Middle-East Journal of Scientific Research 25 (6): 1178-1183, 2017
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2017.1178.1183

Wastewater Irrigation Effect on Mineral Constituents of *Moringa oleifera*

A.A. AL-Toukhy, S.A. Alghamdi and M.S. Alzahrani

Department of Biological Sciences, Faculty of Science,
P.O. Box: 80203 King Abdulaziz University, Jeddah, 21589. Saudi Arabia

Abstract: The effect of different wastewater levels (Raw, aeration, clarifier, return sludge, filter, storage and ordinary water (As a control) on mineral ion concentration (Na, K, Ca, Mg, P, N, Ba, B and Al) in addition to heavy metals (Zn, Pb, Ni, Mo, Mn, Fe, Cu, Co and Cd) in *Moringa oleifera* were studied. Results showed that wastewater had a significant effect for essential elements (Nitrogen, Phosphorous and Potassium) in the various treatments; raw, aeration and return sludge in shoot and root of *Moringa oleifera* except aeration water treatment Nitrogen and Potassium and Calcium. Also *Moringa oleifera showed a* high ability for accommodation for Zinc and Calcium.

Key words: Wastewater · Moringa · Trace elements · Essential elements

INTRODUCTION

The lack of food is one of the most important problems in the world, especially in the arid and semi-arid areas, including Saudi Arabia. There are several rezones for food shortages, as a result as climate change and water shortage [1]. Wastewater is a complementary water resource, it reduces the requirement for high quality water. The recycle of wastewater, particularly for irrigation, is an extremely common practice, encouraged by governments around the world mainly, in the countries leaking shortage in the original water resources [2].

Wastewater contains a large quantity of nutrient elements which help improving soil fertility. Wastewater irrigation leads to inference in different stages: change the physical and chemical characteristic and microbiological content of the soil, also contributes the increase of chemical and biological pollution in soil. Firstly, it may affect soil fertility and productivity, secondly it may leads to serious threats to the human health and environmental. The sustainable of wastewater reprocesses in agriculture should not support both kinds of implication, requesting assessment risk. Several investigators [3-5] showed that the effects of wastewater irrigation, presents and the negative side effect the heavy metal toxicity which, exceeded the positive side that, effects the organic nutrients. Additionally, the wastewater raises soil salinity, organic carbon, N, K, Ca and Mg. Wastewater can be resulted in several problems, for example; pathogenic infection and heavy metal increase in soil, underground water and crops to toxic levels. Therefore, the system water-soil-plants is connected to natural ecosystem and is a complex heterogeneous system. Moreover, wastewater irrigation leads to contaminants especially, when heavy metals go into the soil with water and then get a movement into plants; and then, when it absorbed in the process of plant growth, the system completes the transformation and migration of contaminants from water to soil to plants [2, 6]. Wastewater can be used for irrigation and that benefit to keep water and nutrients, decreasing the pollution of water sources as rivers and canals, provide micronutrients, organic matter, nitrogen and many of the required phosphorus and potassium for plants production. The previous studies showed that Irrigation with wastewater leads to raising the accumulation of K, Na, Fe, Mn, Zn, Cu and B in the soil, compared to freshwater [7] also they found regular use of wastewater for irrigation leads to increase soil electrical conductivity (EC) and reduce soil pH. Lu *et al*. [8] recovered that, the wastewater is not causing any pollution to soil and plants by concentration of heavy metals (Cd, Cr, Cu, Zn) and the index for heavy metals content is way below the certain value of the national standard.

Corresponding Author: AL-Toukhy A.A., Department of Biological Sciences, Faculty of Science. P.O. Box: 80203 King Abdulaziz University, Jeddah, 21589. Saudi Arabia. E-mail: abdalmtoukhy@yaho.com.

