Flow hydraulics consideration information of the grey water reuse: towards sustainable water management

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Abstract

In this article, the effect of water quality on the hydraulic parameters of furrow irrigation was tested with 60 experiments with the quality of fresh water (FW), magnetic (MW) and non-magnetic effluent (WW). It was found that magnetism has no significant effect on the quality parameters of wastewater. Also, the effect of water quality on infiltration parameters such as final infiltration, average infiltration in certain time periods, especially in the advance stage, was not significant. But the final penetration reduction during the test period in MW and WW was more severe than FW and magnetism had little effect. These observations were similar to the results in the average penetration in certain time intervals except for the advance stage. Water quality did not have a significant effect on the time of discharge and progress and regression and the time of reaching the final infiltration. The results showed that the hydraulics of furrow irrigation was more affected by the soil and tillage than the quality of irrigation water and the magnetic field did not change the hydraulic effects of WW compared to MW.

Keywords

Hydraulic Parameters; Furrow Irrigation; Water Quality; Effluent; Magnetic; Infiltration; Advance and Recession;

Introduction

The reuse of treated wastewater in farming can be a feasible arrangement to confront water shortage [1]. Water system with wastewater may have suggestions at two diverse levels: change the physicochemical and microbiological properties of the soil and/or present and contribute to the collection of chemical and organic contaminants in soil. The primary may influence soil efficiency and ripeness; the moment may posture genuine dangers to the human and natural wellbeing. Hence at the same time, reasonable innovative arrangements with negligible natural impacts must be developed in arrange to guarantee wastewater treatment forms congruous with sustainable employments [2]. Wastewater water system can be a really appealing recommendation with benefits within the shape of water preservation, supplement reusing, surface and ground water contamination anticipation, especially for bone-dry and semi-arid locales in case utilized with appropriate and satisfactory administration plans in put. For illustration, at whatever point and wherever wastewater water system is embraced, it is imperative that a customary checking of soil physical and chemical properties be done routinely in arrange to preserve the auxiliary astuteness of the as of now salt influenced soils. Too a few supplements, especially N, in spite of the fact that is basic for plant growth, can frequently be a constraining figure [3]. Herbaceous crops inundated with wastewater can deliver calculable biomass and vitality yields. This is often moreover an ecologically and financially sound way of wastewater transfer [4]. With treated sewage water system, a slight increment within the natural substance of the soil was watched [5]. Immersed pressure driven conductivity of soil soil diminished with civil wastewater. This diminishment was more momentous within the clay soil. Reenactment of both ponded and sprinkler water system with metropolitan wastewater brought about in decreased penetration and expanded surface ponding condition compared to the application of new water [6]. Water system with treated wastewater has been detailed to actuate moo to direct hydrophobicity in soils of different texture with or without vegetation cover [7]. Thinks about have illustrated that wastewater water system may diminish soil hydraulic conductivity and penetration rate. Plots watered with exceedingly sodic and soluble mechanical wastewater appeared vital basic harms, particularly within the subsurface skyline where the soil pore organize collapsed significantly, coming about in a compact impermeable layer additionally pH increment within the topsoil. Insufficient wastewater quality is likely to cause profound and irreversible harms to inundated soils and coming about diminish of the abdicate [8]. Impacts of water system with wastewater on soil chemical and physical properties have been examined in numerous investigates. In any case few thinks about have done around wastewater stream on the soil surface. Hence in this ponder stream pressure driven of treated wastewater in wrinkle water system was considered by parameters comprises of penetration and development, capacity, consumption and subsidence stages and new water was utilized as control. Attractive field impacts were moreover explored on stream water powered of treated wastewater by magnetized wastewater.

Materials and Methods

Experimental Site

To do research, we chose three different types of water to study: fresh water, used water, and water that has been magnetized. Wastewater was released from a treatment plant at Isfahan University of Technology. This plant has two ponds where air is pumped in to clean and stabilize the water. FW was also provided from water pipes. The Chah-Anari experimental field was chosen at the University of Technology, and its soil characteristics are shown in Table 1. Based on Table 1, the soil is light in texture.

Field Preparing

The field was prepared for plowing, disking, and leveling. After making the ground smooth and even, a furrower made furrows that are 42 meters long, 60 centimeters wide, and 25 centimeters deep. The slope of the furrows was found by measuring them one by one. The average angle of the furrows was calculated to be 0. 1%.

Experimental Instruments

The water transport system in the furrow includes FW and WW tanks, stabilization tanks (with float valves) and gate pipes. Two tanks of six and ten cubic meters are used separately to supply cold and hot water at the upstream end of the furrow. Flow into the bed was determined to be 0. 8 liters/sec using bed slope and maximum non-erosive flow [9] and based on flow out of the stabilized tank. To generate the mentioned inflow, the opening value of each port on the valve spool is determined by the graded container and timer and the gate is opened in the same way in each practice. WSC channels are used to measure the entrance and exit of the track. The channels are installed completely horizontally and in such a way that any nearby leakage current is avoided and free circulation is also established (Figure 2). The MW treatment was also created using three magnets with a constant magnetic field strength (10 milli-Tesla for each magnet). These magnets are installed on pipes near emergency exits.

Statistical Design and Experiment Implementation

The experimental design used in this study was a randomized complete block with three treatments (FW, WW and MW) and four replicates and five irrigation treatments in each bed. To carry out the research, four experimental blocks were applied in the field. Each block has one main bed and two sub-beds for each water treatment (a total of three main beds and six sub-beds). To apply real field conditions, two side beds were considered for each main bed and tests were carried out on the main bed. 60 furrow irrigations were evaluated in this study with a 4-day irrigation interval (20 irrigations with FW treatment first, followed by 20 irrigations with WW treatment and 20 irrigations with MW treatment method). It is important to note that MW irrigation is performed with the same quality as WW irrigation but in a magnetized form during each practice. The test farm had no crops and irrigation had not been implemented there before. The length of the beds is divided into three meter intervals from the inlet channel installation location to the downstream (15 stations in each bed). The irrigation process begins with the transfer of water into the furrow and parameters such as advance and retreat times as well as inflow and outflow rates are measured in each experiment. The water flow in the bed continues until the output rate remains constant. Degradation time was also recorded at many stations immediately after the power cut.

