Почвознание агрохимия и екология, **52**, *2/2018*
Soil Science Agrochemisty and Ecology, **52**, *2/2018*

Effects of the Municipal Wastewater Use on Some Soil Properties

Masoud Dadivar[1*], Mahommad Ali Khodshenas[2], Javad Ghadbeiklou[2]

1. Faculty Member of Soil and Water Department, Khorasan Razavi Agricultural and Resources Research and Training Center,AREEO, Mashhd, Iran
2. Faculty Member of Soil and Water Department, Markazi Agricultural and Resources Research and Training Center,AREEO, Arak, Iran
Email*: dadivarm@yahoo.com

Abstract

Dadivar, M., Ali Khodshenas, M., Ghadbeiklou, J. (2018). Effects of the Municipal Wastewater Use on Some Soil Properties. *Bulgarian Journal of Soil Science, Agrochemistry and Ecology,* **52**(2), 27-32

Today, due to the existing constraint in availability of the freshwater for irrigation, the municipal wastewater is being used for irrigation of agricultural fields. This study was conducted in the agricultural farm nearby Meighan desert in arak city (Iran). On this field crops were irrigated with wastewater for three years. The results indicated that in 50% of the soil samples treated with municipal wastewater, the organic carbon amount was over 1.6%. Also the amounts of potassium and phosphorous were 256 and 23.5 $mg.kg^{-1}$, respectively. The average amounts of zinc (Zn), copper (Cu), iron (Fe) and manganese (Mn) were 1.41, 1.10, 4.68 and 7.18 $mg.kg^{-1}$, respectively. The average amounts of pH and Ec were 8.1 and 1.17 $dS.m^{-1}$, respectively. The concentration of bicarbonate (HCO_3^-), sodium (Na^+) and chlorine (Cl^-) in wastewater were over the hazardous levels. The mean amounts of wastewater EC reduced noticeably and the mean pH decreased slightly compared to groundwater level. But the amounts of potassium (K^+) and boron (B) increased in wastewater.

Key words: Irrigation, wastewater, Soil properties

Population growth, especially in the developing countries has increased the demand for a huge quantity of water for domestic, municipal, and industrial sectors. With the increasing scarcity of freshwater resources that are available to agriculture, the use of urban wastewater for irrigation is increasing, especially in the arid and semi-arid regions of the world (Singh and Agrawal, 2012). Wastewater can be considered as both a resource and a problem. Wastewater and its nutrient content can be used extensively for irrigation and other ecosystem services. Its reuse can deliver positive benefits to the farming community, society and municipalities. However wastewater reuse also exacts negative externality effects on humans and ecological systems, which need to be identified and assessed (Hussain et al, 2002). The availability of wastewater and its nutrients content makes it an attractive source of irrigation water with likely fertilizer cost saving (Arienzo et al, 2009). There are several opportunities for improving wastewater management via improved policies, institutional dialogues and financial mechanisms, which would reduce the risks in agriculture (Qadir et al, 2010). Research results in Saudi Arabia indicated that using treated municipal waste water in crop irrigation saved 45% and 94% in the cost of the fertilization programs for wheat and alfalfa, respectively. Additionally, wheat yield increased by 11% and alfalfa production improved by 23%. The concentration of heavy metals such as Copper (Cu), Lead (Pb) and Cobalt (Co) in plant tissue was low compared to established standards; these heavy metal concentration are well below hazardous levels. This study showed that treated municipal wastewater can be used safely for irrigation of a selected groups of crops (Aljaloud, 2010). A study was carried out to investigate the effects of treated wastewater on accumulation of heavy metals in plants in north of Isfahan Province. The experiment consisted of six plants including wheat, alfalfa, corn, tomato, cucumber and cantaloupe. The evidence provided by this experiment indicated that treated wastewater caused increase of heavy metal in most plan samples, particularly for Mn, Zn and Cu. Some plants such as corn and alfalfa irrigated with well water, had slightly higher values of Cu, Fe and Mn (Feizi and Rastghalam, 2012). Abunada and Nasser(2014) showed that SAR and EC increased significantly by about 160% and 130% respectively, due to wastewater irrigation (WWI) compared with well water irrigation. WWI caused slight decrease in soil pH while it increased the soil organic matter content. Alizadeh et al (2001) during a two-year corn irrigation study with treated wastewater in Mashhad, observed that the soil pH decreased compared to the time before the start of investigation, which was the result of high concentrations of organic matter in the wastewater.

