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Effects of Magnetized Municipal Effluent on Some Chemical Properties of Soil in Furrow Irrigation

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ABSTRACT: Due to the water crisis, wastewater reuse is an effective method in order to supply crop water requirements. In order to study the impact of treated and magnetic wastewater on the soil properties, this research was conducted in randomized complete block design with three irrigation treatments; including "wastewater", "magnetic wastewater" and "normal water" in four replications. Soil samples were taken from two surface and subsurface soil layers and at the upper and the downstream of each furrow. The results indicated that based on the amount of soil salinity, there was no significant difference between treatments statistically; however, considerable changes in the increasing of salinity were observed on subsurface layers in the magnetized wastewater treatment. This is probably due to the increasing salt portability of magnetized wastewater and accumulation of salts in the lower soil layer. The soil pH was also affected by wastewater and was decreased. However, magnetizing the wastewater had no considerable effect on soil pH.

Keywords: Wastewater, magnetic, EC, soil pH, furrow irrigation

INTRODUCTION

In the arid and semi-arid regions like Iran, employing policies for development and exploitation of unusual water resources like industrial, urban, and agricultural waste waters can, while compensating part of the water deficiency, prevent unwanted effects of discharging wastewaters into the environment (1). In non-arid regions as well, continuous demand for water, has raised the need for employing wastewaters as an economical resource in planning's (2). In the meantime, using wastewater for irrigation, depending on the region, application conditions and also it quality can prove "either useful or harmful". Investigations indicate that application of wastewater and sewage sludge causes decreased superficial specific weight of soil in most cases (3). On one side, wastewater and sewage sludge can, due to its content of organic substances, cause increased water retention capacity of the soil (4).

Regarding the impact of application of unusual waters on chemical properties of the soil researches indicate particular effects of such waters. Regarding soil salinity, results indicate that "Wastewater" application causes soil salinity. These results are expected in such conditions that the waste water salinity is higher than the non-wastewater treatment. For example in studying the effect of wastewater and drinking water with salinities of respectively 1.05 and 0.6 Decisiemens/m in the silty loam results indicated increased soil salinity (EC_e) compared with the drinking water (5). Also, irrigation with urban wastewater and well water with respectively 1.91 and 0.59 ds/m for a period of 6 months and on daily basis in a soil with clay-loamy texture showed that urban wastewater causes significant soil salinity at different soil depths (6). The issue of increased soil salinity in "raw wastewater and sewage sludge" has been also reported (7). Meanwhile, in the farm and during the growth season, and due to the "plant effect" the impact of wastewater on soil salinity compared to no-culture conditions varies. For example in a research conducted in a semi-arid region, effect of drip irrigation using wastewater on different textures for three years along with cultivation of olive, corn, spinach, and potato was performed. Results showed that, wastewater has not been much influencing the soil salinity (3). Results of a similar project also showed that in presence of colza plant and employing furrow irrigation, soil salinity in the soils irrigated with home wastewater compared with well water has been slightly increased (8).

In connection with the alkalinity or acidity degree (pH) of the soil caused by application of wastewaters different studies have shown different and oven contradictory results in this regard:

A) Some studies indicate that application of treated wastewater, raw sewage and its sludge, has led to decreased pH of the soil. For example results of a 10-yr research, irrigation using wastewater and non-wastewater in sandy soil showed that due to presence of organic acids, wastewater applications has caused a decrease of 1.76 unit in the soil pH (9). In a similar research, 100ha of lands under wheat cultivation was irrigated during 29 years by wastewater. Results showed that wastewater has caused significant pH decrease at various depths of the soil (8). Also, research conducted using wastewater and drinking water in the silty loam showed that irrigation with wastewater causes decreased pH of the soil the reason of which has been the lower pH of wastewater compared with drinking water (9).

