higher than fresh water and reported that N present in treated wastewater increased the N concentration in soil more than the levels in the soil receiving fresh water.

Generally, the data in Table 3(a,b,c) show that applying primary treated wastewater resulted in a significant increase in available N at all the studied soil depths and this increase is more indicated at 40-60 cm depth. This result may be attributed to the increase in N concentration of the primary treated wastewater; also increasing available N at 40-60 cm depth may be due to decreasing the losses of N at this depth and to accumulation of added N from the surface layers.

It is worthy to note from the data in Table 3(a, b, c) that there is no significant difference in available N due to applying fertilizers treatments at 0-20 cm depth. It was found that the treatment of 100% NPK gave the highest values of available N (31.83, 34.9 and 38.95 mg N/Kg soil) at 0-20, 20-40 and 40-60 cm, respectively.

Generally, there is no clear effect on accumulation of N in the studied soil as indicated from the data in Table 3. This result may be attributed to the high losses of applied N from fertilizers under condition of this experiment. Modaihsh *et al.* (1995) reported that there was a high loss of applied N to the soil by volatilization.

As shown in Table 4(a, b, c), data reveal that application of the different treated wastewater resulted in significant increase in available phosphorus in the studied soil in comparison with well water. The results also indicated clearly that the effect of primary treated wastewater was the most conspicuous on available P content of the soil. This result may be due to the high content of P presented in the primary treated wastewater as shown in Table 2 in compared to the other wastewater treatments and well water. It is worthy to note that there is no significant difference between all treated wastewater at the various soil depths.

Table 4a: Effect of irrigation water and fertilization on available P (ppm) at 0-20 cm

Fertilizer(F) treatments	Water treatments (W)				
	W.W	P.W	S.W	T.W	Mean
Control	0.98	13.40	6.97	7.21	7.14b
NPK 100%	10.33	11.27	16.50	15.3	13.35a
NPK 50%	6.43	15.97	14.93	15.33	13.17a
NPK 25%	5.73	16.90	14.32	12.12	12.27a
PK 100%	7.55	18.83	14.93	17.93	14.81a
NK100%	0.91	10.09	6.23	5.16	5.60b
Mean	5.32b	14.41a	12.31a	12.18a	

LSD (0.05) for W means = 6.21 **LSD (0.05) for F means = 3.15**

On the other hand, data in Table 4 indicated that there is a significant increase in available P due to applying fertilizer treatments at 0-20 cm depth. Also, it was found that the level of available P in the 0-20 cm depth under primary treated wastewater and without fertilizer treatments, markedly higher than available P under applying fertilizer treatments. This result may be attributed to fixation of the added P under the calcareous soil conditions and high pH value, also, addition of treated wastewater could have served as a readily available source of P. Sample *et al.* (1980) mentioned that $CaCO_3$ content in the soil may lead to a great fixation of the added P. The presence of high $CaCO_3$ in the investigated soil may explain the great decline of P content in soil. Also, Modaihsh *et al.* (2002a) concluded that phosphorus present in sewage water resulted in an accumulation of available P in the soil.

Table 4b:Effect of irrigation water and fertilization on available P (ppm) at 20-40 cm

Fertilizer(F) treatments	**Water treatments (W)**				
	W.W	**P.W**	**S.W**	**T.W**	**Mean**
Control	0.85	6.22	5.47	5.70	4.56b
NPK 100%	8.96	5.44	8.17	9.23	7.95a
NPK 50%	2.77	10.89	9.95	9.65	8.32a
NPK 25%	3.36	8.09	6.23	11.03	7.18ab
PK 100%	5.52	11.33	10.87	8.68	9.10a
NK100%	1.07	10.34	3.67	4.12	4.80b
Mean	3.76b	8.72a	7.39a	8.07a	

LSD (0.05) for W means = 3.22 **LSD (0.05) for F means =2.73**

Table 4c: Effect of irrigation water and fertilization on available P (ppm) at 40-60 cm

