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EFFECT OF IRRIGATION SYSTEMS WITH SECONDARY TREATED WASTEWATER ON GROUNDWATER CONTAMINATION

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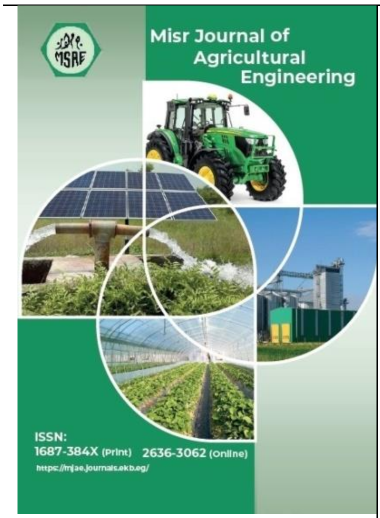


Keywords:
Irrigation system;
Groundwater;
NO3;
Microbial load;
Heavy metals

ABSTRACT

The impact of Drip and sprinkler irrigation systems with secondary treated wastewater on groundwater was investigated six monitoring wells including 3 sallow wells and other deep wells were installed at two field trials grown with canola and soybean and irrigated with drip and sprinkler irrigation systems. Samples of groundwater were taken from all of the monitoring wells and analyzed for a range of chemical parameters. The findings demonstrated that the salinity of groundwater under drip irrigation was comparable to that of secondary treated wastewater and was less than half of that under sprinkler. The drip irrigation system had lower nitrate concentrations than the sprinkler system. It seems that irrigation systems could affect nitrate concentration in groundwater according to the water table depth. The amounts of heavy metals in the groundwater of both irrigation systems were negligible and comparable. The microbial load of the groundwater samples under the two irrigation systems by secondary treated wastewater was similar and substantial. It is not quite clear from the short-term monitoring period that irrigation with secondary treated wastewater has absolutely affected groundwater quality. Some evident effects could be occurred by the most soluble and mobile components, such as total dissolved solids and nitrate under drip irrigation and sprinkler irrigation systems, respectively. These results indicate that irrigation system could affect the mobile components of the treated wastewater such as TDS (764 and 1953 mg/l), TSS (25.8 and 26.3) and nitrate (48.4 and 62.7 mg/l) concentration for drip and sprinkler irrigation systems, respectively in groundwater.

INTRODUCTION

Treated wastewater may minimize water crisis in many nations, including the United States, Germany, India, Kuwait, Saudi Arabia, Oman, Jordan, and Tunisia, treated wastewater may reduce the severity of the water issue **(Thebo et al., 2017)**. A number of studies have demonstrated the usefulness of wastewater in raising agricultural yields without posing any dangers to plants, soil, groundwater, or human health **(Qadir et al., 2020), (Hamilton et al., 2007), (Khalid et al., 2007), (Ashraf et al., 2021), (Hashem and Qi, 2021),**

(Pulido-Bosch et al., 2018). Reusing treated home wastewater for irrigation, either alone or in combination with fresh water, is one method of increasing the amount of water available for irrigation. The overall volume of wastewater accessible for reuse will rise as a result of rising residential water needs brought on by population growth, improvements in living standards, and expanding industrial water usage due to the expansion of Egyptian industry in the future. There aren't many treatment facilities in Egypt's big cities for the collected household wastewater. At the moment, particular areas outside of the Greater Cairo region are receiving irrigation from 1.4 billion cubic meters of primary processed effluent. This treated wastewater flow is anticipated to reach 2.4 BCM by 2017 in the near future **(NWRP, 2005)**.

Furthermore, it is clear from the economical scan that significant amounts of macronutrients (NPK) might be irrigated into the produced crops using treated wastewater. Based on Egyptian market prices, the fertilizer value was calculated in EGP, and the results showed that the ranges for nitrogen addition were 315 and 1178 EGP, P was between 194 and 1128 EGP, and K was between 585 and 2398 EGP. EGP (LE) based on the crop and the duration of irrigation with wastewater. Based on the crop's NPK needs and irrigation length, the total NPK value of the fertilizer applied to the field crops varied from 1049 to 4303 LE, according to the economic input of fertilizer. These findings highlight the fact that wastewater contains naturally occurring nutrients that may be used to reduce fertilizer costs. **(Drechsel et al., 2010), (Winpenny et al., 2013), (Corcoran et al., 2010), (Moscoso, 2017), (Abd El Lateef et al., 2010), (Abd El Lateef et al., 2020).** Another estimate was made by **(WRc, 2001)**, who calculated that in sandy calcareous soil in Alexandria, wastewater may provide up to 100% of the crop requirements for K and around 30% of the crop requirements for N. However, they pointed out that in the long-term monitoring for potential toxic elements (mainly heavy metals), groundwater and pathogen survival is necessary to protect the environment and human health. The study results highlight the fact that, even when using treated wastewater for irrigation, the recommended fertilizer rates are required to provide sufficient wheat yields on this kind of soil. This might be because fertilizer is administered in several dosages that are timed to correspond with crop development to guarantee proper nutrition, but the addition of nutrients through treated wastewater irrigation builds up throughout the course of the crop's growth. This effect is significant because it contributes to wastewater pricing strategies for Egypt and other comparable nations' new territories **(Abd El Lateef et al., 2020)**. However, employing treated wastewater in agriculture may affect environment through some biological and chemical properties of soil and groundwater impacts **(Abd El Lateef et al., 2020). (Abuzaid and Jahin, 2021)**. The protection of groundwater quality is critical for sustainable agricultural production and consequently understanding the potential consequences of irrigated treated wastewater on soil is crucial to the long-term viability of treated wastewater reuse schemes. Therefore, this work aims to study the impact of drip and sprinkler irrigation systems with secondary treated wastewater on groundwater characteristics and the degree of groundwater contamination.