Moringa oleifera grows on top and feet of hillocks in Saudi Arabia. It has been recorded in different areas at the western coast of Saudi Arabia. *M. oleifera* is one of plant species which have crucial role in developing the diet in countries suffering from malnutrition, traditional medicine usually used *M. oleifera* leaves, seeds, bark, roots and flowers and it also can be used in human nutrition as a food products. . Leaf extracts exhibit huge antioxidant action and several fair studies in animals including aqueous leaf extracts specify a high scale of safety. Furthermore, the leaves are noted to contain different kinds of antioxidant compounds for example, ascorbic acid, flavonoids, phenolics and carotenoid [9-12]. M. oleifera has been used in traditional medicine. While studies from human subjects are incomplete, numerous experiments demonstrating likely benefits for treating hyperglycemia and dyslipidemia mainly in people with type 2 diabetes has been published. This plant has nutritional elements important at the same time had the ability to presume the environmental conditions such as drought and salinity [13, 14]. The objective of this investigation was to determine the effects of untreated and treated wastewater irrigation on growth of M. *oleifera* and bio accumulation of nutrients and metals in shoots and roots of M. *oleifera* irrigated with wastewater. The impact of Six different wastewater treatments were used in this study, raw sewage water, aeration water, clarifier water, return sludge water, filter water and storage water.

MATERIALS AND METHODS

Seeds of Moringa oleifera were sown in perforated plastic pots, each containing 10 Kg of mixed sand with peat moss (3:1 by volume) washed by acid. Pots were irrigated with fresh water till complete germination and seedling emergence. The pots were divided into seven groups, three pots for each treatment. Seedling per pots left to grow in green house in Biology department of Science Faculty in King Abdulaziz University; water potential near field capacity, then watered with half strength Hog land nutrient solution prior to wastewater irrigation with corresponding levels (25, 50 and 100%). Plants were irrigated at two days intervals. In order to prevent accumulation of salts the soil in each pot was leached every ten days with fresh water. At the end of experiment period (Three months) from imposing wastewater, plants harvested shoots and roots were then dried in aerated oven at 75°C and then dry samples were ground into fine powder for determination of mineral ions (Na, K, Ca, Mg, N, P, Fe, Mn and Mo) concentration using wet digestion method of Humphries [15]. In every case three replications were used and data were statistically analyzed to calculate the mean and standard deviation.

RESULTS AND DISCUSSION

Irrigation Water: Three type for irrigation water were used in this experiment, where suitable water for irrigation must be include nutrients (N, P and K) cations and anions such as HCO, CO_3, SO_4, Cl, Ca, Mg, Na and K also trace elements especially Fe, Mn, Cu, Zn, Cd, Pb, Ni & Co and acidity, alkalinity (PH) in levels permitted with World Health Organization (WHO) [16]. Results of chemical analysis for irrigation water used; untreated & treated wastewater and potable water (UTWW, TWW and PW) were present in Table (1), values for electrical conductivity (Ec) and pH were higher for UWW and TWW where they were lowest for PW, 2.11, 182 & 1.54 ds/m and 7.85 , 7.30 & 7.01 respectively. According to FAO [16] the tolerance limit of Ec &PH of water samples for irrigation should be 1- 4 ds / m and 6.50- 8.40 [17]. The calculated electrical conductivity (Ec) and PH values for UWW, TWW and PW indicated that the salinity and alkalinity for wastewater were stable to use in water irrigation accordingly [16]. Total of N, P and K level in UWW, TWW and PW which are considered essential nutrients for plant growth and soil fertility were found in high concentration. All nutrients and heavy metals concentration in wastewater and potable water were lower the standard values presided for wastewater reuse as irrigation water that the recommended level of 0.01mg/L as presided by FAO [16].

Wastewater Irrigation Impact on Soil pH, Ec, Nutrient and Heavy Metal Content: The results of the present study (Table 2) indicated that application of wastewater significantly had effect on pH and Ec of soil, the pH values for soils irrigated with UWW, TWW and PT were 6.32, 7.39 & 7.10 and Ec were 3.50, 1.58 and 0.40 Ds/m. respectively, means that decreasing in PH and increasing in Ec values by using wastewater, this may be probably due to the high organic matter content of the irrigation wastewater having high N levels that could be cause. This results in agreement with the finding of Liu *et al*. [6], Fahey [18] and Arise *et al*. [19]. Decrease of pH in soil may be due to the decomposition of organic meter producing organic acids in soil irrigated with wastewater and increased Electrical conductivity. For soil irrigated