B) In some cases as well, it has been observed that irrigation with wastewater has led to increased pH of the soil. For example in a study, comparison of irrigation using urban wastewater and well water showed pH of 7.63 and 7.2 in the clay-loamy soil respectively indicating that the pH of the soil irrigated with urban wastewater is significantly more than that of the soil irrigated with well water and this difference was seen in all soil depths (4). Increased soil pH in some of the studies has been due to alkalinity, concentration of the present salts and high pH of the wastewater (7).

C) In some of the studies relative to application of wastewater too, no considerable effect has been reported (2). Meanwhile, the magnetism issue in connection with the challenge of inappropriate quality of waters is a debating choice. Results have shown that “Magnetism” as well can decrease soil salinity (6). In some of the conducted researches too, magnetized water has been negligibly effective on the soil pH (4).

Magnetic water

Magnetic force can convert the simple water to a liquid with particular chemical effects, such that the arrangement of its electric charges and molecules due to increased solubility power of water and also some of its physical properties including temperature, specific weight, surface tension, viscosity and electric conductivity are changed (2). Through exertion of inductive power raised from the magnetic field, water molecules become smaller and penetrate more rapidly into the soil. Also, water becomes more fluent and its wetness property increases and its particles easily adhere to the colloidal and micronic soil particles and they are prevented to run to the soil (depths. As such, the water retention capacity of soil is increased. Through the modifications exerted on water, even the gypsum which in ordinary state does not dissolve in ordinary water (hard water), is dissolved in magnetic water and in conversion with the soil sodium, facilitates water permeation into the soil. This process helps aggregate formation that finally leads to soil fertility, productivity, porosity and aeration (7).

In connection with magnet application for improvement of plant growth various results are observed. For example, results has shown that magnetic water has increased the number of flowers of cucumber and its yield (about 10%) (10), however in an experiment performed in the Yazd center of Agricultural Researches on the some crop no significant result was obtained (3). No significant effect has been reported on application of magnetized water on the yield of corn seed, weight of one thousand grain and the number of grains in each cob, in studies performed at the Khuzestan Center of Agricultural Research at the level of consumed water (Gusheh, 2010). Nevertheless, application of magnetism for irrigation of tomato via drip irrigation and in greenhouse conditions resulted in increased yield of the plant (9). It seems that, qualitative and quantitative conditions of water, soil salinity, plant type and the period of consuming magnetized water by the plant in this connection has had a reciprocal effect on effective magnetism application.

Anyway, alongside the problems raised from decreased quality and quantity of water resources in agriculture and the necessity of using unusual waters, reports indicate that magnet application, probably can be effective on intensify magnet application, probably can be effective on intensifying or decreasing the impact of wastewaters. On the other side, investigation of “surface irrigation” and its technical problems, through application of unconventional waters “from the non-environmental view point” and its combining with the magnetism issue, is one of the works the absence of which in scientific reports is felt. In this research, through emphasis on expected modifications of the urban wastewater on properties of salinity, and acidity alkalinity of the soil) pH and EC) effect of the magnetic field in the condition of furrow irrigation was studied.

MATERIALS AND METHODS

This research project was conducted in the Chah-Anari farm located in the Isfahan University of Technology. Tests of the research ware performed through three treatments of normal water (non-sewage), outflow run off from the sewage treatment pool of the university and the outflow runoff subjected to the magnetic field (established by constant magnetic field) in the frame work of complete random blocs with four replications. Some of the specifications of the farm’s soil are presented in table 1.

To irrigate furrows (12 furrows) gated pipe was employed; the required and non-erosive discharge to each of the gates regarding the ground slope and soil texture was estimated to be 0.8 l/s.

Duration of research was about two months through five irrigation operations were performed for each furrow (a total of 60 irrigations). Soil samples were collected from the furrows after the first, third and fifth irrigations at the two soil depths of (0-15 and 15-40 cm as surface and subsurface soil layers) and at two intervals of (9-12 and 27-30m) from the beginning of the furrows.

As a whole, 72 samples were studied. Soil samples were sent to the laboratory inside the plastic bags. Then the samples were dried in the oven and after crushing with the metallic hammer were passed through a 2mm sieve.