Fertilizer(F) treatments	Water treatments (W)				
	W.W	P.W	S.W	T.W	Mean
Control	0.73	3.19	6.80	4.70	3.86a
NPK 100%	2.17	3.07	2.41	2.94	2.65a
NPK 50%	1.81	3.55	6.90	6.77	4.76a
NPK 25%	1.49	2.63	2.43	1.85	2.10a
PK 100%	1.37	4.04	3.38	2.39	2.80a
NK100%	0.97	3.63	1.86	2.56	2.26a
Mean	1.42a	3.35a	3.96a	3.54a	

LSD (0.05) for W means is N.S **LSD (0.05) for F means is N.S**

Regarding the data in Table 4, it was indicated that fertilizer treatment of 100% PK increased the available P at the surface soil (0-20 cm) and gave the highest value (14.81 mg P/ Kg soil) with no significant differences by using fertilizer treatments of 100% NPK, 50% NPK and 25% NPK. On the other hand, the fertilizer treatment of 100% NK and the control (without fertilizer) gave the lowest values of available P (5.60 and 7.14 mg P/ Kg soil, respectively) and this decrease was significant when compared with the other fertilizer treatments.

Also, it is observed from the data in Table 4 that the available P at 20-40 cm and 40-60cm depths, markedly decreased in compared to the surface soil depth (0-20 cm). This result indicated the low mobility of added P to the subsurface of the soil.

On the other hand, it was shown from the data that there are more decreases in available P at 40-60 cm depth in compared to the other depths due to applying water treatments or fertilizer treatments with no significant differences among these treatments.

The effect of treated wastewater and fertilization on availability of potassium in the studied soil is shown in Table 5(a, b, c). The data reveal that there is an increase in available K due to applying the treated wastewater as well as well water and this result attributed to the high amounts of K present in the different irrigation waters.

Table 5a: Effect of irrigation water and fertilization on available K (ppm) at 0-20 cm

Fertilizer(F) treatments	Water treatments (W)				
	W.W	P.W	S.W	T.W	Mean
Control	109.30	147.33	161.33	166.00	145.99ab
NPK 100%	145.67	122.67	171.33	155.33	148.75ab
NPK 50%	116.70	166.33	142.00	128.67	138.43ab
NPK 25%	83.42	142.00	142.00	134.00	125.36b
PK 100%	144.67	158.00	157.67	149.00	152.34a
NK100%	134.67	149.67	138.00	161.67	146.00ab
Mean	122.41b	147.67ab	152.06a	149.11ab	

LSD (0.05) for W means = 26.99 **LSD (0.05) for F means = 26.78**

Table 5b: Effect of irrigation water and fertilization on available K (ppm) at 20-40 cm

Fertilizer(F) treatments	Water treatments (W)				
	W.W	P.W	S.W	T.W	Mean
Control	91.30	96.00	119.00	114.33	105.16ab
NPK 100%	112.67	115.00	135.33	116.67	119.92a
NPK 50%	94.70	115.00	128.33	94.67	108.18ab
NPK 25%	64.17	103.70	98.33	111.67	94.46b
PK 100%	101.33	119.30	115.33	79.53	103.88ab
NK100%	126.67	117.70	122.33	124.00	122.67
Mean	98.47a	111.11a	119.78a	106.81a	

LSD (0.05) for W means is N.S **LSD (0.05) for F means = 20.78**

Table 5c: Effect of irrigation water and fertilization on available K (ppm) at 40-60 cm

Fertilizer(F) treatments	Water treatments (W)				
	W.W	P.W	S.W	T.W	Mean
Control	87.30	93.00	109.00	104.67	98.49ab
NPK 100%	96.67	94.00	104.67	99.00	98.59ab
NPK 50%	97.30	109.00	104.67	93.00	100.99a
NPK 25%	61.95	88.00	90.00	90.33	82.57b
PK 100%	99.33	110.00	118.00	89.67	104.25a
NK100%	96.33	106.00	107.33	121.33	107.75a
Mean	89.81a	100.00a	105.61a	99.67a	

LSD (0.05) for W means is N.S **LSD (0.05) for F means = 18.26**

Data in Table 5 indicated that applying of tertiary treated wastewater increased significantly available K at the 0-20 cm depth in compared to the well water, whereas there is no significant difference in available K between all water treatments at 20-40 and 40-60 depths. The slight higher contents of soil in treated wastewater than well water could be attributed to higher levels of K in the treated wastewater treatments (Al-Jaloud, 1994).