MATERIALS AND METHODS

This work was carried out in two sites using all the facilities installed by the project "Cairo East Bank Wastewater 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). After completing the study, the facilities (irrigation networks, equipment) were used in this study. Both experimental trials were carried out in summer and winter seasons inside El Berka

WWTP located about 20 km northeast of Cairo using two irrigation systems. The first irrigation system was drip irrigation was applied to canola and soybean, a same area was chosen in the second irrigation system (sprinkler) with the same crops. The mechanical analysis of the soil indicated that 95 % sand and 6% silt ,he soil could be classified as sandy soil The chemical analysis of the soil was$^-$ (pH8.5;EC 0.24dsm^{-1} ;OM 0.73 ;N 1400ppm ;P132ppm ;K 826ppm ;Fe 3694 ppm; Mn 56.8ppm; Zn 17.8; Cu 3.78; Cd 0.02ppm ; pb 1.36ppm ; Ni 2.9 ppm) ..Each trial's design was based on sixteen big plots, eight of which got wastewater with additional fertilizer that was tailored to each crop's prescribed rates and irrigation method, while the remaining four received wastewater alone. Under each irrigation system, two crops were grown on summer and winter seasons under each irrigation system, Crop selection included focused on two industrial (oil) crops canola and soybean according to **(WHO, 1989)**. Thus, there were four replicate plots for each crop and treatment. Each experiment area was one hectare (10000 m^2 =2.47 acre). Fertilizing of both crops was applied according to the recommendations of Ministry of Agriculture where Nitrogen was applied at 60 and 45 kg N, P at 31and 22.5 kg $P2O_5$ and K at 48 and 24 kgK_2O /ac for soybean and canola, respectively. Nitrogen was applied as ammonium sulphate 20.6%, P was applied as Calium superphosphate 15.5 % and K as potassium sulphate 48% and all fertilizers were soil applied in the proper timing.

General description of all monitoring wells in the site for all field trials

Shallow wells

Nine boreholes (three twin and three single boreholes) were installed in and around the trial site to monitor groundwater Wells were bored to reach the groundwater table (around 4 m), and for the twin wells, one of each pair was drilled deeper, as follows:

Single boreholes:	AW3	depth 4.13 m
	AW5	depth 5.05 m
	AW9	depth 5.15 m
Twin boreholes:	AW1 }	depth 5.51 m
	AW2 }	depth 8.89 m
	AW7 }	depth 4.71 m
	AW8 }	depth 7.45 m
	AW11 }	depth 5.55 m
	AW12 }	depth 7.08 m

Deeper wells

Seven boreholes (two twin and three single boreholes) were installed in and around the trial site to monitor groundwater. Wells were bored to reach the groundwater table (about 14 m), and for the twin wells, one of each pair was drilled deeper, as follows:

Single boreholes:	BW1	depth 15.18 m
	BW5	depth 15.24 m
	BW9	depth 16.37 m
Twin boreholes:	BW3 }	depth 15.28 m
	BW4 }	depth 17.00 m
	BW7 }	depth 14.70 m
	BW8 }	depth 18.02 m

Monitoring wells around field trials:

Six monitoring wells including 3 sallow wells and other deep wells were installed at two field trial grown with canola and soybean and irrigated with drip and sprinkler irrigation systems (Table 1) All of the monitoring wells provided groundwater samples, which were then examined for a variety of chemical characteristics. It is important to note that all safety measures were taken to avoid exposing the workers to the irrigation method, and that sprinkler irrigation was included in accordance with WHO rules. Furthermore, there shouldn't be any risks for the field workers because all of the treated wastewaters utilized in the field experiments go through sand filters before being irrigated. Sprinkler irrigation was done with the help of 1.170 m^3 h^{-1}, wetted radius of 13.5 m, operating pressure of 300 KPa, and irrigation intensity of 8.10 mmh−1 are all features of a metal impact sprinkler 3/4" male. At the head of the irrigation system, a flow meter and a pressure-regulated valve were placed to monitor the applied water and manage the system pressure. The control unit of the irrigation system included two sand filters with a 3 inlet/outlet diameter and a rand screen filter with 200 mesh. Following the filtration system, 27 60-meter-long laterals for the sprinkler irrigation system were erected in the designated sprinkler irrigation area. The network of drip irrigation consisted of (1) The control head is situated near the water supply source. The components include a diesel-powered centrifugal pump with a QRM charge of 100 m3 h-1 and a 50 m lift; two-tank sand media filter 48; a screen filter with 120 mesh; a backflow prevention device; a pressure regulator; pressure gauges; a flow meter; and control. (2) Main line: 125 mm (OD) PVC pipes that carry water from the source to the field's primary control stations. (3) Sub-main lines: A control device with a 2 ball valve and pressure gauges linked PVC pipes with a 75 mm (OD) diameter to the main line. (4) Manifold lines: 40 mm (OD) PVC pipes were connected to the under main line via 1.5 control valves. (5) Emitters: These emitters are built-in (GR) drippers made of Polyethylene (PE) tubes with an Out-diameter OD of 16 mm and a length of 50 m. At 1.0 bar working pressure, the emitters have a QRM charge of 4 lph, with a 0.3 m spacing between them and a 1.0 m spacing between lateral lines.