From the thus obtained soil saturated mud was prepared and extract of saturated mud of each sample was obtained using suction pump and filter paper (Fig. 1). The two intended chemical properties were assessed using the pH meter and Ec-meter (1). Also properties of employed ordinary water, wastewater and magnetized water were investigated at the beginning, middle and at the end of the study period from the physical point of view (EC, total suspended solids…), chemical (acidity-alkalinity degree, various captions, anions) and biological (oxygen required for the bacteria, and frequency of pathogenic bacteria) viewpoints. Results of quality of such waters have been shown in table 2.

1. Adapted from the Environment organization of Iran, (3).

As it is observed, quality of the non-wastewater has been at the usual and permitted level for irrigation. Regarding wastewater as well, except for total number of coliforms, all other variables are within the permitted level for irrigation. Concerning the effect of the magnetic field on quality of wastewater, amount of positive and negative ions following passage through the magnetic field has shown no considerable change. Also, wastewater standard for BOD_5 and COD has been with I the permitted level and a slight change is observed in them due to being subjected to the magnetic field. This effect in the number of coliforms has been significant and in two cases from the three performed tests the number of coliforms had a significant increase.

RESULTS AND DISCUSSION

Prior to study of results, there are common issues which are worth mentioning.

Point 1. Using “partial changes” instead of raw figures

Preliminary study of data showed that in executive conditions of this project, and regarding the fluctuations observed in the primary values of variables, comparison of measured raw figures at the termination of tests of the project, can misrepresent the analyses. On one side, in this research, changes of soil properties following several irrigation turns compared with the primary conditions, is more important than their quantitative values. Therefore, in analyzing the results, the level of change of data compared with the first irrigation was used.

Points 2. Significance probability level

Due to numerous reasons such as high percentage of gravel (30 to 50 percent) unevenness and heterogeneity of the farm’s soil, probability of error in extracting, and also the soil being light, along with high evaporation from its surface (40°C), most of the results of this research has not become statistically significant. Accordingly, in the report of results of statistical analyses, the figures of “the smallest level of significance or p-value” have been used.

The p values, while being comparable with the five or on percent level of significance (The α coefficient usually employed), enjoys a higher power for precise quantification of the significance level and development of its meanings. It is worth reminding that, values less than five or one percent of the probability level (α) indicate a significant” or highly significant” difference between the data. In the other words, in such cases, with a probability of 95 or 99% there exists a real difference between the data. Determination of true value of this probability will be possible through employment of p value.

Point 3. Unreliable data

from the view point of statistical principles, outlier’s data are referred to the values out of the first and third quarters in a radius 1.5 times the interquartile index ($IQ=Q_3-Q_1$), i.e. values outside the ($Q_1-1.5\times IQ$, $Q_3+1.5\times IQ$), distance. In this research, in order to increase accuracy of the statistical analysis, merely a very few number (regarding limited number of information) o data showing contradictory results were omitted and the statistical analysis appropriate to them was performed.

Effect of wastewater and magnetized wastewater on saturated extract of soil (EC_e):

Mean soil salinity values in different treatments and turns of the irrigation water (along with displaying the scope of their changes) is presented in figure 2. As it can be observed, the soil salinity value in the surface layer after five times irrigation using water and wastewater, has decreased compared with the relative increase of salinity in the ordinary water and wastewater in the soil surface layer, has been relevant to fluctuations of result of the various furrows). This can be explained regarding slight salinity of these waters and as a result of continuous washing of the soil (which from the very beginning has been saline). In the subsurface soil as well, there exists a similar trend, with the difference that the level of soil salinity in the magnetized water following fire irrigation times has significantly increased compared with the first irrigation. This increase probably has been due to increased potential of carrying minerals by the magnetized water and accumulation of minerals in the depth of the soil.

Statistical analysis of these results (in the form of relative changes) is presented in table 2. As it can be observed, in the surface (top) layer is no statistically significant difference can be identified between treatments of the project however, through elimination of outliers data amongst the treatments in the subsurface layer, a significant difference around 5% is observed.

