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Soil chemical properties affected by application of treated municipal wastewater

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ABSTRACT

In a twelve months pot experiment irrigation with Treated Municipal Wastewater Effluent (TMWE), the changes of some soil properties such as salinity, pH, organic carbon, soluble calcium and magnesium, available potassium and phosphorus was studied. The experiment carried out in the region of Bovirahamad in 2010-2011 in the presence of some green space non-fruit seedling trees . The irrigation treatments include potable water as control (W), "full (F) and intermittent (WF) application of TMWE". The results showed significant changes in some of the soil properties. Electrical Conductivity (salinity), organic carbon, soluble Ca and Mg, available soil phosphorus and potassium increased significantly. However, the percentage of total neutralizing Value (T.N.V) decreased. A little but not significant reduction was occurred in soil pH.

Keywords: Electrical conductivity; irrigation; Municipal; Wastewater; Soil

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INTRODUCTION

The use of wastewater for irrigation propose has increased as availability of the other water resources become more limited and the disposal of wastewaters into streams have been more restricted. The availability of wastewater and its nutrients content makes it an attractive source of irrigation water with likely fertilizer cost saving [Arinzo etal., 2009 3].

Shortage of fresh water in Iran, leading to the increasing use of wastewater as a reliable non-conventional irrigation source for agricultural, industrial and commercial purposes greatly [Rahmani,2010 19].

Waste water not only is a supplemental irrigation water but also is a source of plant nutrients such as nitrogen, phosphorus; organic matter [Gibbs et al., 2006 8].Soil is a natural medium for plant growth, serves as a natural pool of water and nutrients, a medium for the filtration and breakdown of injurious wastes. Soil also is a participant in the cycling of carbon and other elements through the ecosystem.

So any changes in soil properties may influence on the above mentioned soil functions, therefore on plant growth and production. It is predicted that the total sewage effluent in all sectors in Iran will be around 10000mcm in year 2022[Panahi kordlaghari,2012 16]. Undoubtedly a large portion of the wastewater will be use for irrigation of farmyards and green spaces. To examine the effects of sewage effluent wastewater on soil properties may help to plan a better management on the use of this kind of water. And this is the idea behind of this study.

MATERIALS AND METHODS

The study was conducted in Bovirahamad region of Kohgiloyeh &Bovirahmad Province in south west of Iran. A pot experiment was laid out to evaluate the effect of continuous and intermittent application of treated wastewater effluent on some soil properties. Some Seedlings of non-productive green space plants including: Cupressus Semperyins, , Morus nigra, Salix alba, Pinus eldarica, Syringa Amurensis, Nerium Oleander, Platycladus Orientalis، Hibiscus Rosa Sinensis and Myrtle Myrtus Communis were planted in pots and the following treatments were investigated in a Randomized Block Design with three replications: Irrigation with potable water as control (W),full irrigation with TMWE (F) and intermittent irrigation with potable water and TMWE (WF). After twelve months, the plants dig out and soil samples were collected from the pots, air dried, powdered and sieved through a 2 mm sieve. Stones and plant residuals were removed manually. The water samples were also collected in polyethylene bottles from the last sewage treated disposal pond and from tap water near the experimental site. The pH and EC of treated sewage effluent and tap water samples were determined immediately after collection by glass electrode pH meter and electrical conductivity meter respectively. the Biochemical oxygen demand or B.O.D, calcium, magnesium, Phosphorus ,Nitrate, Sulphate and chloride were measured using methods given by APHA[1992 2]. SAR and TDS by the methods described in USDA Agricultural Handbook No 60[US Salinity Laboratory Staff,1954 26].The pH of soil samples were measured in saturated extracts using glass electrode pH meter. Electrical conductivity of soils in saturated extracts were determined by conductivity meter. The concentration of available K^+ , phosphorus, Ca^{++}, Mg^{++} and Na^+ were determined using soil analysis standard methods[Soil and Water Institute,1977 23, Ali ehiaee and Bebehanizadeh 1993 1].

RESULTS AND DISCUSSION

Water quality: The result of analysis of irrigation waters presents in table 1. According to the results both waters are in permissible limits. However, the wastewater has a higher salinity. The quality of potable water and TMWE are classified in C_2S_1 and C_3S_1 groups [Miller and Donahue, 1990 14] respectively, in which there is no sever hazards for surface irrigation [FAO, 1992 7]. Salts concentration of wastewater is an important parameter determining its suitability for irrigation. According to salt tolerance of crops diagrams [Maas, 1986 13; Shalhevet, 1994 22] high concentration of soluble salts in irrigation water may limti its use and decreases crop yields. The pH of the treated wastewater was 8.2 which is in optimum range. Since the optimal range of pH of wastewater treatment for irrigation is 6.5-8.4[Ayers and westcot,1985 4].