Treated wastewater applied to soybean during the season was 5316 and 6912 m^3/ha while it was 5184 and 4980 m^3/ha for canola under drip and sprinkler irrigation systems ,respectively.

Groundwater quality and treated wastewater were included in the sampling program. wastewater treatments were examined in accordance with **(APHA, 1992)**. Every sample was examined using the accepted standard procedures. Under drip irrigation, six groundwater monitoring wells (Table 1) were set up, three of which were positioned above the water table with a drip irrigation system built in three wells at the top of the water table (mean depth 5.78 m) and three deeper wells (mean depth 16.77 m). Six more wells were drilled around the trial area for the sprinkler irrigation system, three of which were drilled to the top of the water table (mean depth 7.28 m) and two of which were drilled deeper (mean depth 15.60 m). Using a submersible pump, groundwater samples were drawn from each of the monitoring wells. A variety of chemical (pH, total NPK, and heavy metals) and microbiological (salmonilla and total coliform counts) characteristics were examined in the samples in accordance with **(APHA, 1992)**. The analysis was undertaken in Berka WWTP laboratory for the routine analysis, BOD, COD, and macronutrients. Other measurements were done in The Central Lab of The National Research Centre.

Table 1: Type, Number and Depth of Groundwater Monitoring Boreholes at drip and sprinkler irrigation system.

Well No	Drip irrigation	Sprinkler irrigation
W1	4.13 m	5.51 m
W2	5.05 m	8.89 m
W3	5.15 m	7.45 m
Mean	4.78m	7.28m
W4	15.28 m	15.18 m
W5	17.00 m	15.24 m
W6	18.02 m	16.37 m
Mean	16.77m	15.60m

Table 2. Mean concentrations of treated wastewater chemistry and microbiology applied as drip and sprinkler irrigation.

Parameters	Mean	Min.	Max.	CV%
pH	6.613	6.5025	6.681	0.68
Total N	10.88	6.29	15.895	20.315
Total P	2.89	1.02	4.505	24.905
K	11.73	7.055	20.485	19.805
Fe	0.49045	0.0544	0.833	46.58
Mn	0.09775	0.0085	0.272	57.29
Cr	0.02295	0.0051	0.07395	102
Ni	0.03315	0.00595	0.0697	58.395
Zn	0.0799	0.00935	0.153	57.545
Cu	0.04165	0.0119	0.07905	47.77
Cd	<0.005	<0.005	<0.005	11.9
Pb	0.079	0.031	0.13	26.945
Mo	<0.01	<0.01	<0.01	22,1
Co	<0.005	<0.005	<0.005	11.4
Salmonella	1.53	0.85	1.7	22.185
F. coliforms	29.75	2.55	69.7	60.945
Helminth	41.65	4.25	171.7	87.635

Units: (n==30) All determinants in mg/L except: EC (dS/m); salmonella qualitative range 0 = absent, 1 = low, 3 = high; faecal coliform bacteria 10^5 MPN/100 ml; helminth ova/L.

STATISTICAL ANALYSIS:

MSTAT-C (*a microcomputer program for the design, arrangement and analysis of agronomic research)* was used to perform a statistical analysis of variance of split plot design on the data **(MSTAT-C, 1988).** Using the least significant difference (LSD) at 5%, means were compared.

RESULTS AND DISCUSSION

Secondary treated wastewater irrigation characteristics

Table 2 presents the mean concentrations of treated wastewater chemistry and microbiology parameters. The analysis of the secondary treated wastewater irrigation characteristics from both drip and sprinkler irrigation systems over the period of the trials showed that the pH of the wastewaters was within the acceptable range for reuse, according to the Egyptian decree for wastewater reuse **(Decree 44, 2000)**. Nutrient contents of the wastewater applied through both irrigation systems complied with the Egyptian cod of reuse. The heavy metal delivered via irrigation systems was negligible and much below the thresholds for the reuse of secondary effluent. The maximum levels of heavy metals as stipulated by the Egyptian wastewater reuse ordinance (**DECREE 44, 2000**) include 0.05 for Co, 5 mg kg-1 for Fe, 0.01 for Cd and Cr, and 0.2 for Cu, Ni, and Mn. Salmonella was identified in every sample, and given the irrigation water's pathogenic content, the treated wastewater's microbial load was determined to be 106 MPN/L, far more than what was allowed by the standards of **(WHO, 1989)**. All treated wastewater samples contained more nematode eggs than the 41.65 ova/L reuse limit (Table2).

