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Original Research

Evaluation of pH and EC changes in wastewater application in different depths of soil

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ABSTRACT:

Scarcity of water as well as scarcity for food production and environmental protection in the world have forced human beings to seek new water sources. Nowadays, application of unconventional water resources (wastewater) have been proposed in the countries facing shortage of water resources. However, minimal studies have been focused on this issue. The present study evaluated changes in the elements of the soil irrigated with wastewater. For this purpose, an experiment was conducted as a randomized complete block design with three replications. Soil samples were collected from the studied regions at the two depths of 0-30 cm and 30 -60 cm. Studied parameters included acidity (pH) and Electrical Conductivity (EC) of the soil. Three regions were taken into consideration for the study such as no irrigation, irrigation with treated wastewater and irrigation with river waters. The results showed an increase in pH of the effluent from Zahedan wastewater treatment plant compared to the control. However, electrical conductivity decreased in the soil irrigated with wastewater.

Keywords:
Irrigation, wastewater, electrical conductivity, Zahedan

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INTRODUCTION

Iran has arid and semi-arid ecosystems. The highest percentage of water consumption is accounted for agricultural sector compared to other purposes. Critical state of water scarcity in many parts of Iran has made water resource planners and managers to consider conventional and unconventional water resources (low quality water resources) in development planning. Urban treated wastewater is one of the low quality water resource whose application in agriculture necessitates careful management. Population growth in recent decades, development of human needs and increased public health have led to excessive exploitation of surface and underground water resources, which might result in a massive crisis. This problem is exacerbated in drought periods. This crisis is more highlighted and requires special attention in such countries as Iran, which lies in the arid belt. Unconventional freshwater resources (wastewater) should be used in agriculture in order to solve this problem, so that water resources would be available for other purposes (Oghli, 2002). Application of unconventional water resources (such as wastewater from water treatment plants) is increasingly important since less pressure is imposed on freshwater resources (Moazed and Hanife, 2006). In fact, wastewater is rich in nutrients and is the most accessible source of water for irrigation in most countries facing water scarcity (Fatta and Kythreotou, 2005). Wastewater as a rich source of nutrients can be used as a fertilizer. Koupai *et al.* (2001) evaluated the effect of wastewater of Shahin Shahr water treatment plant on the irrigation of sugar beet, maize and sunflower. They showed that irrigation with wastewater reduces saturated Electrical Conductivity (EC) and increases bulk density and pH of the soil. Shojaei (2014) evaluated the effect of urban sewage on soil chemical properties. He showed that irrigation with wastewater reduces electrical conductivity, dissolved sodium content, total soluble calcium, magnesium and potassium and increases nitrogen and phosphorus of the soil compared to control. The present study aimed to assess the effect of application of wastewater of Zahedan water treatment plant on accumulation of pH and EC at different depths of the soil, so that more adequate water resource can be identified for agricultural purposes.

MATERIALS AND METHODS

This research lasted for three years in which the effects of wastewater application on levels of sodium, total calcium and magnesium, pH and electrical conductivity of soil were determined. Zahedan water treatment plant was selected as a case study. Three sites were selected where following treatments were applied, no irrigation, irrigation with treated wastewater and irrigation with river water (Lar River). The area without irrigation (control) was the pasture around the water treatment plant. The experiment was conducted as a randomized complete block design with three replications by drilling soil profiles. Two samples were collected from each profile at two shallow depths viz: (0.30 cm) and deep (30-60 cm). Soil samples were dried in the open air before being transferred to the laboratory. The samples were screened using a 2mm sieve and transferred to the laboratory. Soil samples were saturated with distilled water to determine soil acidity. After 24 hours, acidity of the soil saturated extract was measured using a pH meter (Sparks *et al.,* 1996). After preparing saturated mud and saturated extract of the soil, electrical conductivity of the samples was recorded using an electrical conductivity meter device in terms of 25 $cdsm^{-1}$ (Sparks *et al.,* 1996). SPSS version 11.5 was used for data analysis.

RESULTS

ANOVA results at various depths for the first year showed a significant difference between level and electrical conductivity of the soil at 5% significance level. ANOVA and Duncan's test results also showed no significant difference between acidity of the soil at 1%

Table 1. Results of analysis of variance relevant to the effect of applied treatments at different depths

	Parameter	Sum of squares	Mean of squares	Statistical F	Sig.
	Acidity	0.842	0.210	22.286^{ns}	0.1
First year	Electrical conductivity	68.342	17.085	66.616*	0.00
Second year	Acidity	0.875	0.219	393.14*	0.00
	Electrical conductivity	67.187	16.797	1379.29*	0.00
Third year	Acidity	1.471	0.368	115.114^{ns}	0.02
	Electrical conductivity	72.129	18.032	405.279*	0.00

^{ns} No Significant Difference in probability of 1%

* Significance in probability of 1%

significance level (Table 1). Table 1 shows results of analysis of variance relevant to the effect of applied treatments at different depths in the second year. The results showed that all parameters (acidity and electrical conductivity) were significant at 5% significance level.