Table 1: Analysis for irrigation water, untreated, treated wastewater and potable water

	UWW*	TWW*					PW*
Parameters	1	2	3	4	5	6	7
PH	5.4 2	7.88	7.40	7.50	7.35	7.40	7.20
EC	3.40	3.50	3.10	1.40	1.90	1.3 0	1.40
P	0.93	0.64	0.56	0.12	0.05	0.057	0.02
N	0.63	0.37	0.11	0.54	0.56	0.51	0.001
Na	263.65	199.95	200.95	232.45	232.85	239.85	6.60
Mg	2.08	2.61	1.92	1.11	1.15	1.09	0.66
K	4.17	4.76	3.83	3.75	3.47	3.79	0.58
Ca	33.73	15.39	16.75	37.39	33.40	33.48	9.83
Ba	0.016	0.003	0.002	0.015	0.011	0.014	0.001
B	0.63	0.038	0.040	0.059	0.057	0.055	0.003
Al	0.03	0.015	0.0065	0.061	0.57	0.058	0.002
Zn	0.023	0.095	0.038	0.0035	0.005	0.006	0.001
Pb	0.002	0.0035	0.0015	0.002	0.004	0.001	0.00
Ni	0.01	0.029	0.023	0.005	0.005	0.001	0.0005
Mo	0.02	0.15	0.021	0.017	0.017	0.018	0.005
Mn	0.005	0.018	0.0025	0.005	0.005	0.005	0.001
Fe	0.03	0.11	0.042	0.0095	0.011	0.001	0.0015
Cu	0.19	0.084	0.035	0.054	0.017	0.006	0.001
Co	0.0015	0.003	0.001	0.005	0.005	0.005	0.002
Cd	0.002	0.002	0.005	0.003	0.002	0.001	0.0004

*UWW: Un-treated wastewater

TWW: Treated wastewater

PW: Potable water

Table 2: Chemical analysis for soil irrigated with untreated, treated wastewater and potable water

	UWW	TWW					PW
Parameters	1	2	3	4	5	6	7
PH	6.32	7.52	7.50	7.45	7.30	7.20	7.10
EC	3.50	3.00	2.10	1.50	0.90	0.40	0.40
P	11.03	5.63	2.06	0.93	0.24	0.11	0.04
N	0.43	2.93	2.91	0.30	0.83	0.25	0.18
Na	1.82	1.74	1.68	1.33	1.13	1.57	0.05
Mg	7.15	9.49	8.37	8.79	8.63	10.65	6.92
K	3.42	3.78	4.42	3.73	2.80	4.15	1.00
Ca	11.47	13.23	11.72	12.92	12.22	14.90	4.55
Ba	0.03	0.03	0.02	0.02	0.02	0.02	0.01
B	0.12	0.10	0.10	0.10	0.10	0.02	0.01
Al	10.68	15.41	12.64	14.10	14.19	16.42	7.97
Zn	0.04	0.04	0.10	0.10	0.04	0.03	0.02
Pb	0.01	0.01	0.01	0.01	0.01	0.01	0.004
Ni	0.10	0.10	0.10	0.10	0.10	0.10	0.001
Mo	0.02	0.02	0.01	0.02	0.02	0.02	0.003
Mn	0.40	0.39	0.31	0.39	0.38	0.40	0.10
Fe	17.24	21.55	17.79	18.93	18.98	22.09	10.74
Cu	0.05	0.05	0.05	0.05	0.05	0.05	0.01
Co	0.01	0.01	0.01	0.01	0.01	0.02	0.001
Cd	0.001	0.001	0.003	0.003	0.002	0.002	0.003

with UWW and TWW compared with PW may be to the same reason. It is observed from the results that all elements especially P, Na, Ca Al and Fe were highly significantly increased in UWW and TWW soils compared to control PW. This is may be due to the content of each water. Treatment with UWW and TWW increased concentration of all heavy metals in soils highly significantly compared to control PW. Soil fertility increased with irrigation by wastewater [5]. Also similar results were showed by Bedbabis *et al.* [4] where they noticed that irrigation with treated wastewater increased soil pH, Ec, OM, N, P, K, Na, Cl, Mg salts and heavy elements such as Mn , Zn and Fe contents compared with potable water [19, 20].