On the other hand, all fertilizer application treatments slightly increased available K at the various soil depths. This result may be due to the high amounts of K present in the different irrigation water treatments. Gebril (1997) mentioned that potassium involved in irrigation water is enough to increase the amount of K in the soil.

Effect of wastewater and fertilization on availability of trace elements:

1- Available Cu:

Data in Table 6 (a,b,c) reveal that applying well water showed a significant increase in available Cu at 0-20 cm depth only, whereas there is no significant difference in available Cu at 20-40 and 40-60 cm depths, respectively. Also, the data indicated that there is no significant difference in available Cu among the primary, secondary and tertiary treated wastewater treatments at all the studied soil depths.

Table 6a: Effect of irrigation water and fertilization on available Cu (ppm) at 0-20 cm

Fertilizer(F) treatments	Water treatments (W)				
	W.W	**P.W**	**S.W**	**T.W**	**Mean**
Control	0.61	0.55	0.46	0.43	0.51a
NPK 100%	0.61	0.30	0.40	0.35	0.42a
NPK 50%	0.59	0.45	0.35	0.43	0.46a
NPK 25%	0.60	0.58	0.30	0.51	0.50a
PK 100%	0.67	0.46	0.35	0.31	0.45a
NK100%	0.63	0.43	0.52	0.36	0.49a
Mean	0.62a	0.46b	0.40b	0.40b	

LSD (0.05) for W means = 0.11 **LSD (0.05) for F means is N.S**

Table 6b: Effect of irrigation water and fertilization on available Cu (ppm) at 20-40 cm

Fertilizer(F) treatments	Water treatments (W)				
	W.W	**P.W**	**S.W**	**T.W**	**Mean**
Control	0.52	0.43	0.41	0.42	0.45a
NPK 100%	0.55	0.33	0.27	0.31	0.37a
NPK 50%	0.28	0.41	0.43	0.45	0.39a
NPK 25%	0.38	0.45	0.14	0.40	0.34a
PK 100%	0.37	0.39	0.46	0.36	0.40a
NK100%	0.51	0.42	0.45	0.39	0.44a
Mean	0.44a	0.41a	0.36a	0.39a	

LSD (0.05) for W means is N.S
LSD (0.05) for F means is N.S

On the other hand, all fertilizer treatments did not result in any significant increase in available Cu at the various soil depths.

It is worthy to note from the data in Table 2 that available Cu content in the studied soil is medium according to Soltanpour and Schwab (1977). The increase in available Cu values at the various soil depths may be due to impurities of trace elements presented in inorganic fertilizers used in this investigation. The same conclusion was reported by Modaihsh *et al.* (2002b).

Table 6c: Effect of irrigation water and fertilization on available Cu (ppm) at 40-60 cm

Fertilizer(F) treatments	Water treatments (W)				
	W.W	P.W	S.W	T.W	Mean
Control	0.40	0.40	0.40	0.35	0.39a
NPK 100%	0.44	0.23	0.38	0.22	0.32a
NPK 50%	0.38	0.41	0.41	0.34	0.39a
NPK 25%	0.31	0.41	0.33	0.31	0.34a
PK 100%	0.41	0.42	0.31	0.38	0.38a
NK100%	0.35	0.31	0.34	0.26	0.32a
Mean	0.38a	0.36a	0.36a	0.31a	

LSD (0.05) for W means is N.S LSD (0.05) for F means is N.S

2- Available Zn:

Data in Table 7(a,b,c) showed that applying the tertiary treated wastewater treatment increased significantly available Zn at the various soil depths in compared to the other treated wastewaters and well water.