Figure 1 shows mean comparison of soil acidity at 0-30 cm depth. The results showed that irrigation with wastewater has increased soil acidity compared to the control. This difference was significant. However, irrigation with freshwater did not increase acidity. There showed no difference between irrigation with freshwater and control. According to the graph, soil acidity has increased in later years (second and third year) due to the irrigation with wastewater. There showed no difference between the first and second year of irrigation with wastewater in terms of soil acidity. Irrigation with freshwater did not significantly increase soil acidity (Fig 1). Figure 2 shows mean comparison of soil acidity at 30 -60 cm depth. Irrigation with wastewater increased soil acidity compared to other treatments in the first year at 30-60 cm depth. However, no significant difference was observed between irrigation with wastewater and control. No significant difference was also observed between irrigation with freshwater and irrigation with wastewater in terms of soil acidity in the second and the third year. The least soil acidity was obtained in the soils irrigated with freshwater at all studied periods. However, no significant difference was observed between all studied periods in terms of soil acidity. Comparison of soil acidity at 0-30 cm and 30- 60 cm depths showed that application of wastewater for irrigation has increased acidity in the surface layer (0-30 cm). Increased soil acidity at 0-30 cm and 30-60 cm depths at all studied periods were due to high acidity of wastewater compared to the freshwater.

Figure 3 shows mean comparison of soil electrical conductivity at 0-30 cm depth. The results showed that soil electrical conductivity has significantly

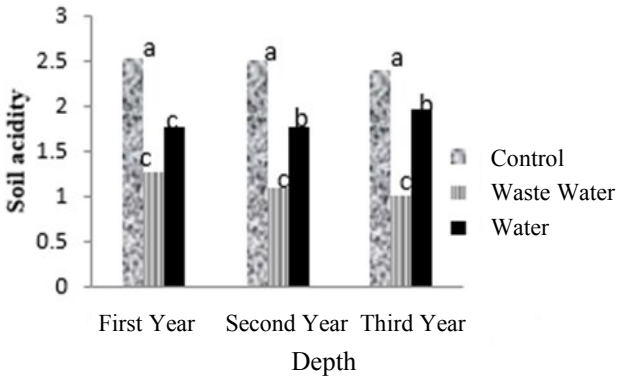

Figure 1. Soil acidity at 0-30cm depth

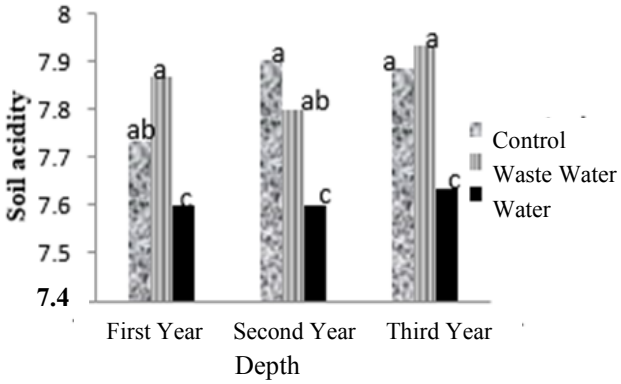

Figure 2. Soil acidity at 30-60cm depth

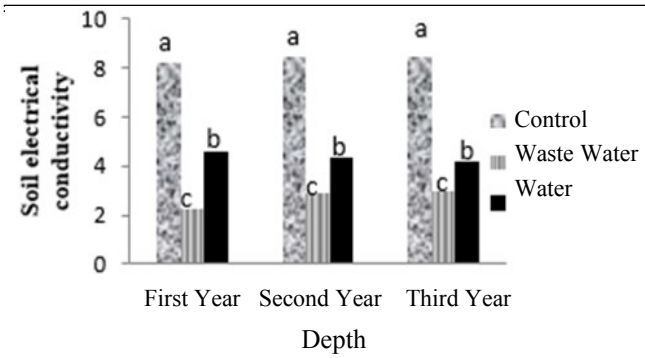

Figure 3. Soil electrical conductivity at 0-30cm depth

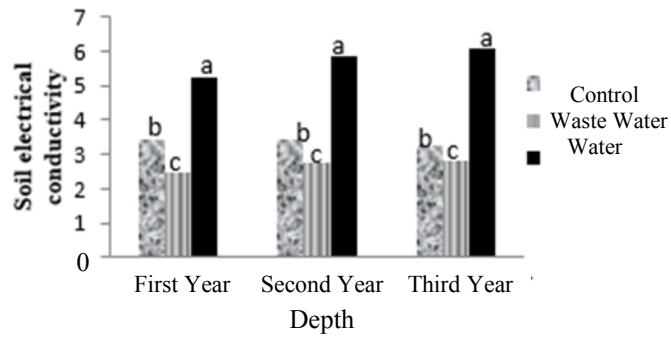

Figure 4. Soil electrical conductivity at 30-60cm depth

reduced in the first year of irrigation with wastewater and freshwater compared to control. In addition, a significant difference was found between irrigation with wastewater and freshwater in terms of electrical conductivity. The results also showed that electrical conductivity has reduced in the land irrigated with freshwater at surface layer after the second year. However, no significant difference was observed between all studied periods in this treatment in terms of electrical conductivity. Mean comparison results in terms of electrical conductivity at 30-60 cm depth showed that the highest electrical conductivity belonged to irrigation with freshwater, which increased electrical conductivity in deeper layers compared to surface layers. This was due to increased leaching and transport of salts to deeper layers of the soil (Figure 4). However, significant changes were observed in electrical conductivity of the soil in irrigation with wastewater at all studied periods at the two depths. According to Figure 3 and 4, lack of leaching and transport of soil elements in the control area caused no significant changes in the soil electrical conductivity.