The groundwater samples beneath the two irrigation systems included pathogenic bacteria (salmonella), faecal coliform bacteria, and helminth ova. These were obtained from secondary treated wastewater (Fig3). Under both irrigation systems, there were comparable levels of faecal coliforms—between 102 and 103 MPN/100 ml. Most of the wells had a small amount of parasite eggs, with the sprinkler irrigation system having a larger quantity.

The analysis of irrigation water under the two irrigation systems indicated the beneficial role of irrigation with the treated waste water as well as the characteristics do not impose any constraints environment. The analysis indicated that irrigating most field crops with treated wastewater produced significant agronomic benefits. According to **(Abd El Lateef et al., 2020),** irrigation with treated wastewater requires fertilizer compensation and may be able to save some NPK crop requirements. They underlined that when field crops are watered with treated wastewater, the prescribed levels of fertilizer are required to provide sufficient yields. This might be because fertilizer is administered in the growing season, whereas the supply of nutrients by treated wastewater irrigation occurs cumulatively during the crop's growth span. a number of dosages, scheduled in accordance with crop development to guarantee proper nutrition.

It is clear from an economical scan that treated wastewater irrigation might provide growing crops with significant levels of macronutrients (NPK). Based on the crop's NPK needs and irrigation length, the total NPK value of the fertilizer applied to the field crops varied from 1049 to 4303 LE, according to the economic input of fertilizer. These findings highlight the fact that wastewater contains naturally occurring nutrients that may be used to reduce fertilizer costs **(Drechsel et al., 2010), (Winpenny et al., 2013), (Corcoran et al., 2010), (Moscoso, 2017), (Abd El Lateef et al., 2010), (Abd El Lateef et al., 2020).**

However, chlorination at levels to achieve faecal coliform compliance, however, does not appear to appreciably lower the number of live nematodes, according to microbial and parasite levels. Therefore, in order to attain compliance, further treatment of this treated wastewater—such as by UV, sand filters, or lagooning—would be required. A similar outcome was recorded by **(Pulido-Bosch et al., 2018)**.

Groundwater Quality

Groundwater qualities (mean, minimum and maximum values of basic parameters for all monitoring wells regardless of their depth under both irrigation systems are given in (Figs 1-3). The data presented showed that the salinity of groundwater under drip irrigation was less than half of that under sprinkler irrigation. The salinity of the groundwater under sprinkler irrigation was comparable to that of the secondary treated wastewater (Figs. 4 and 5) and less than half of that under drip irrigation. Sodium and chloride ion concentrations were also much smaller than that under drip irrigation. Total dissolved solids in groundwater at Sprinkler irrigation system, revealed an increasing trend (Fig 5). The data at the drip irrigation system was first rather erratic, but there is also a little tendency, although one of declining concentrations over time. The same effects on the reference wells at both irrigation systems are indicative of general water movement under both systems.

Nitrate concentrations under drip irrigation system was less than that of sprinkler irrigation system. It is worthy to note that at shallow monitoring wells nitrate concentration was greater under drip irrigation system while reversal magnitude was observed under sprinkler irrigation in the deeper monitoring wells (Fig 6). In other words, irrigation system could affect nitrate concentration in groundwater according to the water table depth.

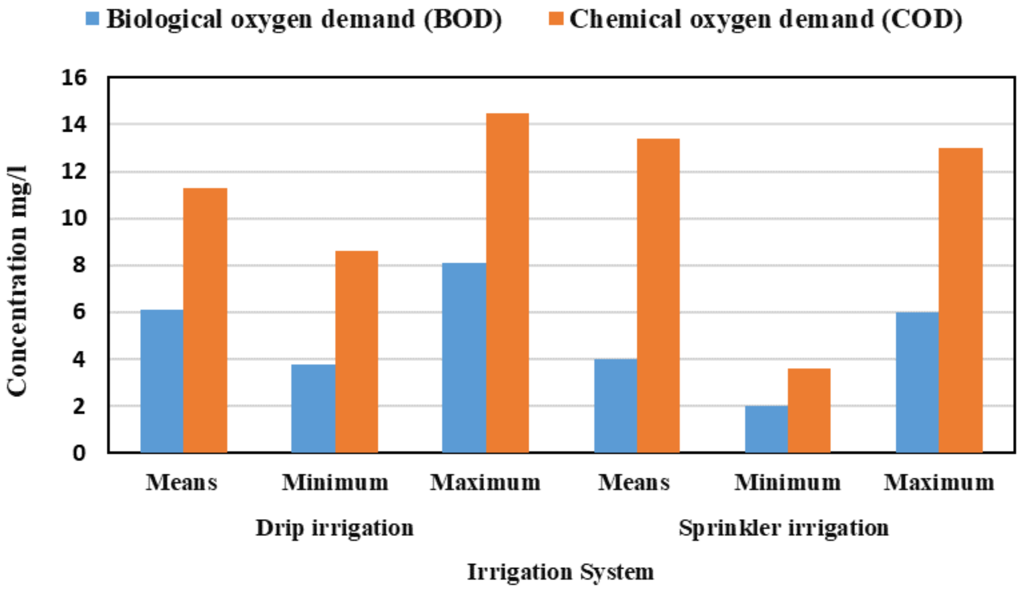


Fig. (1): Effect of irrigation system on biological oxygen demand (BOD) and Chemical oxygen demand (COD) concentration (mg/l) in monitoring groundwater wells (Mean of all wells)