Determining of Infiltration Parameters

To get the invasion condition was utilized from the inflow-outflow strategy. In this strategy after the progress arrange completion, invasion rate is break even with to the influx and outpouring rate contrast at a indicated time in wrinkle length with presumption of little changes in surface capacity. Surface capacity changes can be dismissed in wrinkles with a few conditions. For case, in this paper agreeing to water system time, development time [9] and wrinkle length [10] from changes in surface capacity rate were ignored. In this way, invasion rate and aggregate penetration conditions were decided by Eq. 1 and Eq. 2:

$$I = \frac{Q_{in} - Q_{out} - R_{ss}}{L} \ \& \ R_{ss} \approx 0 \ , \qquad \text{Eq. (1)}$$

$$Z = \int I \, dt \qquad \text{Eq. (2)}$$

Where Q_{in} = inflow rate; Q_{out} = outflow rate; R_{ss} = surface storage rate; L = furrow length; I_{ave} = average infiltration rate in furrow length; and Z = cumulative infiltration equation. “I” is for when the inflow and outflow rates are “Q_{in}” and “Q_{out}” values respectively. Finally, parameters of

Kostiakov infiltration rate equation ($I = k.t^a$) were calculated by various values of "I" and times related to them. In this paper average infiltration in three time intervals consists of 0-30, 30-60 and 60-90 minutes was calculated for each water treatment from the following Eq. 3:

$$I_{ave} = \frac{Z_2 - Z_1}{t_2 - t_1} \qquad \text{Eq. (3)}$$

Where I_{ave}= average infiltration in time interval of "$t_2 - t_1$"; Z_2 , Z_1= cumulative infiltration to "t_2" and "t_1" times respectively (using Eq. 2). The soil basic infiltration rate (fo) was also calculated with Eq. 4:

$$f_o = \frac{Q_{in-const} - Q_{out-const}}{L} \qquad \text{Eq. (4)}$$

Where $Q_{in-const}$ and $Q_{out-const}$ are fixed values of inflow and outflow rate in furrow irrigation practice.

Water and Wastewater Quality Experiment

Sampling is the first step in determining water and wastewater quality and deciding how to manage them. In this study, samples representative of the water and wastewater quality of the supplies were used in this paper. Samples were collected at the tube port outlet during the second, fourth, and fifth irrigations. For FW treatment due to insignificant changes in water quality, tests were performed once during the irrigation season. Sample transfer to the laboratory is carried out in a short time and at low temperatures (samples are kept near ice floes). The sampling bottle is plastic and not transparent. The standards used to determine water and wastewater quality tests are taken from the book "standard methods for the examination of water and wastewater" [10].

Statistical analysis

Data were analyzed using SPSS and Excel software. Data relative changes were used for analysis and evaluation. These relative changes were calculated as follows Eq. 5:

$$P_r = \frac{P_5 - P_1}{P_1} \qquad \text{Eq. (5)}$$

Where P_r = relative change of " P " parameter in fifth irrigation than first one; P_5 , P_1 = measured parameter in the fifth and first irrigation respectively. The " P_r " shows that " P " parameter how much has changed after five irrigations. Multi-Soil-Layering eco-knowledge has full-fledged in approval for internal sewage conduct subsequently. Multi-Soil-Layering knowledge was showed effectual in eliminating postponed objects, organics, nitrogen and phosphorus from a quantity of diverse polluted waters with internal sewage, polluted river water, livestock sewage runoffs, nourishment dispensation waste, dairy sewages, leachate, textile sewage. The foremost objective was to control the result of irrigation applying dissimilar kinds of waters, specifically conduct sewage through crust bioreactor organization, conduct sewage through occasionally transferred sparkling pond procedure and blow water on soil pH and electric conduction. Water and soil examples removed from diverse soil depths were examined in workshop. Substantial variations happened in soil features under numerous conducts. A varied nitrogen-protective soil cyanophyte nation was confirmed to conduct community sewage and make entire carbohydrates in a one-phase process. Then, lesser hydraulic preservation period and therefore high nutrients load endorsed carbon reduction, which directed to minor nitrogen and phosphorus eliminations, short biomass production and pollution of green algae types. The consequences highpoint the nourishing and operative instruments of soil bacteria and plans to concurrently fresh waste watercourses and make appreciated by-creations.

Results and Discussion

Water Quality Analysis

According to the measurements, the pH of the FW treatment is lower and more acidic than the other two treatments, WW and MW. Also, electrical conductivity (EC) in MW treatment is more than the other two treatments. In two wastewater treatments, total suspended solids (TSS) is significantly more than FW treatment. The main difference in treatments is in their biological properties. The statistical results show that the magnetic field does not affect the quality parameters.

Water Treatments Effects on Basic Infiltration Rate

The changes of fo parameter in different irrigation practices and treatments are plotted in Figure 3. The results show the downward trend of f_o in all treatments, which is an expected result. In most cases, fo is more in the two wastewater treatments than in the non-sewage treatment. And the magnetic field has also increased it. The severity of the downward trend of fo during irrigation practices is greater in two wastewater treatments than in FW and even more in WW. The further reduction of this parameter in the WW treatment is due to the qualitative parameter of TSS, which prevents water penetration. After the establishment of the soil structure after several irrigations (the third irrigation here), the water quality does not affect the infiltration factors much and is imperceptible.

According to the obtained results and due to the effect of qualitative parameters such as irrigation frequency, TSS and COD, which caused differences in the fo parameter in this research, a multivariable equation was established between these parameters as equation 6:

$$f_o = 2.185 - 0.042TSS + 0.017COD - 0.131N \qquad \text{Eq. (6)}$$

where fo = base penetration rate value (mm/min)

TSS = total suspended solids (mg/L)

COD = chemical oxygen demand (mg/liter)

N = irrigation turn

where the correlation coefficient is 0.26.

Equation 6 shows that with the increase of TSS and N, the value of fo decreases, while COD has a direct relationship with it. Statistical results show that treatments do not have a significant effect on fo (Table 3).