It is worth mentioning that, the effect of treatments not becoming statistically significant, does not necessarily mean lack of influence of treatments on the soil salinity; especially that move minute examination of results shows that, more than slight difference between treatment leading to insignificance, “ high fluctuations between various blocs”, has impeded detection of significance of the differences. For this purpose, twin comparison of treatments “through the least significant differences test” was considered (table 3). Study of these results indicate that in the surface soil the difference between salinity values in the treatment of magnetized wastewater with the water treatment is significant at the level of close to 5%. In the subsurface layer as well, difference of the salinity values between the magnetized wastewater and waste water at the 5% level and between the magnetized wastewater treatment and water is significant at a level close to 5%. This finding shows the existence of a considerable difference between the above said treatments.

Anyway, study of relative changes of data in different replications of the test (Fig. 3) also indicates that the mean changes in both top soil and subsurface soil show the deceasing trend of salinity resulting from irrigation with water and wastewater and that magnetism has slowed down this trend in the top layer and inversed in the subsurface layer.

Acidity – alkalinity degree of the saturated soil extract (pH)

Acidity-alkalinity level of soil in treatments and different turns of the irrigation water has been presented in Fig. 4 a mean of raw figures and as relative changes in Fig. 5. As it can be observed, effect of wastewater (with acidity – alkalinity rat of 7.84 for wastewater and 7.88 for the magnetized wastewater) on soil has appeared as a slight decrease and in the water treatment (7.6) has had an increasing trend during the season. These results, regarding the acidity – alkalinity rate 7.6 of water and considering the difficulty of modification of this chemical property in the soil, can be probably attributed to the chemical reaction of the soil solution which has not been studied in this project.

Statistical analysis of these results (as relative changes) is presented in tables 4 and 5. As it can be seen, the soil reaction difference in normal water with sewage treatments has resulted to significant statistical changes.

Anyway, this difference has been due to the sewage effect and magnetizing the wastewater has shown no significant effect. This phenomenon in the subsurface (which naturally has born less leaching) has been slightly different and the effect of wastewater and magnetism is shown slightly more prominently.

Table 1. Some field characteristics two layer 0-15 and 15040 centimeter.

Section	Depth (cm)	Soil particles (%)			Soil texteure	Gravel (%)	Organic matter (%)	Bulk density (g/cm^2)	EC (ds/m)	pH	Initial moisture (%)	FC (%)	PWP	Field gradient (%)	
		Sand	silt	clay										Longitudinal	Transverse
1	0-15	50.4	21.8	27.8	Loam sandy clay	38	< 1	1.57	1.82	7.87	4	31.57	15	0.06-0.3	0.1
	15-40	52.3	20.3	27.4	Loam sandy clay	50	< 1	1.68	1.97	7.84	4	33.71	15		
2	0-15	54.2	18.8	27	Loam sandy clay	34	< 1	1.78	0.98	8.29	4.2	20.87	15	0.02-0.2	0.1
	15-40	56.1	17.3	26.6	Loam sandy clay	43	< 1	1.71	0.89	8.43	4.2	19.81	15		

Table 2. Some variables characteristics such as chemical, physical and biological water, sewage and magnetic wastewater.