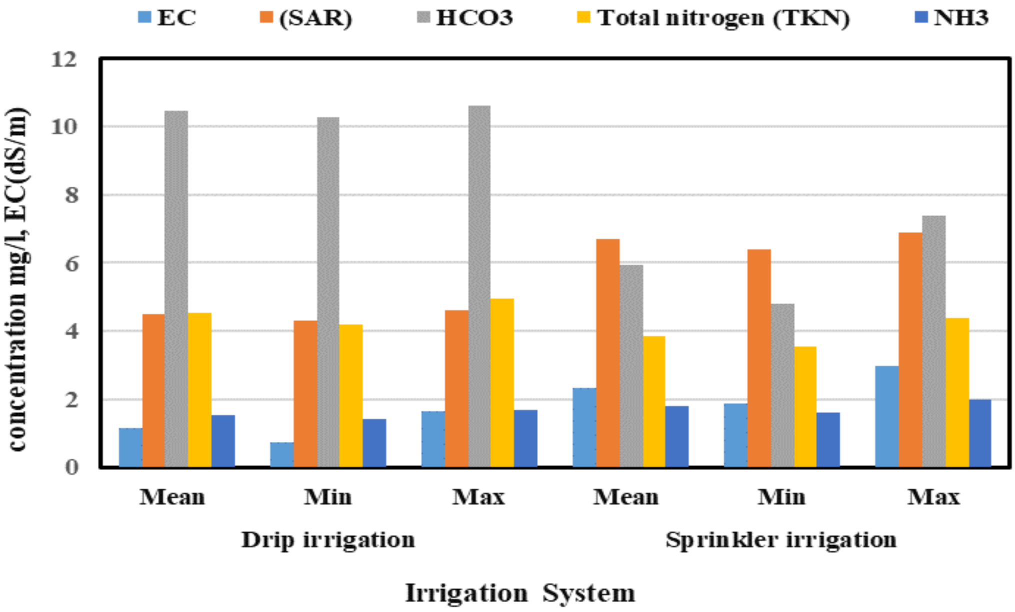


Fig. (2): Effect of irrigation system on EC, SAR, HCO_3, TKN, and NH_3) in monitoring groundwater wells (Mean of all wells, All parameters in mg/L except EC dS/m).

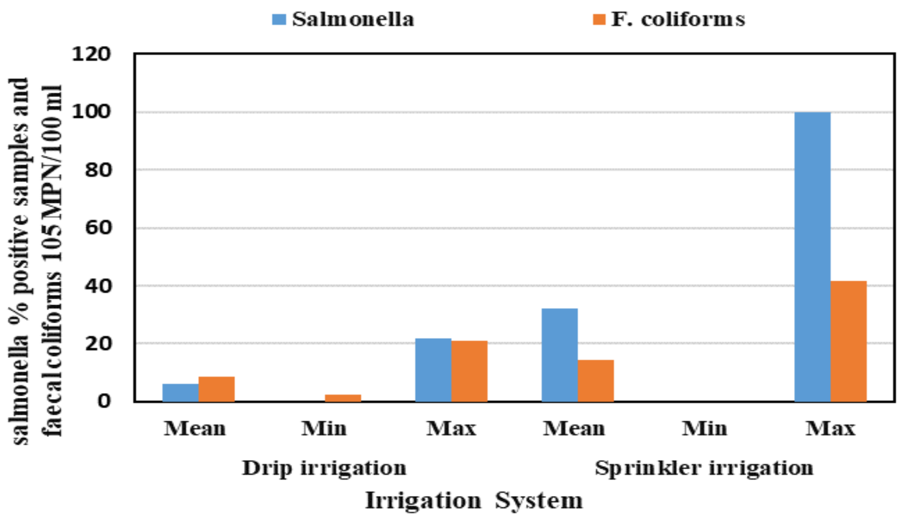


Fig. (3): Effect of irrigation system on salmonella % positive samples and faecal coliforms 10^5MPN/100(Most Probable No.) ml; in monitoring groundwater wells (Mean of all wells).

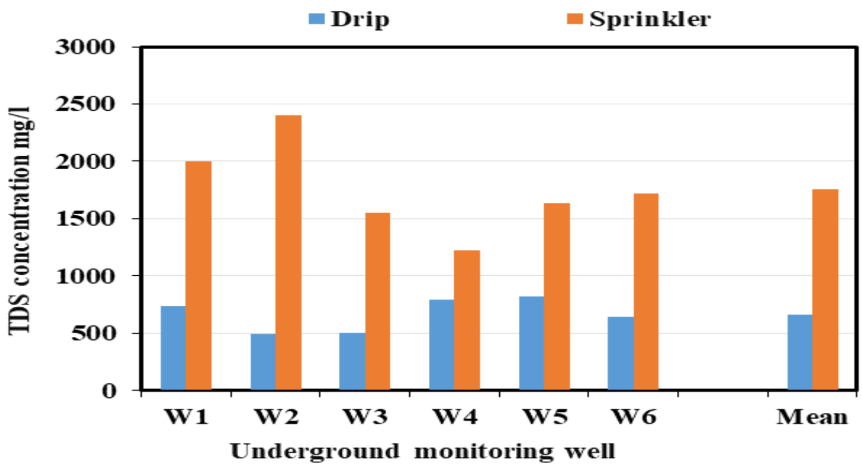


Fig. (4): Effect of irrigation system on Total Dissolved Salts TDS (mg/l) in monitoring ground water wells (W1-W3) shallow, (W4-W6) deep.