Mean Infiltration Rate in 0-30 min and 30-60 min Intervals

Equations 1-3 were used to investigate the effect of treatments on the average rate of infiltration in three time periods. In Figure 4, the interval 0-30 minutes is examined. According to that, the average infiltration rate in this period for the non-sewage treatment was higher than the two sewage treatments. which can be due to the important role of suspended materials in the early times of penetration. This parameter is mostly in WW treatment than MW. As expected, a downward trend for this characteristic is seen during irrigation practices. In order to investigate the qualitative factors on this characteristic, a multiple regression relationship was established between important qualitative parameters and it (equation 7):

$$MIR_{0-30} = 1.922 - 0.012TSS + 0.003COD - 0.071N \qquad \text{Eq. (7)}$$

with a regression coefficient of 0.05, which is weak and indicates a weak relationship between these parameters and a non-significant effect (Table 4) of qualitative parameters on this characteristic.

where

MIR_{0-30} = the average value of penetration speed in the period of 0-30 minutes (mm/min)

And the rest is like the previous relationship

This relationship shows a positive relationship between the average infiltration rate in this interval with COD and a negative relationship with TSS and N.

However, the changes of this characteristic in the two wastewater treatments are about twice that of the non-sewage treatment, and it has decreased less in the non-sewage treatment (Figure 4 and Table 4).

The average speed of penetration was also checked in the interval of 30-60 minutes. The results showed that this characteristic was higher in wastewater treatments and its reduction intensity during irrigation processes was less in non-sewage treatment (Figure 5). The magnetic field has increased this characteristic. The changes of this characteristic were observed in two similar wastewater treatments. In equation 8, the multiple regression between qualitative parameters and this characteristic has been established:

$$MIR_{30-60} = 2.272 - 0.026TSS + 0.006COD - 0.139N \qquad \text{Eq. (8)}$$

With a regression coefficient of 0.3 more than the previous relationship, which shows the greater influence of quality parameters with the passage of time.

where

MIR_{30-60} = average amount of penetration in the period of 30-60 minutes (mm/min)

The rest as before.

The statistical results show the insignificant effect of the treatments on this characteristic in this period of time (Table 5).

Treatments Effects on Advance Time

The time it takes for the water to reach the end of the groove is plotted under Time Advance in Figure 7. This characteristic shows the effect of the treatments on the speed of water progressing on the surface of the soil. The results showed that the speed of progress in wastewater treatment is higher than that of non-wastewater treatment (Figure 6), which was predictable considering the results obtained in the discussion of infiltration. Equation 9 established between qualitative parameters and this characteristic is as follows:

$$T_{adv} = 31.555 - 0.560TSS + 0.254COD - 1.998N \qquad \text{Eq. (9)}$$

with a correlation coefficient of 0.23

where

T_{adv} = advance time as min

The rest as before.

The speed of advancement in WW treatment was higher than other treatments, and the magnetic field did not have much effect on this characteristic due to MW treatment. The advance time in the first irrigations are more similar in different treatments (Figure 6). The statistical results also do not show a significant effect of treatments on this characteristic (Table 6).

Treatments Effects on Storage Stage

The time to reach final infiltration after the start of runoff in the gully was compared between the treatments as the storage stage time. A downward trend was observed in this characteristic compared to the irrigation cycle (Figure 7). Treatments also did not have a significant effect on this characteristic, but in two wastewater treatments it was more than the non-sewage treatment.

For further investigation, the multiple regression equation (Equation 10) was established between qualitative parameters and this characteristic

$$T_{str} = 35.553 + 2.213TSS - 1.398COD + 0.161N \qquad \text{Eq. (10)}$$

The regression coefficient is 0.1

where

T_{str} = time to reach f_0 (minutes)

And the rest as before.

The results showed that the magnetic field increases this characteristic.

Treatments Effects on Depletion Stage

The discharge phase was also investigated (Figure 8). The result showed an increasing trend in all treatments, which is caused by the changes in soil structure during Abilary practices. The intensity of this increase was higher in non-sewage treatments.

For further investigation, the regression equation (Equation 11) was established between qualitative parameters and this characteristic:

$$T_{dep} = -9.437 + 0.409TSS - 0.115COD + 2.316N \tag{11}$$

The correlation coefficient was 0.47, which is stronger than the previous relationships and is one of the signs of a significant effect.

where

T_{dep} = discharge time (min)

And the rest as before.

The results showed that there is a significant difference at the level of 5% in the discharge time between wastewater treatment and non-wastewater treatment (Table 8).

Treatments Effect on Recession Time

The effect of the treatments on the recession time in the furrow was also investigated (Figure 9). The result showed that This characteristic is mostly higher in non-sewage treatment than in sewage treatment.

These results can be justified according to the speed of the final penetration in the treatments.

For further investigation, the recession equation (Equation 12) was established between qualitative parameters and this characteristic (Table 9). $T_{rec} = 5.795 - 0.173TSS + 0.233COD + 0.272N$

Eq. (12)

with a correlation coefficient of 0.03, which is weak and indicates the insignificant effect of the treatments on this characteristic.

where

T_{rec} = stagnation time as (min)

And the rest as before.

The possible for recycle of preserved sewage in irrigation can be measured over a collective three-dimensional and Rate Advantage Analysis. Economic practicality of recycle is complex to water equilibrium and zone to be irrigated. The cost of the tax for sewage releases affects the economic practicality of recycle in agronomic irrigation. For Higher stream washbasin economic feasibility was assumed in mainly due to little aquatic prices. The economic feasibility of recycle of treated sewage for the irrigation in the stream in Iran was considered. Price-Advantage Examination was applied to contrast the possibilities (recycle of conduct sewage). Cost of initial investment was considered. Profits were measured like evaded price by usage of nourishments, decrease of tolls for water usage and releases straight to water forms and savings budgets of substructure for irrigation with groundwater. The consequences of the Price-Profit Investigation and sensitivity investigation display that affect economic practicality of conduct sewage for the water equilibrium and irrigation necessities, and budgets conforming to the organization of sewage for agronomic irrigation, with supplementary conduct and the substructure to take the conduct sewage. The economic practicality of recycle was restricted since the standards of toll for sewage releases and water rates in Iran do not link to the standards. It was showed to examine the features of influx and discharge sewage of the sewage conduct herbal on the foundation of the information assembly of process dated. Similarly, the properties of normal-period usage of the sewage for irrigation on soil physical and chemical features were considered. Many examples were reserved from the influx and discharge sewage and many quality components were examined. Consequences displayed that even though some limitations happen about chlorine and bicarbonate, the conduct sewage is appropriate for irrigation depend on state and worldwide values and standards. In contrast with soft water, the average-period uses of sewage triggered a slight rise of soil brininess. In comparison with fresh water, the middle-period uses of sewage triggered the rise of total N, absorbable P and absorbable K in soil owing to great absorption of those fundamentals in conduct sewage. Irrigation with sewage had diminutive result on vegetable dry weight, shoot N and P absorption or obtainable N and P, and bacterial biomass N and P in soil in together implanted and unfarmed conducts. The soil, brief-period sewage irrigation had diminutive consequence on herbal development, N and P approval, and N and P absorption in soil. But, attendance of floras condensed obtainable N and P in soil contrasted with unfarmed soils which would decrease possible of nutrient leakage after sewage irrigation.