varialbel	Scale	Normal water	Sewage wastewater			Magnetic wastewater			Wastewater border	standard
			First	Middle	Last	First	Middle	Last	Agriculture	Drain water
EC	DS/ m	0.7	1	1	1	1	1	1.1	-	-
TSS	Mg/l	10	60	68	53	61	65	56	40	100
pH	-	7.6	8.3	7.3	8	8.3	7.6	7.8	6- 8.5	6.5-8.5
Sodium	MEq/l	5.2	9.5	-	4.8	10.5	-	4.8	-	-
Potassium	MEq/l	0.1	0.9	-	0.3	0.9	-	0.3	-	-
Calcium	MEq/l	4.6	4.5	-	6.2	4.7	-	6.4	-	75
Magnesium	MEq/l	1.4	1.7	-	5	0.9	-	6.2	100	100
Bicarbonate	MEq/l	7.8	4.4	-	4.9	4.8	-	4.8	-	-
Carbonate	MEq/l	0	0	-	0.5	0	-	0.6	-	-
Sulfate	MEq/l	1.1	1.6	-	0.3	1.6	-	4.2	500	400
Claire	MEq/l	6.3	10.6	-	10.6	10.6	-	8.1	600	600
SAR	-	3	5.4	-	2	6.3	-	1.9	-	-
DO	Mg/l	6.8	-	-	-	-	-	-	2	2
BODs	Mg/l	0	55	66	50	57	61	56	100	30
COD	Mg/l	0	92	110	84	95	102	93	200	60
Total clay form	1000 per 100cc	0	233	69	176	356	105	20	1	1

From the Environment Department Of Iran (Mohammadi, 1385)

Table 3. Statistical analysis results of a randomized block design (relative changes in soil salinity).

Source of variation	Degrees of freedom	Minimum significance		Degrees of freedom	Significance level with ignoring unreliable data	
		Surface layer	Sub surface layer		Surface layer	Sub surface layer
Water	2	38%	13%	2	13%	8%
Wastewater	3	45%	90%	3	26%	33%
Magnetic wastewater	6	-	-	4	-	-

Table 4. Mean "relative change" and a significant level of soil salinity in irrigation treatments

treatments	Relative change mean	Significant level Water	Wastewater	Magnetic wastewater
Surface layer				
Water	-0.603	100%	-	-
Wastewater	-0.262	86%	100%	-
Magnetic wastewater	0.525	9%	11%	100%
Subsurface layer				
Water	-0.331	100%	-	-
Wastewater	-0.231	64%	100%	-
Magnetic wastewater	1.011	9%	5%	100%

Table 5. Statistical analysis results of a randomized block design "changes in soil pH."

Source of variation	Degrees of freedom	Minimum significance		Degrees of freedom	Significance level with ignoring unreliable data	
		Surface layer	Sub surface layer		Surface layer	Sub surface layer
Treatment	2	9%	8%	2	6%	1%
Block	3	34%	50%	3	57.8%	16%
Experimental error	6	-	-	4	-	-

Table 6. Mean "relative change" and a significant level of pH (pH) in different irrigation treatments.

treatments	Relative change mean	Significant level Water	Wastewater	Magnetic wastewater
Surface layer				
Water	0.07	100%	-	-
Wastewater	- 0.024	2%	100%	-
Magnetic wastewater	- 0.02	2%	57%	100%
Subsurface layer				
Water	0.062	100%	-	-
Wastewater	- 0.015	1%	100%	-
Magnetic wastewater	- 0.037	0.4%	28%	100%

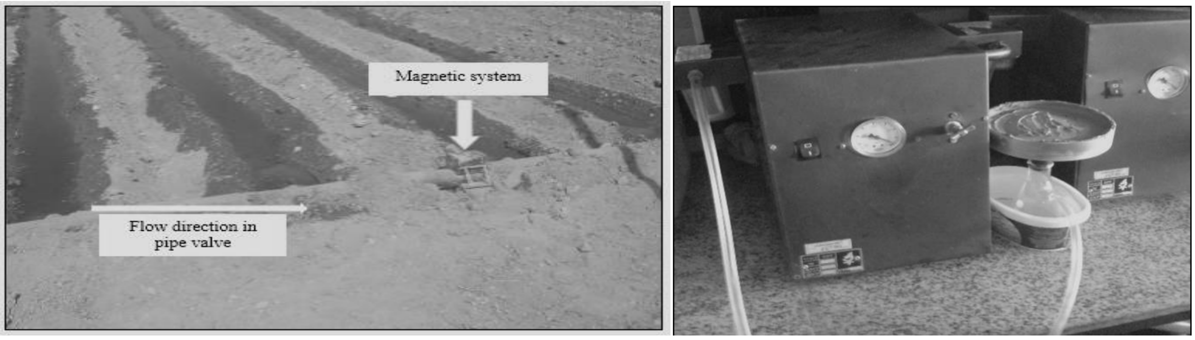

Figure 1. Wastewater and effluent applied magnetics furrow and extracted for determination of EC and pH of soil samples.