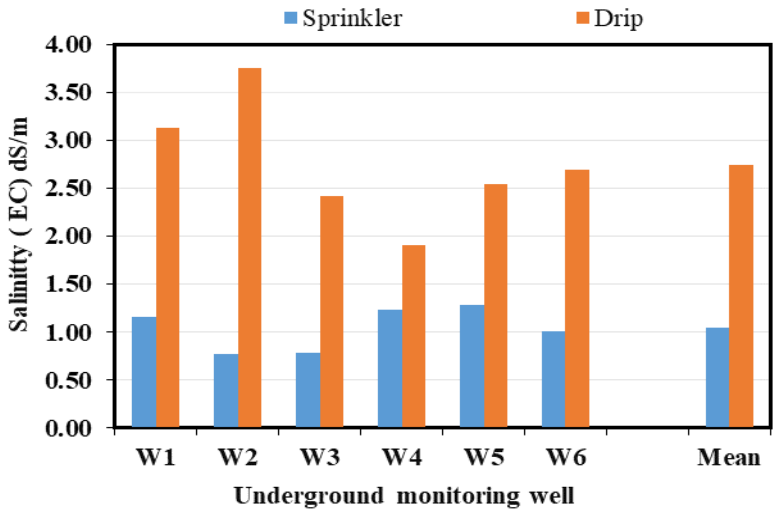


Fig. (5) Effect of irrigation system on Salinity expressed as EC (ds/m) in monitoring ground water wells (W1-W3) shallow, (W4-W6) deep.

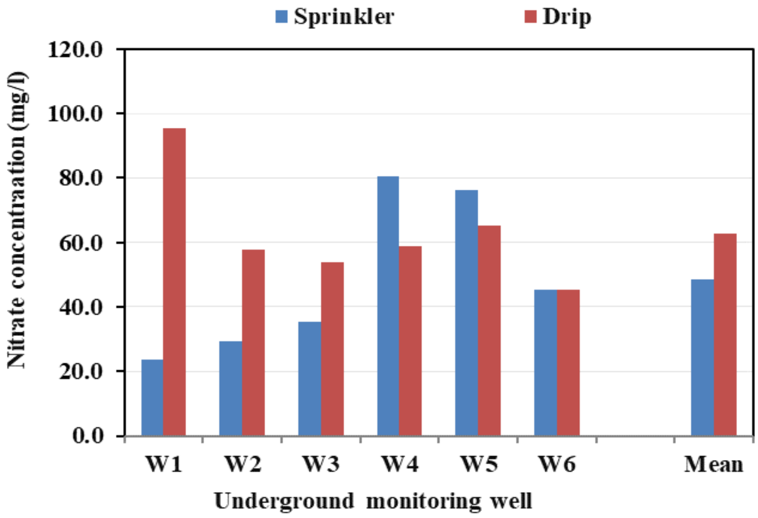


Fig 6: Effect of irrigation system on Nitrate concentration (NO_3 mg/l) in monitoring ground water wells(W1-W3) shallow, (W4-W6) deep.

The concentration of heavy metals in the groundwater of both irrigation systems were negligible and comparable. This is true even if drip irrigation has resulted in higher concentrations of heavy metals building up. However, this data shows that heavy metals are tightly linked to soil and are not often soluble, which causes buildup in groundwater (Fig 7).