Conclusions and Results

Inspection of the parameter changes on the graph shows that the WW and MW treatments compared to FW produced more changes in the “Fo” decreasing trend during the irrigation season and the influence of the magnetic field was insignificant. “fo” in WW and MW is generally larger than FW. It was found that the magnetic field increases “Fo” in MW compared to WW. Similar results were found at two time periods of the infiltration process. Also excluding the depletion time period, the time parameters evaluated, including time to end of bed, time to “fo” and withdrawal time, none of the differences were significantly affected. by water quality treatment methods, but the values of lead time and “fo” time for WW and MW compared to FW were generally higher. According to the regression equation between water quality parameters and flow hydraulic parameters, a negative correlation was found between “fo”, the average infiltration rate between 0–30 min and 30 to 60 min and time taken with TSS and number of irrigations; and positive correlation between these parameters and COD; There was also a negative correlation between the time needed to achieve “fo” and the time to exhaustion with COD; and positive correlation between these parameters with TSS and number of irrigations. Regarding degradation time, a positive correlation existed with irrigation number and COD; and negative correlation with TSS. So as to current hydraulic examination of the sewage on the soil were experienced channel irrigations with sewage that the subsequent consequences were gained: Attractive ground result on WW superiority was not substantial, but electrical conductivity amplified a little. The straightforward penetration degree had downtrend throughout irrigation period. MW had similarly maximum standards of elementary penetration degree and for WW was developed than FW. Without period of reduction stage, components of current hydraulic of WW and MW on soil for example development, collapse and loading period had not alteration meaningfully inclined by water superiority conducts, then standards of development and loading period for WW and MW than FW were developed regularly. To carry out hydraulic research on wastewater on the ground, trench irrigation with wastewater was carried out to obtain the following results:

1. The influence of the magnetic field on wastewater quality is insignificant, however the conductivity increases slightly.
2. In all treatments, the basal infiltration rate tended to decrease during the irrigation season. In most cases, MW also has the highest base penetration rate value and is higher for WW than FW.

3. A decreasing trend in the average infiltration rate in the ranges from 0 to 30 and 30 to 60 was observed during irrigation. The values of this parameter for WW and MW relative to FW are lower and higher in the ranges 0-30 and 30-60, respectively, in more cases.

4. Except for the duration of the depletion phase, the hydraulic flow parameters of ground WW and MW such as forward, backward and storage time have no significant differences affected by the quality of process water, but the lead values and storage times for WW and MW compared to FW were mostly higher.

5. According to the regression equation, a negative correlation was found between "f_o", the average infiltration rate between 0 to 30 minutes and 30 to 60 minutes, and T_{adv} with *TSS* and number of irrigation times; and positive correlation between these parameters and *COD*.

6. The regression equation shows a negative correlation between T_{str} and T_{dep} with *COD*; and positive correlation between these parameters with *TSS* and number of irrigations.

7. In the T_{rec} parameter, there was a positive correlation with irrigation number and *COD*; and negative correlation with *TSS*.

FOR COI STATEMENT

Conflict of Interest Statement

There is no conflict of interest.

Availability of Data and Materials

Some or all data, models, or code generated or used during the study are available from the corresponding author by request

Ethical Approval

The present Study and ethical aspect was approved by Water Engineering Department.

Consent to Participate

All authors designed the study, collected data, wrote the manuscript and revised it.

Consent to Publish

All authors agree to publish this manuscript. There is no conflict of interest.

Author's Contributions

All authors designed the study, collected data, wrote the manuscript and revised it.

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Competing Interests

There is no competing of interest.

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References

Aghajani Shahrivar A., Hagare D., B Maheshwari B. 2020. The effect of irrigation using recycled waters obtained from MBR and IDAL wastewater treatment systems on soil pH and EC under kikuyu grass (Pennisetum . Water Supply. Volume 20, Issue 4. 2020 - iwaponline.com

A. Galvis A., Jaramillo M.F., Gijzen H.J. 2018. Financial aspects of reclaimed wastewater irrigation in three sugarcane production areas in the Upper Cauca river Basin, Colombia. Agricultural Water Management.

Arias D.M., Uggetti E., García J. 2020. Assessing the potential of soil cyanobacteria for simultaneous wastewater treatment and carbohydrate-enriched biomass production. Algal Research. Volume 51, October 2020, 102042. , 2020 – Elsevier.

Bedbabis, S., B. B. Rouina, M. Boukhris and G. Ferrara. 2014. Effect of irrigation with treated wastewater on soil chemical properties and infiltration rate. J. Environ manage. 133: 45–50. DOI:10.1016/j.jenvman.2013.11.007.

Becerra-Castro, C., A. R. Lopes, I. Vaz-Moreira, E. F. Silva, C. M. Manaia, and O. C. Nunes. 2015. Wastewater reuse in irrigation: A microbiological perspective on implications in soil fertility and human and environmental health. Environ Int. 75: 117–135. DOI: 10.1016/j.envint.2014.11.001.

Muyen, Z., G. A. Moore, and R. J. Wrigley. 2011. Soil salinity and sodicity effects of wastewater irrigation in South East Australia. Agr. Water Manage. 99: 33–41. DOI: 10.1016/j.agwat.2011.07.021.

Zema, D. A., G. Bombino, S. Andiloro, and S. M. Zimbone. 2012. Irrigation of energy crops with urban wastewater: Effects on biomass yields, soils and heating values. Agr. Water Manage.

115: 55–65. DOI: 10.1016/j.agwat.2012.08.009.

Jun-feng, W., W. Gen-xu, W. Hua. 2007. Treated wastewater irrigation effect on soil, crop and environment: Wastewater recycling in the loess area of China. J. Environ Sci. 19: 1093–1099. DOI: 10.1016/S1001-0742(07)60178-8.

Viviani, G., and M. Iovino. 2004. Wastewater reuse effects on soil hydraulic conductivity. J. Irrig. Drain Eng. 130 (6): 476–484. DOI: http://dx.doi.org/10.1061/(ASCE)0733-9437(2004)130:6(476).