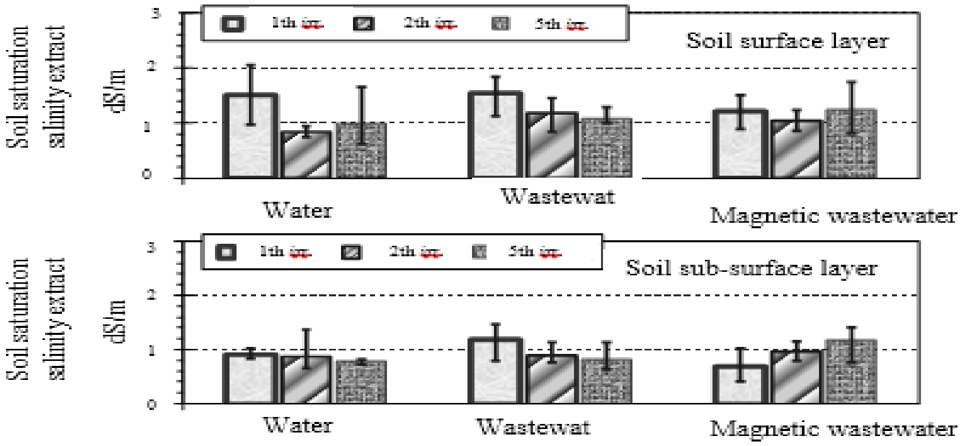

Figure 2. Soil saturation salinity extract during the water irrigation treatments, in two soil layers.

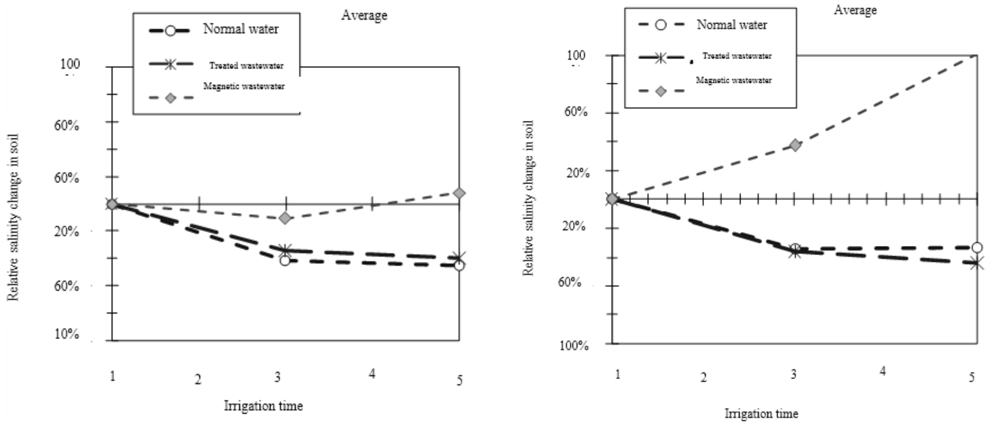

Figure 3. The relative mean change in surface and subsurface soil salinity and soil saturation extract during the irrigation season.