Table 3: Effect of wastewater irrigation on nutrient and heavy metals content in *Moring olefra* plant tissues(meg/g dw)

	UWW		TWW										PW	
	1		2		3		4		5		6		7	
Parameters	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
N	0.72±0.34	0.39±0.16	0.42±0.32	0.33±0.74	0.69±0.26	0.24±0.18	1.07±0.54	0.37±0.26	0.26±0.01	0.29±0.19	0.46±0.37	0.29±0.20	0.10±0.05	0.12±0.04
P	0.59±0.29	1.68±1.14	0.27±0.17	1.64±1.12	0.36±0.18	1.42±1.10	0.42±0.27	0.89±0.79	0.46±0.26	1.14±0.76	0.46±0.24	0.63±0.24	0.17±0.54	0.35±0.10
K	29.39±4.69	19.45±5.05	25.84±1.73	15.62±5.32	30.59±2.95	20.99±2.63	28.27±3.68	28.30±5.58	23.24±5.56	32.13±8.13	32.13±8.13	21.83±6.08	13.14±8.13	11.34±5.24
Ca	13.92±1.89	9.64±2.44	13.81±2.51	9.28±2.46	13.60±2.51	10.52±1.08	11.27±1.02	12.56±1.41	12.06±1.41	10.58±1.98	11.99±2.49	10.54±2.05	4.89±2.12	4.12±2.78
Mg	3.61±0.47	3.46±1.02	3.26±0.18	2.89±0.67	3.23±0.49	3.46±0.26	3.03±0.37	3.85±0.51	2.91±0.50	3.57±0.44	3.57±0.81	3.35±0.73	2.0±1.00	1.00±0.02
Na	8.19±1.58	7.12±2.54	4.86±0.47	5.30±1.04	5.67±0.79	6.02±1.74	5.14±0.76	6.75±1.50	6.68±1.43	7.22±1.79	7.36±1.74	7.08±1.96	2.78±1.76	4.04±2.33
Mn	0.03±0.01	0.04±0.02	0.03±0.02	0.04±0.02	0.02±0.05	0.03±0.01	0.02±0.01	0.04±0.01	0.02±0.01	0.04±0.02	0.03±0.02	0.03±0.02	0.01±0.004	0.02±0.01
Fe	0.97±0.10	1.97±1.16	0.72±0.13	1.07±0.36	0.61±0.14	1.23±0.19	0.61±0.13	1.43±0.45	0.64±0.16	1.37±0.59	0.86±0.55	1.26±0.61	0.44±0.29	0.06±0.04
Cu	0.02±0.001	0.02±0.005	0.02±0.003	0.02±0.003	0.02±0.005	0.02±0.003	0.02±0.01	0.02±0.01	0.02±0.004	0.02±0.004	0.01±0.002	0.02±0.003	0.04±0.004	0.01±0.03
Zn	0.13±0.01	0.02±0.01	0.11±0.01	0.03±0.01	0.07±0.01	0.03±0.01	0.03±0.02	0.03±0.01	0.07±0.02	0.03±0.02	0.04±0.01	0.02±0.01	0.02±0.01	0.01±0.03
Cd	0.01±0.001	0.001±0.001	0.01±0.001	0.00	0.002±0.001	0.002±0.001	0.01±0.001	0.002±0.001	0.002±0.001	0.003±0.001	0.001±0.001	0.003±0.001	0.004±0.002	0.001±0.001
Pb	0.005±0.002	0.003±0.001	0.01±0.002	0.003±0.001	0.01±0.002	0.002±0.001	0.003±0.001	0.01±0.003	0.002±0.001	0.01±0.002	0.002±0.001	0.003±0.001	0.003±0.001	0.001±0.004

Table 4: Effect of wastewater irrigation on heavy metals accumulation ratio in *Moring oleifera* tissues.