Arye, G., J. Tarchitzky, and Yona Chen. 2011. Treated wastewater effects on water repellency and soil hydraulic properties of soil aquifer treatment infiltration basins. J. Hydrol. 397: 136–145. DOI: 10.1016/j.jhydrol.2010.11.046.

Sou/Dakouré, M. Y., A. Mermoud, H. Yacouba, and P. Boivin. 2013. Impacts of irrigation with industrial treated wastewater on soil properties. Geoderma. 200-201: 31–39. DOI: 10.1016/j.geoderma.2013.02.008.

Kincaid., D. C. 1986. Intake rate: border and furrow. American Society of Agronomy-Soil Science Society of America, Methods of Soil Analysis, Part I. Physical and Mineralogical Methods-Agronomy Monograph no. 9 (2nd Edition). 871–887.

Anonymous. 1998. Standard methods for the examination of water and wastewater, 20th edition.

Latrach L, Ouazzani N, Mandi L, 2018. Optimization of hydraulic efficiency and wastewater treatment performances using a new design of vertical flow Multi-Soil-Layering (MSL) technology. Ecological Engineering.

Mackay, J.R. Downward water movement into frozen ground, western arctic cost, Canada. Can. J. Earth Sci. 1983, 20, 120–134.

Le T, Mosley L, Nguyen D.T., Marschner P. 2020. Effect of Short-term Irrigation of Wastewater on Wheat Growth and Nitrogen and Phosphorus in Soil. - Journal of Soil Science and Plant Nutrition volume 20, pages1589–1595.

Latrach L., Ouazzani N., Hejjaj A., Zouhir F., Mah. M., 2018. Optimization of hydraulic efficiency and wastewater treatment performances using a new design of vertical flow Multi-Soil-Layering (MSL) technology. Ecological Engineering. Volume 117, July 2018, Pages 140-152., 2018 – Elsevier.

Naji A., Azadkhah S., Farahani H., Uddin S., Khan F.R. 2020. Microplastics in wastewater outlets of Bandar Abbas city (Iran): A potential point source of microplastics into the Persian Gulf . Chemosphere.Volume 262, January 2021, 128039. Chemosphere, 2020 – Elsevier.

Tables and Figures:

Table 1. Soil properties of the experimental field in two layers

Depth	Particle-size distribution			Textural class (USDA)	Bulk density	Initial volumetric moisture
	Sand	Silt	Clay			
cm	%	%	%		$gr.cm^{-3}$	%
0-15	50.4	21.8	27.8	Sandy clay loam	1.45-1.73	2.94
15-40	52.3	20.3	27.4	Sandy clay loam	1.56-1.79	2.87

Table 2. Fresh Water, wastewater and magnetized wastewater quality used in the study

Parameters	Unit	Fresh water	Wastewater			Magnetized wastewater		
			Second	Fourth	Fifth	Second	Fourth	Fifth
Na^+	$mmolL^{-1}$	5.20	9.50	-	4.80	10.50	-	4.80
K^+	$mmolL^{-1}$	0.06	0.90	-	0.30	0.90	-	0.30
Ca^{++}	$mmolL^{-1}$	2.30	2.25	-	3.10	2.35	-	3.20
Mg^{++}	$mmolL^{-1}$	0.70	0.85	-	2.50	0.45	-	3.10
HCO_3^-	$mmolL^{-1}$	7.75	4.40	-	4.90	4.80	-	4.80
CO_3^{--}	$mmolL^{-1}$	0.00	0.00	-	0.25	0.00	-	0.30
SO_4^{--}	$mmolL^{-1}$	0.55	0.79	-	0.15	0.79	-	2.10
Cl^-	$mmolL^{-1}$	6.25	10.63	-	10.60	10.63	-	8.10
SAR	$(mmol)^{0.5}L^{-0.5}$	4.25	7.63	-	2.87	8.87	-	2.70
pH	-	7.55	8.26	7.26	8.01	8.30	7.56	7.79
EC	dSm^{-1}	0.656	0.990	1.095	1.099	1.002	1.108	1.100
TSS	mgL^{-1}	10	60	68	53	61	65	56
DO	mgL^{-1}	6.8	-	-	-	-	-	-
COD	mgL^{-1}	0	92	110	84	95	102	93
Total-coliform	$MPN(100cc)^{-1}$	0	23.3×10^4	6.9×10^4	17.6×10^4	35.6×10^4	10.5×10^4	2.0×10^4

Note: second, fourth and fifth are irrigation numbers

Table 3. Statistical analysis for soil basic infiltration rate

Change source	Free degree	Significant level	Treatment	Mean values of relative changes	Significant level		
					FW	WW	MW
Treatment	2	94%	FW	-0.331a	100%	94%	67%
Replication	3	39%	WW	-0.337a	94%	100%	70%
Experimental error	6	-	MW	-0.363a	67%	70%	100%

Note: Relative changes were calculated by Eq. 5.

Table 4. Statistical analysis for mean infiltration rate in 0-30 min

Change source	Free degree	Significant level	Treatment	Mean values of relative changes	Significant level		
					FW	WW	MW
Treatment	2	31%	FW	-0.094 a	100%	46%	31%
Replication	3	16%	WW	-0.209 a	46%	100%	73%
Experimental error	6	-	MW	-0.260 a	31%	73%	100%

Table 5. Statistical analysis for mean infiltration rate in 30-60 min

Change source	Free degree	Significant level	Treatment	Mean values of relative changes	Significant level		
					FW	WW	MW
Treatment	2	39%	FW	-0.360 a	100%	30%	13%
Replication	3	51%	WW	-0.432 a	30%	100%	47%
Experimental error	6	-	MW	-0.478 a	13%	47%	100%

Table 6. Statistical analysis for advance time of water front to furrow end

Change source	Free degree	Significant level	Treatment	Mean values of relative changes	Significant level		
					FW	WW	MW
Treatment	2	55%	FW	-0.527 a	100%	30%	62%
Replication	3	3%	WW	-0.584 a	30%	100%	55%
Experimental error	6	-	MW	-0.552 a	62%	55%	100%

Table 7. Statistical analysis for storage time

Change source	Free degree	Significant level	Treatment	Mean values of relative changes	Significant level		
					FW	WW	MW
Treatment	2	25%	FW	0.041 a	100%	37%	28%
Replication	3	43%	WW	-0.200 a	37%	100%	69%
Experimental error	6	-	MW	-0.309 a	28%	69%	100%