DICUSSION

Water scarcity is one of the most important barriers to the preservation and development of agriculture in arid and semi-arid regions in Iran.

The highest percentage of water consumption is accounted for agricultural sector compared to other purposes. Critical state of water scarcity in many parts of Iran has made water resource planners and managers to consider conventional and unconventional water resources (low quality water resources) in development planning (Hosseinpour, 2008). Unconventional freshwater resources (wastewater) should be used in agriculture in order to solve this problem, so that water resources would be available for other purposes (Salehi *et al.,* 2005). Application of unconventional water resources (such as wastewater from water treatment plants) is increasingly important since less pressure is imposed on freshwater resources (Nadi *et al.,* 2010). Studied wastewater contained significant amounts of nutrients needed by plants. Thereby, wastewater is not only an adequate water supply for irrigation of crops, but also improves soil fertility. pH is the most prominent soil chemical property. Many chemical properties of the soil and consequently plant growth, activity of soil organisms and availability of nutrients to plants depend on soil pH (Guidi *et al.,* 1983, Ghollarata and Raiesi, 2007).

Although existence of qualified water is highly required for growth of plants, successful production of plants needs good soil and presence of appropriate nutrients. Determination of soil chemicals is first step in specifying necessary elements for plant's growth (Alizadeh, 1999).

The results of ANOVA at studied depths showed no significant difference in terms of soil acidity. This can be due to the presence of organic acids and non-acidic compounds in sewage sludge (Bahremand *et al.,* 2002). Zamani *et al.* (2010) studied the effect of sewage sludge of a Polydactyl factory on soil properties. They reduced

soil acidity by 1.8 unit using 45 tons per hectare sewage sludge of the factory compared to the control but there was no significant difference between the treatment and control. The results of examining electrical conductivity of soil samples in three years showed the significant effect of irrigation with wastewater in the region at 5% significance level, so that soil electrical conductivity was significantly increased in the areas irrigated with wastewater compared to the control. These results are consistent with those obtained by Zamani *et al.* (2010) who showed that saturated hydraulic conductivity was reduced by adding sewage sludge to the soil. In another experiment, the effect of irrigation with wastewater on soil properties was studied in the northern Isfahan, which was irrigated with wastewater for nine years. The results of the former experiment showed that wastewater reduced electrical conductivity compared to well water (Shahraki and Mahdavi, 2005).

Sharma *et al.* (2007) performed a study on olive, corn and type of cabbage in the form of factorial random study with three repetitions. They investigated chemical specifications of soil and revealed that increase of nitrogen-nitrate, EC and pH at different depths of soil profile were different because of the repeated usage of wastewater. Researches indicated that using wastewater in irrigation of lettuce, carrot and tomato will increase the performance. Moreover, this study was performed on wheat, broad bean, cotton and rice which revealed that using wastewater may cause higher performance in comparison with drinking water enriched with nitrogen, potassium and phosphor fertilizers because of pH changes and available nutrients in the plants (Bina, 1993). Moreno *et al.* (2001) has used wastewater in investigating cotton and sugar beet. The results showed that practice of one shift of waters with high degrees of salinity throughout the flowering stage or added types of irrigations using capable water (0.9 ds/m) in circumstances that there are irrigation limits which will not cause significant problems for plants and soil. Hussain *et al.* (2002) has also done researches on yearly changes of soil salinity on retaining wastewater and saline. The results exposed that salt attentiveness is not equal in different years and there were no actual connection between salinity of irrigation water and soil salinity in some areas or years. Feizi (2008) considered irrigation with wastewater-saline for a period of three crop year on cotton plants. The outcomes of his revision revealed about 50% of decrease in the usage of competent water. For irrigation in the desert regions, this method could be a significant role in the stability of the plants, reducing cost of irrigation and restoration of biological and fertilization in the areas.

CONCLUSION

Water scarcity is one of the most important barriers to the preservation and development of agriculture in arid and semi-arid regions of Iran. The problem has also been exacerbated by drought in recent Inserts. Around 15 to 25% of water used in the domestic and urban ingestions will be released to the environment as wastewater. Bearing in mind the required nutrients for plants, usage of urban wastewater as a reserve for supplying sustainable water to remove agricultural demands are presently inevitable. Studied wastewater includes considerable values of nutrients that may supply agricultural plant's demands using in combination with irrigation waters. The results of current study revealed that passage of wastewater may change mean value of soil pH and EC in the studied farms. In other words, these samples revealed considerable increase of pH and EC value in both the surface and deep layers in comparison with control samples.

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