	UWW	TWW						
Parameters	1	2	3	4	5	6	MTWW	PW
Zn	810	431	257	317	289	277	314.20	200
Pb	68	220	407	181	293	176	255.40	300
Ni	53	79	131	70	109	101	98.00	133
Mo	659	283	222	128	73	211	183.40	133
Mn	75	75	59	57	60	94	69.00	50
Fe	51	70	51	44	51	71	57.40	73
Cu	67	86	92	69	110	78	87.00	40
Co	43	59	66	39	36	53	50.60	30
Cd	200	0.0	100	283	300	33	143.20	400
Ba	112	106	86	63	75	70	80.00	100
B	163	147	96	289	186	151	173.80	300
Al	58	38	55	38	43	49	44.60	44

MTWW= Mean treated wastewater.

Table 5: Bioaccumulation factors for heavy metals in *Moring oleifera* plant (concentration foe element in shoots /concentration of some elements in soil and heavy metals content in soil

	UWW	TWW						
Parameters	1	2	3	4	5	6	MTWW	PW
Zn	350	329	127	205	200	145	201.2	100
Pb	177	100	173	77	100	80	110.0	75
Ni	85	113	76	67	80	50	81.2	40
Mo	22	5	8	5	4	5	5.4	13
Mn	9	7	7	6	5	7	6.4	10
Fe	6	3	3	3	4	4	3.4	0.4
Cu	38	44	30	30	48	26	35.6	40
Co	10	12	10	8	8	6	8.8	30
Cd	800	467	107	68	128	27	159.4	123
Ba	38	35	37	35	40	29	35.2	30
B	231	387	150	34	222	500	258.6	300
Al	7	3	3	2	3	2	2	2

Impact of Wastewater on Mineral Content of Plant Tissues: Wastewater irrigation affected N, P, K, Ca, Mg, Na and heavy metals in tissues of *Moring oleifera* plant (Table 3). The results showed highly significant increase in the concentration of N, P, K, Ca, Mg and Na in plant tissues grown with treatments with UWW and TWW compared to PW water. This is due to the high concentration of these elements in UWW & TWW while

PW water contained low concentration of total N, P and K. A highly significant increase in Ca, Mg and Na concentration in UWW and TWW treatments as compared to the irrigated plant tissues with PW water was observed. The concentration of macro nutrients increased with increasing wastewater and was in this order UWW, TWW and PW in tissues of *Moring oleifera*. This result is consistent with the study conducted by Bedbabis *et al*. [4] and Alghobar and Suresha [5] where their studies showed that irrigation with wastewater raises soil salinity, organic carbon, N, K, Ca, & Mg and also increased the macro elements N, P, K continents in corn and rice crops tissues. This increase could be related to the amount of sufficient nutrients present in wastewater [21].

The heavy metals concentrations in *Moringa oleifera* tissues plant irrigated with wastewater; unwastewater, treated wastewater and potable water were shown in Table (3). The results showed increase in all heavy metals (Mn, Fe, Cu, Zn, Cd and Pb) content in *Moringa oleifera* tissues irrigated with UWW and TWW as compared to PW. The limit values of heavy metals were (50, 00, 300, 200, 0.6, 100 mg/g) respectively.

CONCLUSION

Irrigation soil planted by *Moringa olifra* using untreated wastewater leaded to decreasing soil pH but increase soil electrical conductivity, nutrients and heavy metal. Also increase bio adsorption ratio for *Moringa olifera* where treated wastewater gave results similar to normal water results. This means treated wastewater can be used in agriculture for human food.