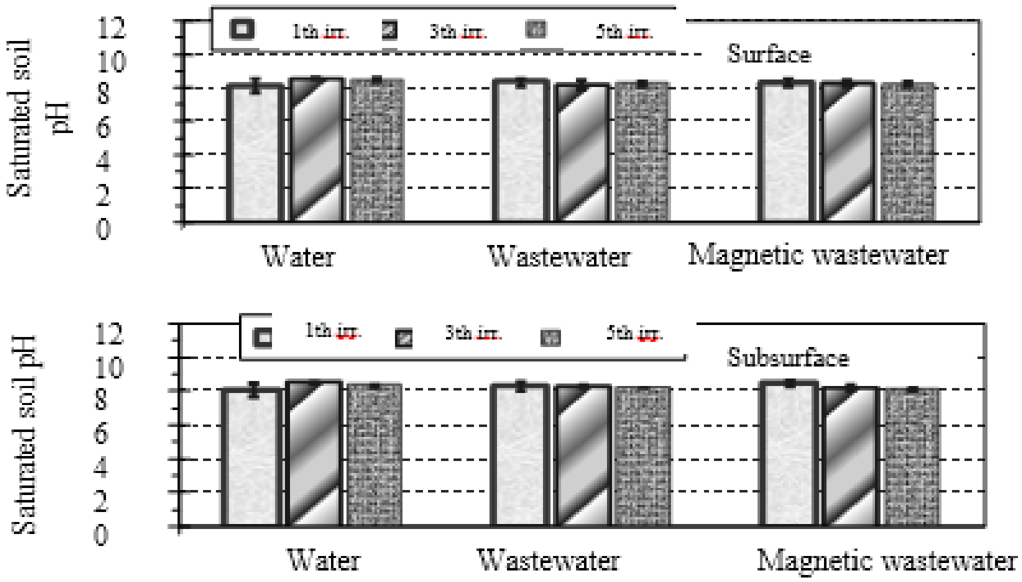

Figure 4. The degree of soil saturation extract, acid-game over the course of irrigation water with different treatments, and the two-layer soil

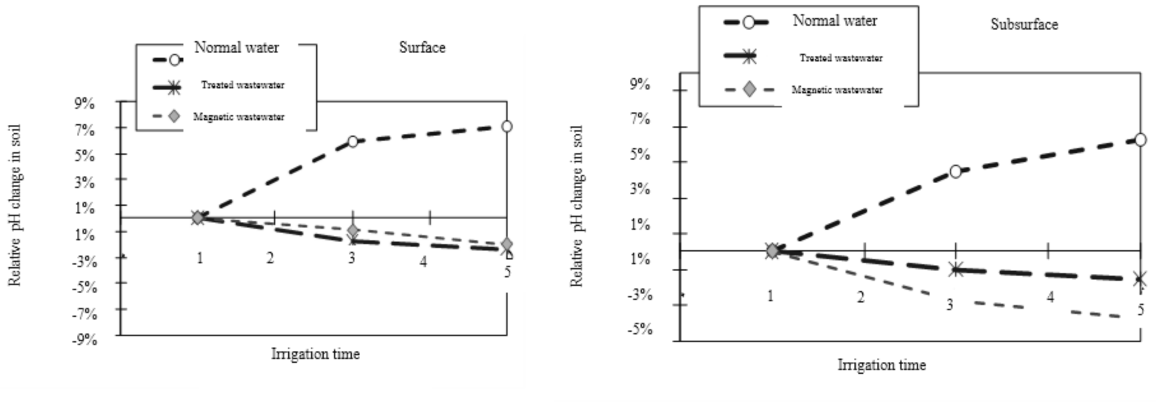

Figure 5. The mean relative change in pH during the irrigation season, in surface and subsurface soil layer.

CONCLUSION

Generally, the “Soil salinity” rate after 5 irrigation times with water and wastewater, compared with the first irrigation shows a relative decrease (about 40%). However regarding irrigation with the magnetized wastewater, the salinity rate in the soil subsurface layer showed a significant increase (over 60% changes). This increase can be consideredas being related to the magnetized water. In connection with the effect of water quality treatments on the soil “rate of acidity – alkalinity” studies showed that using the wastewater with the employed composition and conditions has led to slight decrease of this index during the season. It was while the soil reaction to irrigation with normal water appeared as a slight increase. At any rate, this difference has been mainly due to the sewage compounds and that magnetizing the wastewater has shown no significant effect on this parameter.

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