Panahi Kordlaghari et al (2013), was studied municipal wastewater effects on change of some soil properties in Boyerahmad region in south west of Iran. The results showed electrical conductivity, organic carbon, soluble Ca and Mg, available soil phosphorus and potassium increased significantly. The percentage of TNV (total neutralizing value) and pH decreased. Use of the domestic wastewater with fertilizer has shown the improvement in the physiochemical properties of soil, crop yield and also in the nutrient status as compared to that of the resulted from the application of groundwater with fertilizer (Singh et al, 2012). Undoubtedly a large portion of the wastewater will be used for irrigation of agriculture and green spaces. The aim of this research was to investigated and discuss the impact of irrigation with domestic wastewater on soil properties may help to plan a better management on the use of this kind of water.

Material and methods

This study was conducted in the agricultural farm nearby Meighan desert (Longitude 49° 49' 22.90" to 49° 50' 9.19" E and Latitude 34° 06' 2.49" to 34° 07' 22.54" N) in Arak city in Markazi province. On this field crops (Alfalfa and Barley) were irrigated with wastewater for three years.

Six samples of wastewater were collected from arak municipal wastewater between April and May 2013. The quality of reclaimed water was evaluated by following the guidelines for interpretation of water quality for irrigation by Ayers and Westcot, (1985).

Also twenty two composite samples of soil from 0-30 cm depth were collected between April and May 2013. Soil texture was determined by hydrometer method (Koehker et al, 1984). Calcium carbonate equivalent (CCE) according to Alison et al. (1965). Soil pH and ECE were measured at a 1:2.5 soil/water ratio and saturated extract, respectively. Organic matter (OM) content was determined by walkley and black procedure as recommended by Jackson (1958). Total N was determined by Rutherford et al (2006). Soil available K was determined by 1M NH_4OAc extraction and K assessment in the extract by flame photometer (Thomas, 1982). Soil available P was measured by Olsen method (Bingham,1982). Available Fe, Zn, Mn, Cu, Pb and Cd in the soil were first extracted by Diethylene Triamine Penta Acetic acid (DTPA) and then were read by atomic absorption (Bingham,1982).

Results and discussion

Water quality: The results of analysis of irrigation waters presents in table 1. According to the results, amounts of EC, Cl^-, SO_4^{2-}, Na^+ and Ca^{2+},Mg^{2+} in the grand water has more than wastewater. Versus, amounts HCO_3^-, PO_4^{2-}, NO_3^-, K and B in the wastewater is more. The quality of GM and TMWW are classified in C4S1 and C3S1 group respectively.

Guidelines for interpretation of water quality for irrigation showed in table 2.

Analyses showed that the soil organic carbon

(OC) ranged from 0.72 to 1.18 percent with an average of 1.22% (table 5). 50% of soil samples are more than 1% organic carbon (table 4), while the average value of OC in the soil irrigated with ground water is 0.73% (table 3). Irrigation with TMWW, soil organic carbon was increased significantly. Evidence (Al-Jaboobi et al, 2014) also showed that the soil irrigated with wastewater has the best concentration of organic matter, was equal to 2% compared to 0.74% obtained for soil irrigated with groundwater. Therefor treated wastewater can effectively be used as fertility source for soil. Total Neutralizing Value (TNV) ranged from 19.5 to 33.5 with a mean of 27.7% in soil irrigated with wastewater, while the average value of TNV in the soil irrigated with ground water is 28.0%. 50% of soil samples are more than 28.0% TNV. In relation to potassium and phosphorus the minimum values were 164 and 13.1 $mgkg^{-1}$, and the maximum values were 791 and 78.4 $mgkg^{-1}$ soil respectively. The average amounts of potassium and phosphorus were 292 and 29 $mgkg^{-1}$ soil respectively. Amount of potassium and phosphorus in 50% of soil samples were more than 256 and 23.5 $mgkg^{-1}$ soil respectively. Therefore, the amounts of potassium and phosphorus in soil were high, which were consistent with the results of Panahi Kordlaghari et al (2013) Singh et al (2012). In relation to microelements including, Zn, Cu, Fe and Mn, the minimum values were 0.56, 0.62, 2.6 and 4.0 and the maximum values were 3.96, 2.82, 10.9 and 18.7 mgkg-1 soil respectively. The average amounts of microelements were 1.41, 1.10, 4.68 and 7.18 $mgkg^{-1}$ soil respectively. The amounts of Zn, Cu, Fe and Mn in 50% of soil samples were more than 1.20, 1.03, 4.3 and 6.4 $mgkg^{-1}$ soil respectively. The minimum and maximum pH values were 7.8 and 8.5 respectively, with a mean of 8.1. Also the minimum and maximum EC values were 0.5 and 3.40 dSm^{-1} respectively, with a mean of 1.17 dSm^{-1}. Chlorine reduces the nitrate concentration in plants. This is important for plants to be eaten fresh. Undesirable effects of bicarbonate on the plant may indirectly, through their effects on soil physical properties. If the amount of carbonate in the water is higher than other anions, increased sodium in the soil in the long term reduce the quality of the soil. Because calcium carbonate is deposited in the soil solution and sodium adsorption ratio increases with decreasing the amount of calcium. Increased exchangeable sodium destroys soil structure, and dispersion of fine particles clog the pores of the soil. The NO_3-N concentrations in most surface water and groundwater is usually less than 5 mgl^{-1}, while amount of wastewater nitrate was between 13-10 mgl^{-1}.