REFERENCES

1. Gopalakrishnan, L., K. Doriya and D.S. Kumar, 2016. Moringa oleifera: A review on nutritive importance and its medicinal application. Food Science and Human Wellness, 5(2): 49-56.
2. 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. Environment International. 75:117-35.
3. Oyeyinka, A.T. and S.A. Oyeyinka, 2016. Moringa oleifera as a food fortificant: Recent trends and prospects. Journal of the Saudi Society of Agricultural Sciences. In press.
4. Bedbabis, S., D. Trigui, C. Ahmed and B. Rouina, 2015. Long-terms effects of irrigation with treated municipal wastewater on soil, yield and olive oil quality. Agricultural Water Management, 160: 14-21.
5. Alghobar, M.A. and S. Suresha, 2016. Growth and yield of tomato, Napier grass and sugarcane crops as influenced by wastewater irrigation in Mysore, Karnataka, India. World Research Journal of Agricultural Science, 3: 069-079.
6. Liu, W.H. and A. Soderlund, 2005. Impacts of sewage irrigation on heavy metals distribution and contamination in Beijing China. Research Center for Ecology and Environment Sciences, 31: 109-120.
7. Santos, T.R., M.F. Silva, L. Nishi, A.M. Vieira, M.R. Klein, M.B. Andrade, M.F. Vieira and R. Bergamasco, 2016. Development of a magnetic coagulant based on Moringa oleifera seed extract for water treatment. Environmental Science and Pollution Research, 23(8): 7692-7700.
8. Lu, S., J. Wang and L. Pei, 2016. Study on the Effects of Irrigation with Reclaimed Water on the Content and Distribution of Heavy Metals in Soil. International Journal of Environmental Research and Public Health, 13: 298-320.
9. Kurth, E., G.R. Cramer, A. Lauchli and E. Epstein, 1986. Effects of NaCl and $CaCl_2$ on cell enlargement and cell production in cotton roots. Plant Physiology, 82: 102-1106.
10. Ravikumar, K. and A.K. Sheeja, 2013. Heavy metal removal from water using Moringa oleifera seed coagulant and double filtration. Int. J. Sci. Eng., 4: 10-13.
11. Chinma, C., J. Abu and S. Akoma, 2014. Effect of germinated tigernut and moringa flour blends on the quality of wheat-based bread. Food Process. Preserv, 38: 721-727.
12. Li, B., F. Zhou, K. Huang, Y. Wang, S. Mei Y. Zhou and T. Jing, 2016. Highly efficient removal of lead and cadmium during wastewater irrigation using a polyethyl eniminegrafted gelatin sponge. Scientific Reports, 6: 33573-10.1038.
13. Asante, W.J., I.L. Nasare, T.D. Dery, K.O. Boadu and K.B. Kentil, 2014. Nutrient composition of Moringa oleifera leaves from two agro ecological zones in Ghana. African J. Plant, 8: 65-71.
14. Suhartini, S., N. Hidayat and E. Rosaliana, 2015. Influence of powdered Moringa oleifera seeds and natural filter media on the characteristics of tapioca starch wastewater. International Journal of Recycling of Organic Waste in Agriculture, 2: 1-12.

15. Humphries, E.C., 1956. Mineral components and ash Analysis in modern methods of plant analysis. Spring a Verlag. Berlien, 1: 468-502.
16. Guan, Q., L. Wang, B. Pan, W. Guan, X. Sun and A. Cai, 2016. Distribution features and controls of heavy metalsin surface sediments from the riverbed of the Ningxia-Inner Mongolian reaches, Yellow River, China. Chemosphere, 144: 29-42.
17. Rattan, R.K., S.P. Datta, P.K. Chhonkar, K. Suribabu and A.K. Singh, 2005. Long term impact of irrigation with sewage effluents on heavy metals content in soil, crop and groundwater A case study. Agriculture, Ecosystems and Enviromental Journal, 34: 310-322.
18. Fahey, J.W., 2005. Moringa oleifera: a review of the medical evidence for its nutritional, therapeutic and prophylactic properties. Trees Life J., 1: 1-15.
19. Arise, A.K., R.O. Arise, M.O. Sanusi, O.T. Esan and S.A. Oyeyinka, 2014. Effect of Moringa oleifera flower fortification on the nutritional quality and sensoryproperties of weaning food. Croat. J. Food Sci. Technol., 6: 65-71.
20. Dania, S.O., P. Akpansubi and O.O. Eghagara, 2014. Comparative Effects of different fertilizer sources on the growth and nutrient content of moringa (Moringaoleifera) seedling in a greenhouse trial. Advances in Agriculture, 5: 67-72.
21. Kalappurayil, T.M., B.P. Kumthadathil and J.J. Pharmacogn, 2017. A review of pharmacognostical studies on Moringa oleifera Lam. flowers. Pharmacognosy Journal, 9(1): 1-7.