Table 7a: Effect of irrigation water and fertilization on available Zn (ppm) at 0-20 cm

Fertilizer(F) treatments	Water treatments (W)				
	W.W	P.W	S.W	T.W	Mean
Control	3.19	4.19	5.65	12.89	6.48a
NPK 100%	5.15	2.72	5.39	11.24	6.13a
NPK 50%	3.20	4.86	4.65	7.64	5.09a
NPK 25%	4.39	3.93	4.88	12.21	6.35a
PK 100%	4.49	3.36	4.49	7.75	5.02a
NK100%	3.62	4.56	3.97	13.27	6.36a
Mean	4.01b	3.94b	4.84b	10.83a	

LSD (0.05) for W means = 2.95 LSD (0.05) for F means is N.S

Table 7b: Effect of irrigation water and fertilization on available Zn (ppm) at 20-40 cm

Fertilizer(F) treatments	Water treatments (W)				
	W.W	P.W	S.W	T.W	Mean
Control	2.16	0.98	2.55	3.87	2.39a
NPK 100%	3.03	1.42	1.70	3.16	2.33a
NPK 50%	1.69	1.37	2.70	3.66	2.36a
NPK 25%	2.41	1.34	1.81	4.58	2.54a
PK 100%	2.00	1.58	2.27	2.66	2.13a
NK100%	3.40	1.73	1.94	3.59	2.67a
Mean	2.45b	1.40b	2.16b	3.59a	

LSD (0.05) for W means = 1.06 LSD (0.05) for F means is N.S

This result could be due to the higher content of Zn in the tertiary treated wastewater than the other treated wastewaters (Table, 2).

On the other hand, application of fertilizer treatments did not affect the level of available Zn at the various soil depths. This result may be due to the short time of applying fertilizers in this experiment. Modaihsh *et al.*

(2002b) reported that fertilization with macronutrients for a long time accumulated some trace elements in soil such as Zn. Also, it was observed from the data in Table 1 that the level of available Zn was high according to Soltanpour and Schwab (1977).

Table 7c:Effect of irrigation water and fertilization on available Zn (ppm) at 40-60 cm

Fertilizer(F) treatments	Water treatments (W)				
	W.W	P.W	S.W	T.W	Mean
Control	0.70	0.85	0.80	1.25	0.90ab
NPK 100%	0.80	0.54	0.66	1.04	0.76ab
NPK 50%	1.26	0.74	0.65	1.20	0.96ab
NPK 25%	0.61	0.70	0.71	0.87	0.72ab
PK 100%	0.64	0.82	1.12	1.00	0.90ab
NK100%	0.64	0.77	0.93	3.52	1.47a
Mean	0.78b	0.74b	0.81b	1.48a	

LSD (0.05) for W means is N.S **LSD (0.05) for F means is N.S**

3- Available Fe:

Data in Table 8(a,b,c) indicated that applying the different treated wastewater and well water and all fertilizer treatments did not result in any significant difference in available Fe at various soil depths. It worthy to note from this study that available Fe level is very low (Table 1) according to Soltanpour and Schwab (1977).

Table 8a: Effect of irrigation water and fertilization on available Fe (ppm) at 0-20 cm

Fertilizer(F) treatments	Water treatments (W)				
	W.W	P.W	S.W	T.W	Mean
Control	2.94	3.55	3.39	3.26	3.29a
NPK 100%	2.59	2.90	2.78	3.40	3.91a
NPK 50%	2.73	3.00	3.06	3.15	2.99a
NPK 25%	2.92	3.11	3.01	3.28	3.08a
PK 100%	2.72	3.13	3.04	2.93	2.96a
NK100%	2.91	2.96	3.22	3.20	3.07a
Mean	2.80a	3.07a	3.08a	3.20a	

LSD (0.05) for W means is N.S **LSD (0.05) for F means is N.S**

Table 8b: Effect of irrigation water and fertilization on available Fe (ppm) at 20-40 cm