Table 8. Statistical analysis for depletion time

Change source	Free degree	Significant level	Treatment	Mean values of relative changes	Significant level		
					FW	WW	MW
Treatment	2	17%	FW	-0.060 a	100%	2%	1%
Replication	3	69%	WW	0.630 a	2%	100%	26%
Experimental error	6	-	MW	0.864 a	1%	26%	100%

Table 9. Statistical analysis for recession time

Change source	Free degree	Significant level	Treatment	Mean values of relative changes	Significant level		
					FW	WW	MW
Treatment	2	69%	FW	-0.018 a	100%	19%	33%
Replication	3	19%	WW	0.312 a	19%	100%	55%
Experimental error	6	-	MW	0.184 a	33%	55%	100%

Fig 1. Aeration and stabilization lagoons (left to right respectively)

Fig 2. Three tanks and flume used in research (view from furrow end)

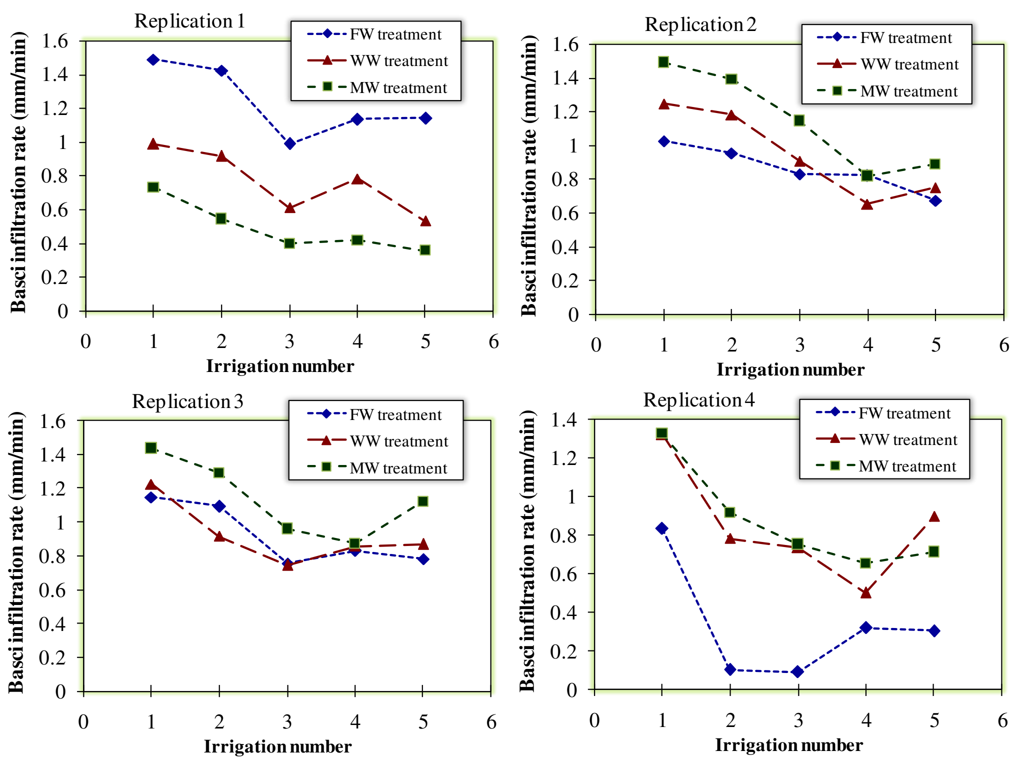

Fig. 3. Basic infiltration rate (f_o) in different irrigation numbers

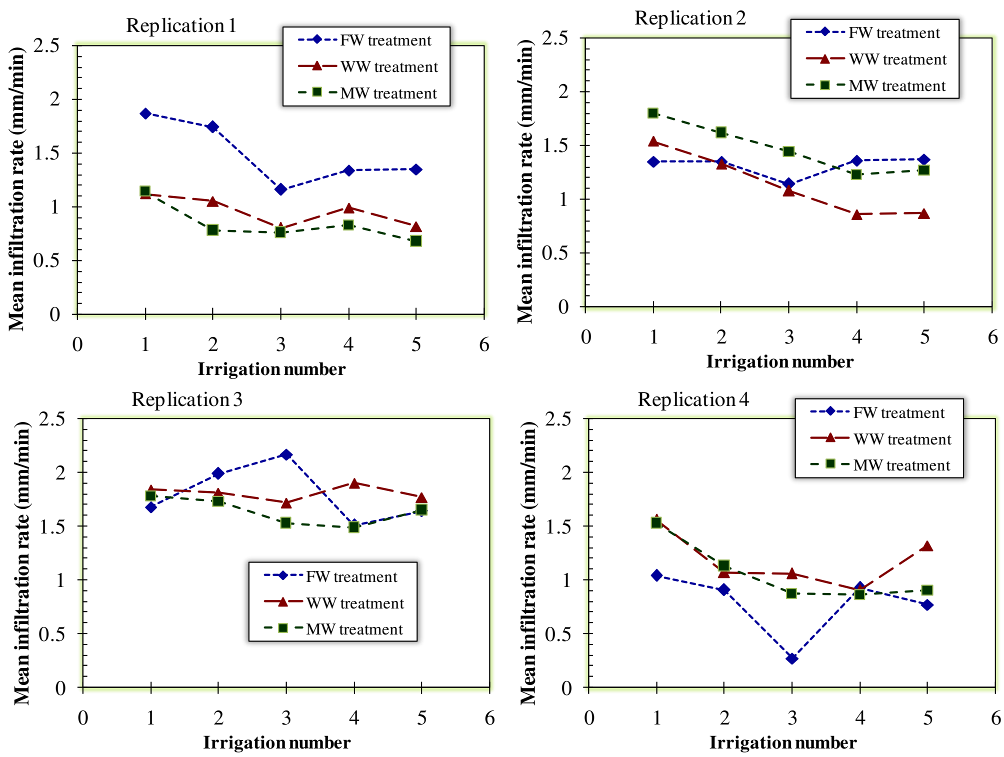