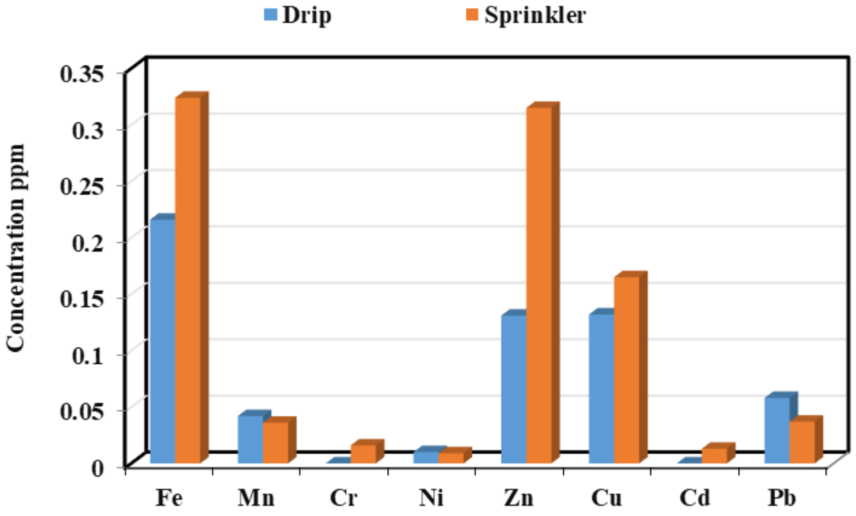


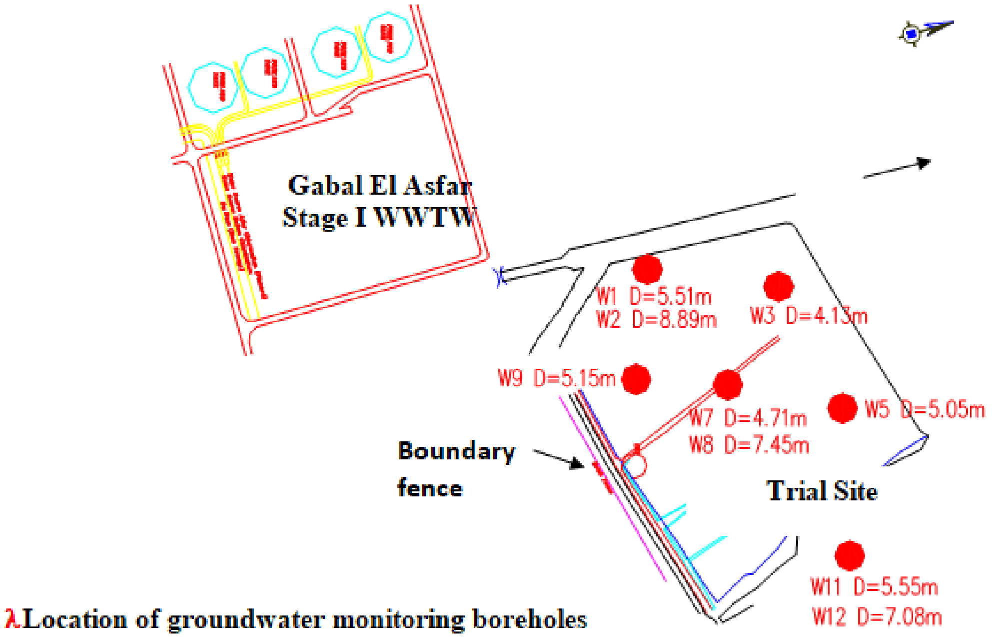
Fig 7: Effect of drip and sprinkler irrigation systems on heavy metals (ppm) in monitoring ground water wells (Mean for all wells).

Since salinity control of irrigated soils requires a continual downward movement of water, there is a risk that substances not fixed in the soil, degraded or taken up by crops, are susceptible to loss by leaching. The leachate would ultimately reach groundwater and may adversely affect this if it is vulnerable and usable for potable water or irrigation. Substantial variation in the effect of irrigation system on groundwater quality is evident, the salinity of ground water under sprinkler irrigation was less than half of that at drip irrigation and similar to that found in this secondary treated wastewater. Sodium and chloride ion concentrations were also much smaller under drip irrigation systems in groundwater. Nitrate concentrations under the drip irrigation system was less than that of sprinkler irrigation system. These results indicate that irrigation system could affect the mobile components of the treated wastewater such as TDS, TSS and nitrate concentration in groundwater according to the water table depth **(Armanuos et al., 2023)**.

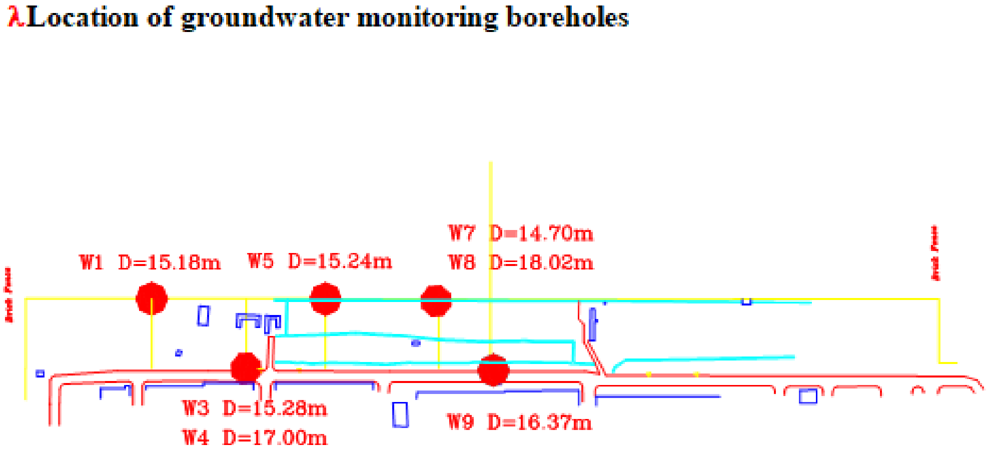
Understanding the possible effects of irrigated treated wastewater with specific irrigation systems on soil is crucial to the long-term viability of treated wastewater reuse. Monitoring these parameters is important for the protection of groundwater quality, which is critical for sustainable agricultural production. The current works have demonstrated that elements such as Cd, Cr, and Pb can migrate to deep soils in areas subjected to long-term WWI, reaching and contaminating shallow aquifers (**Zheng et al., 2014)**, (**Soldatova et al., 2021)**. This may result from increased salinity in the soil systems, because metals such as Cd, Hg, and Pb may be leached from wastewater-irrigated soils to groundwater under elevated soil salinity (between 2% and 5%) **(Zheng et al., 2018)**, (**Zheng et al., 2014)** Concerns exist over the long-term build-up of potentially hazardous components in addition to the possible chemical interactions between treated wastewater and soil on groundwater quality. The possible long-term effects of irrigating these treated fields on the condition of the soil In other investigations, wastewaters were simulated **(WRc, 2001)**.