Fertilizer(F) treatments	Water treatments (W)				
	W.W	P.W	S.W	T.W	Mean
Control	2.82	2.61	2.84	2.93	2.80a
NPK 100%	2.58	2.66	2.71	2.48	2.61a
NPK 50%	2.14	2.83	2.87	2.82	2.67a
NPK 25%	2.56	2.78	2.32	2.98	2.66a
PK 100%	2.59	3.05	2.80	2.76	2.80a
NK100%	2.75	2.70	2.60	2.50	2.64a
Mean	2.57a	2.77a	2.69a	2.75a	

LSD (0.05) for W means is N.S **LSD (0.05) for F means is N.S**

Table 8c: Effect of irrigation water and fertilization on available Fe (ppm) at 40-60 cm

Fertilizer(F) treatments	Water treatments (W)				
	W.W	P.W	S.W	T.W	Mean
Control	2.61	2.44	2.20	2.39	2.41a
NPK 100%	2.12	2.60	2.25	2.26	2.31a
NPK 50%	2.29	2.25	2.39	2.55	2.37a
NPK 25%	2.51	2.48	1.97	2.32	2.32a
PK 100%	2.09	2.47	2.78	2.39	2.43a
NK100%	2.19	2.19	2.43	2.58	2.35a
Mean	2.30a	2.33a	2.27a	2.42a	

LSD (0.05) for W means is N.S **LSD (0.05) for F means is N.S**

4- Available Mn:

As indicated in Table 9(a, b, c), it was found that primary treated wastewater increased significantly available Mn at 0-20 cm depth. There is a significant difference between this treatment, well water and the secondary treated wastewater treatments. Also, there is no significant difference in available Mn level at 20-40 and 40-60 cm depths, respectively.

Table 9a: Effect of irrigation water and fertilization on available Mn (ppm) at 0-20 cm

Fertilizer(F) treatments	Water treatments (W)				
	W.W	P.W	S.W	T.W	Mean
Control	1.77	2.28	1.79	2.04	1.97a
NPK 100%	1.57	1.50	1.35	1.88	1.58a
NPK 50%	1.56	2.38	1.64	1.45	1.76a
NPK 25%	1.65	2.22	1.52	1.80	1.8a
PK 100%	1.62	1.85	1.60	1.41	1.62a
NK100%	1.53	1.95	1.51	1.73	1.68a
Mean	1.62b	2.03a	1.57b	1.72ab	

LSD (0.05) for W means = 0.34 **LSD (0.05) for F means is N.S**

On the other hand, the result in Table 9 reveals that fertilizer treatments did not result in any significant difference. It is worthy to note that available Mn in this study is very high according to Soltanpour and Schwab (1977). This finding is in a good agreement with the data reported by Al-Mustafa (1992). He concluded that available Mn level in some soils in Saudi Arabia is sufficient.

Table 9b: Effect of irrigation water and fertilization on available Mn (ppm) at 20-40 cm

Fertilizer(F) treatments	Water treatments (W)				
	W.W	P.W	S.W	T.W	Mean
Control	1.36	1.58	1.46	1.47	1.47a
NPK 100%	1,36	1.09	1.23	1.19	1.22a
NPK 50%	0.88	1.69	1.49	1.68	1.44a
NPK 25%	1.24	1.74	0.99	1.46	1.36a
PK 100%	1.20	1.63	1.65	1.85	1.58a
NK100%	1.53	1.53	1.36	1.42	1.46a
Mean	1.26a	1.54a	1.36a	1.51a	

LSD (0.05) for W means is N.S **LSD (0.05) for F means is N.S**

Table 9c:Effect of irrigation water and fertilization on available Mn (ppm) at 40-60 cm

Fertilizer(F) treatments	Water treatments (W)				
	W.W	P.W	S.W	T.W	Mean
Control	1.15	1.35	0.79	1.08	1.09a
NPK 100%	1.00	1.30	1.12	1.11	1.13a
NPK 50%	1.09	1.17	1.08	1.10	1.11a
NPK 25%	1.04	1.32	0.87	1.13	1.09a
PK 100%	1.17	1.29	1.56	1.17	1.30a
NK100%	1.03	1.17	1.06	1.34	1.15a
Mean	1.08a	1.23a	1.03a	1.14a	

LSD (0.05) for W means is N.S **LSD (0.05) for F means is N.S**

Thus, from the aforementioned data it can be concluded that irrigation with treated wastewater resulted in a significant increase in available N, P and K nutrients in the studied soil. The primary treated wastewater was the most conspicuous on available N and P at the soil surface depth (0-20 cm), whereas the secondary treated wastewater was the most conspicuous on available K at the same depth.