Table 4. Distribution parameters measured in soil samples

OC	TNV	N	Zn	Cu	Fe	Mn	K	P	Pb	Cd	pH	EC	percent
0.87	25.4	0.087	0.88	0.82	3.1	5.0	228	15.5	1.87	0	7.9	0.8	25%
1.06	28.0	0.105	1.20	1.03	4.3	6.4	256	23.5	2.15	0	8.1	0.9	50%
1.28	29.6	0.120	1.73	1.23	5.7	8.0	342	39.3	2.90	0	8.2	1.5	75%

Table 1. Mean chemical composition of irrigation waters

Parameters	TMWW	GW
EC (dSm^{-1})	1.30	3.50
pH	7.32	7.60
HCO_3^-, (mql^{-1})	8.30	5.0
Cl^-, (mql^{-1})	4.65	28.9
PO_4^{2-} , (mql^{-1})	0.3	-
SO_4^{2-}, (mql^{-1})	1.63	3.10
Na^+, (mql^{-1})	7.43	12.8
K^+, (mql^{-1})	0.38	0.06
$Ca^{2+} Mg^{2+}$,(mql^{-1})	6.78	24.2
NO_3^-, (mgl^{-1})	11.2	7.0
B^{3+}, (mgl^{-1})	0.31	0.17
Fe^{2+}, (mgl^{-1})	-	-
Mn^{2+}, (mgl^{-1})	-	-
Cu^{2+}, (mgl^{-1})	-	-
Zn^{2+}, (mgl^{-1})	0.02	-
Pb^{2+} , (mgl^{-1})	0.03	-
Cd^{2+}, (mgl^{-1})	-	-
SAR	4.0	3.5

TMWW= Treated Municipal Waste Water
GW= Ground Water

Table 2. Guidelines for interpretation of water quality for irrigation (pescod,1992)

WHO	FAO	EPA	parameters
0.1	0.1	0.1	As, (mgl^{-1})
0.7	0.7	1.0	B, (mgl^{-1})
0.01	0.01	0.01	Cd, (mgl^{-1})
0.2	0.2	0.2	Cu, (mgl^{-1})
5.0	5.0	5.0	Fe, (mgl^{-1})
0.2	0.2	0.2	Mn, (mgl^{-1})
0.01	0.01	0.01	Mo, (mgl^{-1})
0.2	0.2	0.2	Ni, (mgl^{-1})
5.0	5.0	5.0	Pb, (mgl^{-1})
2.0	2.0	1.0	Zn, (mgl^{-1})
3.0	3.0	3.0	Na, ($meql^{-1}$)
0.7	0.7	0.7	Ec, (dSm^{-1})
3.0	3.0	-	SAR
6.0- 8.5	6.5- 8.0	6.5- 8.4	pH

EPA= Environmental Protection Agency
FAO= Food and Agriculture organization
WHO= World Health Organization

Table 3. Physico-chemical properties of soils

Parameters	Soil a	Soil b
	Range	
pH	7.8-8.5	7.9
EC	0.5-3.4	2.0
OC	0.72-1.81	0.73
TNV	14.0-33.5	28.0
N	0.07-0.18	0.07
Zn	0.56-3.96	0.52
Cu	0.62-2.82	0.70
Fe	2.6-10.9	2.8
Mn	4.0- 8.7	4.7
K	164-791	195
P	13.1-78.4	12.0
Pb	1.0-4.2	0
Cd	0	0
Clay (%)	46-62	45
Silt (%)	16- 32	20
Sand (%)	18- 31	35

Texture= Clay
Soil a = Soil irrigated with Treated Municipal Waste Water (TMWW)
Soil b = Soil irrigated with Ground Water (GW)