This study suggests that the most soluble and mobile components, such as nitrate **(Aguilar-Rangel et al., 2020 and Soldatova et al., 2021)**, and total dissolved solids under sprinkler and drip irrigation methods, respectively, have some noticeable effects.

Shallow wells



Deep wells



CONCLUSION

This study indicates that irrigation systems could affect the mobile components of the treated wastewater such as TDS, TSS and nitrate concentration for drip and sprinkler irrigation systems, respectively in groundwater. Some evident effects could be occurred by the most soluble and mobile components, such as total dissolved solids and nitrate under both drip irrigation and sprinkler irrigation systems,

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Nomenclature

Symbol	**Meaning**
AW	Shallow wells
BW	Deeper wells
BOD	Biological oxygen demand
COD	Chemical oxygen demand
CWO	Cairo Wastewater Organization
KFAED	Kuwait Fund for Arab Economic Development
W1-W3	Wells Numbers for the shallow groundwater
W4-W6	Wells Numbers for the deep groundwater
WHO	World Health Organization
NO3 mg/l	Nitrate concentration mg/l
EC (ds/m)	Salinity expressed as(ds/m)
TDS (mg/l)	Total Dissolved Salts
105MPN/100 ml	Most Probable Number

تأثير نظم الري بمياه الصرف الصحي المعالجة ثانوياً على تلوث المياه الجوفية

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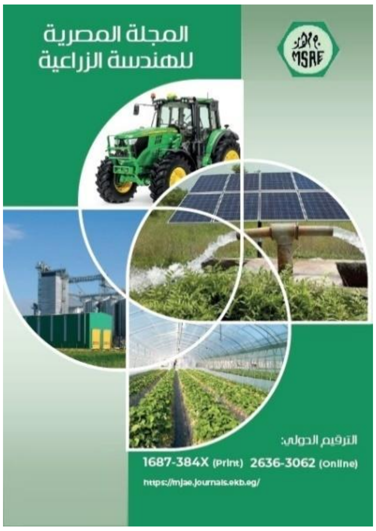

الكلمات المفتاحية:
نظام الري؛
المياه الجوفية؛
NO_3 (نترات)؛
الحمل الميكروبي؛
المعادن الثقيلة

الملخص العربي

أجريت هذه الدراسة بهدف تقييم تأثير استخدام أنظمة الري بالتنقيط والرش بمياه الصرف الصحي المعالجة ثانوياً المستخدمة في بعض المحاصيل الزيتية التي يتم معاملتها أثناء التصنيع ولا تستخدم بطريقة مباشره ومدى تأثيرها على نوعية المياه الجوفية في تلك الأراضي وقد اجريت التجربة في ارض رملية. تم تركيب ستة آبار مراقبة لنوعية المياه شملت ٣ آبار سطحيه وثلاث آبار عميقة أخرى في محيط تجربتين حقليتين مزروعتين بنبات الكانولا وفول الصويا مرويتان بنظامي الري بالتنقيط والرش. وخلال الدراسة تم أخذ عينات دورية من المياه الجوفية من جميع آبار المراقبة وتحليلها لمجموعة من التقديرات الكيميائية. وأظهرت النتائج أن ملوحة المياه الجوفية تحت ظروف الري بالتنقيط كانت مماثلة لملوحة مياه الصرف الصحي المعالجة ثانويا وكانت أقل من نصف تلك الموجودة تحت ظروف الري بالرش. واحتوت المياه الجوفية تحت نظام الري بالتنقيط على تركيزات من عنصر النترات أقل من نظام الري بالرش. وأظهرت الدراسة أن نظام الري يمكن أن يؤثر على تركيز النترات في المياه الجوفية وفقا لعمق المياه الجوفية. كذلك كانت تركيزات المعادن الثقيلة في المياه الجوفية في كلا نظامي الري ضئيلة ومطابقه لمعايير إعادة استخدام مياه الصرف الصحي في الزراعة وطبقا للقرار الوزاري (٢٠٠٠/٤٤) ٠,٠٥ للكوبالت، و٥ ملجم/كجم للحديد، و٠,٠١ للكادميوم والكروم، و٠,٢ للنحاس والنيكل والمنجنيز كما كان الحمل الميكروبي لعينات المياه الجوفية المأخوذة تحت نظامي الري بواسطة مياه الصرف الصحي المعالجة ثانويًا متشابهًا وكبيرًا. حيث قدر الحمل الميكروبي لمياه الصرف الصحي المعالجة بـ $١٠^{٦}$ MPN/L (العدد الاحتمالي)، تشير هذه النتائج إلى أن نظام الري يمكن أن يؤثر على المكونات المتحركة لمياه الصرف الصحي المعالجة مثل تركيز المواد الصلبة الذائبة (٧٦٤ و١٩٥٣ ملغم / لتر) والمواد الصلبة الذائبة الكلية (٢٥,٨ و٢٦,٣) والنترات (٤٨,٤ و٦٢,٧ ملغم / لتر) لأنظمة الري بالتنقيط والرش على التوالي في المياه الجوفية.