Fig 4. Values of mean infiltration rate for 0-30min

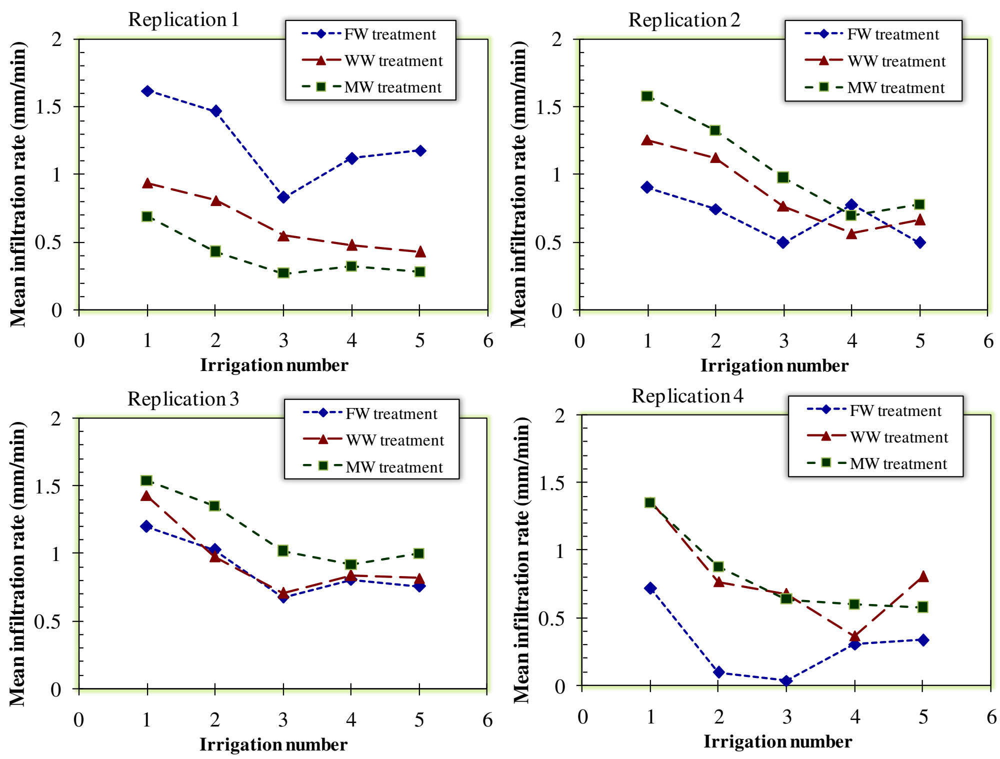

Fig 5. Mean infiltration rate for 30-60min range

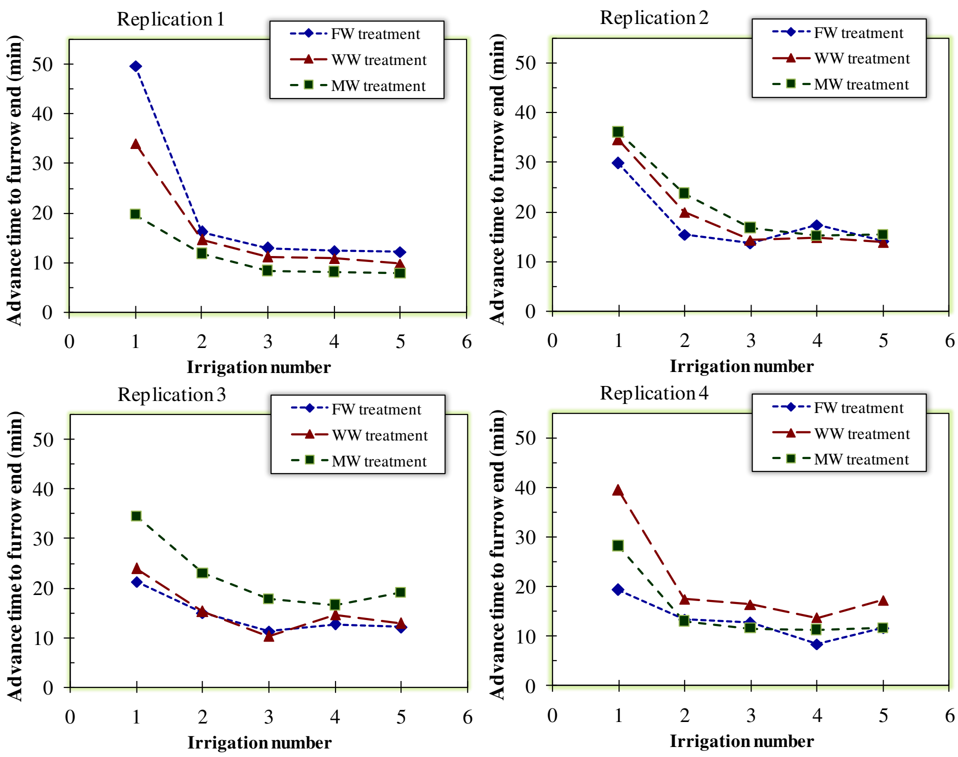

Fig 6. Advance time parameter

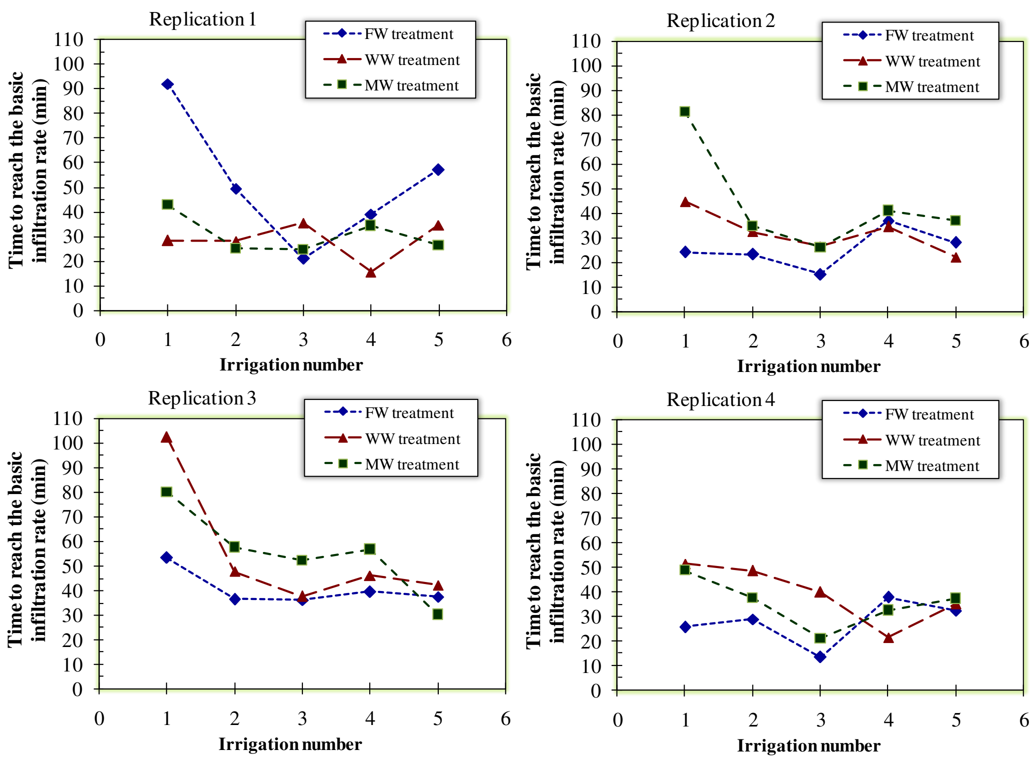

Fig 7. Time to reach the basic infiltration rate after runoff beginning

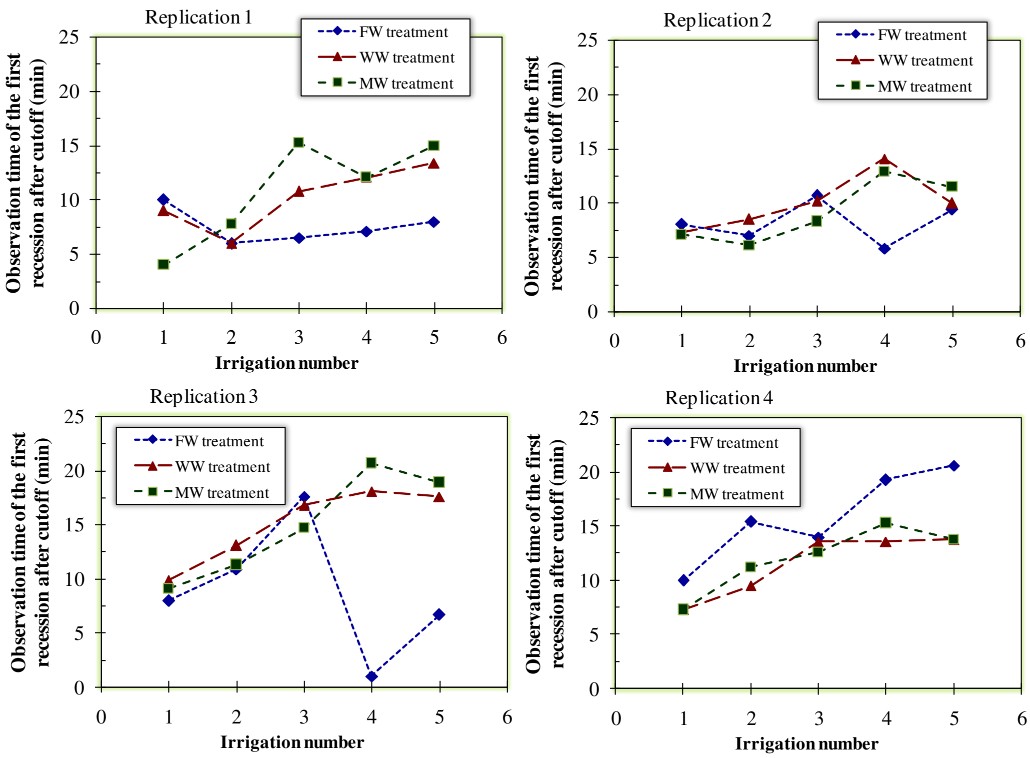

Fig 8. Depletion time after cutoff

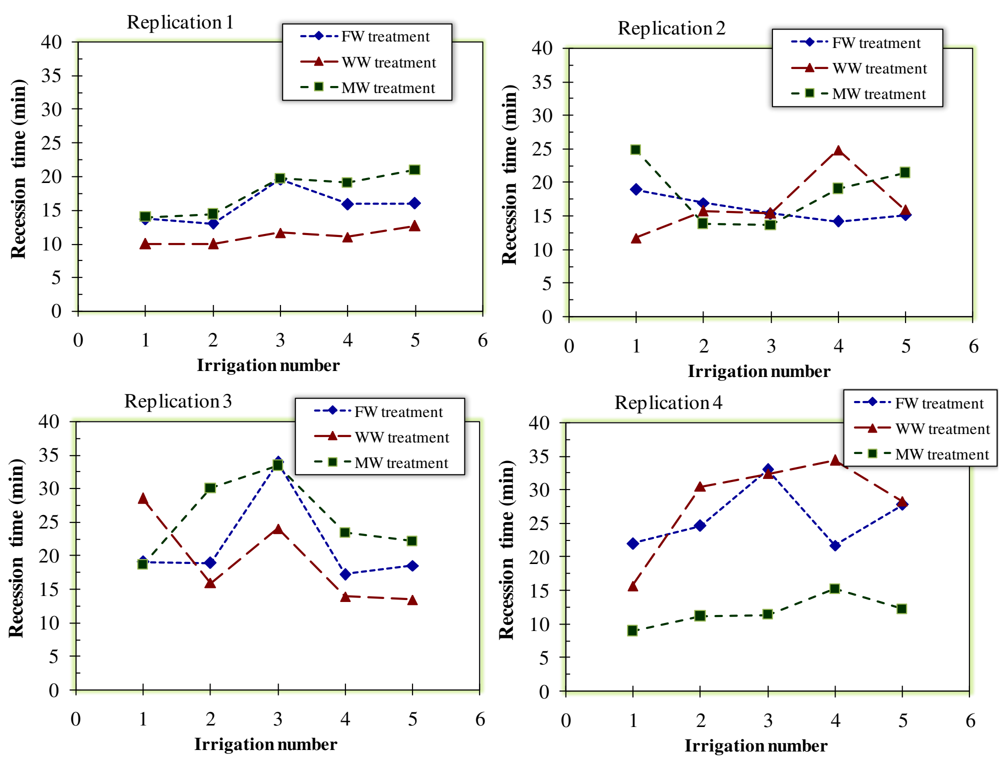

Fig 9. Recession time graphs