Table 5. Descriptive statistics parameters measured in soil

	range	Minimum	maximum	Mean		Standard deviation	CV
	Statistics			Statistics		Standard error	
OC	1.09	0.72	1.81	1.22	0.06	0.3	24.6
TNV	14.0	19.5	33.5	27.7	0.65	3.03	10.9
N	0.11	0.07	0.18	0.12	0.006	0.03	25
Zn	3.4	0.56	3.96	1.41	0.173	0.81	57.4
Cu	2.2	0.62	2.82	1.1	0.093	0.44	40
Fe	8.4	2.6	10.9	4.68	0.41	1.91	40.8
Mn	14.7	4.0	18.7	7.18	0.70	3.30	45.9
K	627	164	791	292	28.03	131.47	45
P	65.3	13.1	78.4	29	3.86	18.12	62.4
Pb	3.2	1.0	4.2	2.4	0.18	0.84	35
Cd	0	0	0	0	0	0	0
pH	0.7	7.8	8.5	8.1	0.04	0.21	2.6
Ec	2.9	0.5	3.4	1.17	0.14	0.67	57

Conclusion

The present study reveals that irrigation with treated municipal waste water (TMWW) compared to ground water (GW), increased soil pH, OC, N, available phosphorus and potassium, Zn, Cu and Fe considerably. Hence, irrigation with TMWW is a potential source of supplemental irrigation not only to meet growing crop water needs, but also for increased agricultural production.

Due to the high amounts of sodium, chloride, bicarbonate and nitrate in wastewater, it is necessary to reduce the amount of pollutants above the permitted limit. However, there are risks that are associated with reuse of wastewater.

References

Abunada, Z and A. Nassar. (2014). Impacts of wastewater irrigation on soil and alfalfa:case study from Gaza Strip. *Environmental progress and sustainable energy.* **34**, 648- 654.

Alizadeh, A., M. E. Bazari., S. Velayati., M. Hasheminia., and A. Yaghmai. (2001). Using reclaimed municipal wastewater for irrigation of corn. ICID. International workshop on wastewater reuse management. Seoul, Korea.

Al-Jaboobi, M., M. Tijane., Sh. EL-Ariqi., A. El Housni., A. Zouahri., and M. Bouksaim. (2014). Assessment of the impact of wastewater use on soil properties. *J. Mater. Environ. Sci*. **5**, 747-752.

Aljaloud, A. (2010). Reuse of wastewater for irrigation in Saudi Arabia and its effect on soil and plant. 19th world congress of soil science, soil solutions for a changing world. 1-6 Augst, Brisbane, Australia.

Arienzo, M., E. W. Christen., W. Quayle., and A. Kumar. (2009). A review of the fate of potassium in the soil- plant system after land application of wastewater. *Journal of Hazardous Materials*. **164**, 415- 422.

Ayers, R. S., and D. W. Westcott. (1985). Water Quality of Agriculture. FAO Irrigation and Drainage Paper No. 29, Rome, 174 pp.

Bingham, F.T. (1982). Boron. In: A.L. Page, (Ed.), Methods of Soil Analysis. Part 2, Am. Soc. Agron. Madison, WI., pp: 431-448.

Feizi, M., and Z. S. Rastghalam. (2012). The effect of treated wastewater irrigation on accumulation of heavy metals in selected plants. The 1th International and the 4th National Congress on Recycling of Organic Waste in Agriculture. 26-27 April, Isfahan, Iran.

Hussain, I., L. Raschid., M. A. Hanjra., F. Maricar., and W. Hoek. (2002). Wastewater Use in Agriculture: Review of Impacts and Methodological Issue in Valuing Impacts. International Water Management Institute. Working Paper 37.

Panahi kordlaghari, Kh., S. Nikeghbali Sisakht., and A. Saleh. (2013). Soil chemical properties affected by application of treated municipal wastewater. *Annals of Biological Research*, **4**, 105-108.

Rutherford, P. M., W. B. McGill., and J. M. Arocena. (2006.) Total Nitrogen. pp: 69-75. In Y.K. Soon and W.H. Hendershot, (Eds). Methods of soil analysis, Part 3. Taylor & Francis Group, LLC

Singh, A., and M. Agrawal. (2012). Effects of wastewater irrigation on physical and biochemical characteristics of soil and metal partitioning in Beta Vulgaris L. *Agricultural Research*, **1**, 379- 391.

Thomas, G. W. (1982). Exchangeable cations. pp: 159- 164. In A.L. Page, R.H. Miller and D.R.