TABLE 1.CHEMICAL PROPERTIES OF IRRIGATION WATERS

Parameters	potable water	Wastewater
$EC*10^6$	435	1500
pH(in saturated paste)	7.5	8.2
HCO_3^-(meq/l)	2	1.6
Ca^{++} (meq/l)	2	2.5
Mg_{++} (meq/l)	1.4	1
Na_+ (meq/l)	0.2	4.5
TDS(mg/l)	220	800
SAR	0.15	4
Water classification	C_3S_1*	C_2S_1*

** No limitation for irrigation [Miller and Donahue, 1990 14]*

Electrical Conductivity of soils: Analysis of the data showed a significant increase in soil electrical conductivity. Application of TMWE increased the electrical conductivity of soil from 0.71 ds/m for potable water treatment (W) to 2.23 and 2.46 ds/m for constantly (F) and intermittent (WF) irrigation respectively (table2). In spite of raise in EC of soils irrigated with TMWE, still the soils are normal (Miller and Donahue, 1990 14] and there is no risk of salinity. Several studies showed the increase of soil electrical conductivity because of irrigation with sewage effluents (Miller and Donahue, 1990 14. Mushtaq and Saifullah khan,2010 15., Rahmani,2007 18., Rana etal. 2010 20]. However the area has high annual precipitation , so the risk of salt accumulation is low.

Soil pH: The results showed a little but not significant reduction in soil pH, in soils irrigated with TMWE (table2) and soil pH is still neutral . The pH of the treated soils varied between 7.33 and 7.53 which is in optimum range for plant growth. Usually soils because of buffering characteristics, resist to pH change [Miller and Donahue, 1990 14]. According to Rana, et al. [2010 20] irrigation with sewage effluent caused a little raise in soil pH. Whereas Rahmani [2007 18] showed that pH of soils in fields irrigated with sewage effluent slightly decreased. Further more soils irrigated with potable water or TMWE in this work had pH in a range suitable for most crop plants[Brady,1990 5] without limitation for plant growth and nutrients availability.

Soil organic carbon

As a result of irrigation with TMWE, soil organic carbon was increased significantly (table2). F and WF treatments increased the soil OC by 50 and 37 percent rather than control (W). Mainly organic compounds of living beings in sewage effluent are rapidly decomposed in the soil. In aerobic condition, the process is generally faster and complete. However, in anaerobic conditions they prevail in to the soil; so fluvic and humic acids can be formed [Poscode, 1992 17] to increase soil organic matter. Soil organic matter is an indication of soil productivity [Tisdale et al. 1975 24]. Organic carbon is the main component of organic matter (≈58percentage), so application of TMWE improved soil fertility by increasing soil organic matter. Rahmani[2007 18] in a two year study found that in soils irrigated with municipal effluent wastewater ,organic matter content was increased. Evidences[Tripathi and Misra, 2012 25] showed that the organic matter of dumpsite soils with municipal wastewater were higher as compared to their adjoining soils.

Soil soluble calcium

The amounts of soil soluble calcium increased in full and intermittent irrigation with TMWE, [F and WF) treatment with compare to control treatment[W) were increased 104 and 121% respectively. (table2). Calcium,a secondary plant nutrition has an important role in plant growth [Bothwell and Ng.2005 5. Hepler, 2005]. There are numerous processes in which calcium ion participates and involves nearly all aspects of plant development [Harper et al., 2004 4; Hetherington and Brownlee, 2004 10; Hirschi, 2004 4; Reddy and Reddy, 2004 21; Bothwell and Ng, 2005 6].

Soil soluble Magnesium:

Application of treated municipal wastewater effluent both full (F) and intermittent (WF) increased soil solution Mg : 75 and 83 % with compare to control treatment(W) respectively (table2).

Table 2. Soil characteristics measured after application of potable water (W), TMEW(F) and intermittent waste water(WF).

Parameters	Potable water(w) or control	Wf(potable+ waste water)	F(waste water)
EC*10^6	0.71	2.46	2.23
pH(in saturated paste)	7.53	7.33	7.46
OC	3.26	4.45	4.88
Ca^{++} (meq/l)	4.7	10.4	9.62
Mg^{++}(meq/l)	3.03	5.54	5.3
P(mg/l)	125	178.3	255.7
K(mg/l)	380	460	650
TNV%	49.2	43	38.3

Soil available phosphorus:

Both treatments of permanent irrigation with TMWE (f)and alternatively irrigation with TMWE (wf) increased soil available phosphorus with compare to control treatment (w).P is the second key plant nutrient. Wastewater usually is a source of P and may have 5-50 mg/l phosphorus, and could be accumulate at the top soil layer[Pdscode, 1992 17].

Soil available potassium:

Wastewater usage caused significant increase of solution potassium (table 2). Wastewatera are usually an important source of K^+. Plants need large amounts of potassium for their growth and development.. Potassium applied to soil by wastewater can be taken up by plants immediately [Levy and Torrento, 1995 12].

Total Neutralized Value(TNV)of soil :

Application of wastewater to soil decreased the amount of soil TNV considerably. Generally, soil of arid and semi-arid area of Iran is calcareous. TMWE application in such this agricultural area may cause chemical reactions, therefore dissolution of a part of calcium and magnesium carbonate**.**

CONCLUSION

The present study reveals that continuous and alternative irrigation with treated municipal wastewater effluent, with compare to fresh water, increased soil: EC, soluble calcium and magnesium, available phosphorus and available potassium considerably. As the data shows the applied TMWE was generally in the favourable range for irrigation, therefore the soil irrigated with wastewater was still in normal condition for plant growth.

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