On the other hand, fertilizer treatments increased, with some exceptions, the available N, P and K at various soil depths.

Well water treatment increased significantly available Cu at 0-20 cm depth. The level of available Zn and Mn were higher under primary and tertiary water treatments, while the level of available Fe was not affected by the irrigation water treatments.

The fertilizer treatments did not result in any significant difference in available Cu, Zn, Fe and Mn at all the depths of the studied soil.

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تأثير الري بمياه الصرف الصحى المعالج والتسميد على تيسير بعض العناصر

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أقيمت تجربة أصص تم زراعتها بنبات الذرة الرفيعة لدراسة تأثير الرى بمياه الصرف الصحى المعالج والتسميد على تيسير بعض العناصر الغذائية فى أعماق مختلفة لتربة رملية طميية. وقد تكونت التجربة من أربعة مصادر لمياه الرى هى: 1- مياه الآبار(كنترول)، 2- مياه صرف صحى ذو معالجة أولية، 3- مياه صرف ذو معالجة ثانوية و 4- مياه صرف ذو معالجة ثانوية، كما إشتملت التجربة على ست معدلات من التسميد هى: 1- معاملة الكنترول، 2- 100% NPK، 3- NPK%50 ، 4- 25% NPK، 5- 100% PK و 6- 100% NK من الكية الموصى بها لتسميد الذرة الرفيعة.

أوضحت نتائج التجربة أن إستخدام مياه الصرف الصحى المعالج معالجة أولية أدى إلى حدوث زيادة معنوية فى مستوى كل من عنصرى النيتروجين والفوسفور الميسر فى جميع أعماق التربة تحت الدراسة وذلك عند مقارنتها ببقية معاملات الرى الأخرى.

أوضحت النتائج أيضاً أن إضافة معاملة التسميد NPK%100 أدت إلى حدوث زيادة معنوية فى مستوى النيتروجين الميسر فى جميع أعماق التربة. أيضاً أدت إضافة جميع معاملات التسميد ماعدا معاملة NK%100 إلى حدوث زيادة فى مستوى الفوسفور الميسر وخاصة فى الطبقة السطحية من التربة (صفر-20 سم).

هذا وقد أظهرت النتائج حدوث زيادة فى مستوى البوتاسيوم الميسر تحت معاملات الرى المختلفة وإن كانت معاملة الرى المعالجة معالجة ثانوية قد أدت إلى حدوث زيادة معنوية فى قيمة البوتاسيوم الميسر فى الطبقة السطحية فقط من التربة. هذا وقد ادت معاملات التسميد المضافة إلى حدوث زيادة طفيفة فى مستوى البوتاسيوم الميسر فى جميع أعماق التربة تحت الدراسة.

ومن ناحية أخرى فقد أدى الرى بمياه الآبار إلى حدوث زيادة معنوية فى مستوى عنصر النحاس الميسر فى الطبقة السطحية للتربة وذلك بالمقارنة بمياه الصرف الصحى ذو المعالجة أولية وثلاثية، وأوضحت النتائج أن مستوى عنصرى الزنك والمنجنيز كان عالياً عند إضافة معاملة الرى المعالجة أولياً وثلاثياً، بينما لم يتأثر مستوى الحديد الميسر فى جميع أعماق التربة بمعاملات الرى المختلفة.

أيضاً فإن إضافة جميع المعاملات السمادية المختلفة لم تؤد إلى حدوث أى إختلافات فى مستوى جميع العناصر الصغرى التى سبق دراستها.