مجلة جامعة بني وليد للعلوم الإنسانية والتطبيقية
تصدر عن جامعة بني وليد – ليبيا
Website: https://jhas-bwu.com/index.php/bwjhas/index
المجلد التاسع، العدد الأول 2024

التأثير طويل المدى للري بمياه الصرف الصحي المعالجة على بعض خصائص التربة

د. خيرية أحمد بن فرج
قسم التربة والمياه، كلية الزراعة ، جامعة طرابلس، طرابلس، ليبيا.
bkhereya@hotmail.com

Long term effect of treated wastewater irrigation on Some soil properties

Khereya A Ben Farag
Department of Soil and Water, Faculty of Agriculture, University of Tripoli, Tripoli, Libya.

تاريخ الاستلام:26-02-2024 تاريخ القبول: 18-03-2024 تاريخ النشر : 27-03-2024

الملخص:

استهدفت هذه الدراسة تقييم أثر استخدام مياه الصرف الصحي المعالجة ثانويا لغرض ري محصول البرسيم ومحصول الشعير وذلك بالموسم الزراعي الخريفي على بعض خصائص الترب الطمئية الرملية بمشروع الهضبة الخضراء الزراعي الواقع جنوب مدينة طرابلس ـ ليبيا. وتبين بأن عينات الترب المروية لم تتميز بمستويات تركيز عالية من كاتيونات الصوديوم القابلة للتبادل والتي وجدت بانها تمثل اقل تركيزا من الكاتيونات الأخرى القابلة للتبادل وقد بدء استغلال تلك المياه لأغراض الري بالمشروع منذ سنة 1970م وحتى تاريخ نشر هده الورقة.

الكلمات الدالة: الري التكميلي، السعة التبادلية الكاتيونية ، الكاتيونات القابلة للتبادل، مياه الصرف الصحي المعالجة ثانويا، نسبة الصوديوم المتبادل.

Abstract

This study aimed to evaluate the impact of using secondary treated wastewater for the purpose of irrigating alfalfa and barley crops during the fall agricultural season on some characteristics of the sandy loam soil in the AL-Hadba EL-Khadra agricultural project located south of the city of Tripoli-Libya. It was found that the irrigated soil samples were not characterized by high concentration levels of exchangeable sodium cations, which were found to be less concentrated than other exchangeable cations, the exploitation of this water for irrigation purposes in the project began in 1970 until the date of publication of this paper.

Keywords: Cation exchange capacity, Exchangeable cations, Exchangeable sodium percent, Secondary treated wastewater, Supplementary irrigation.

1-INTRODUCTION:

The use of wastewater for irrigation purposes is associated with health and environmental risks. This practice is largely unregulated in low income countries (Scot *et al*., 2004). There are several other studies on treated wastewater use in irrigation (Blumenthal *et al*., 2000; Qadir *et al.,* 2010; Kalavrouziotis *et al*., 2015). (Robert S Ayers, 1977) Highly recommended to take into account the degree of salinity, soil permeability and toxicity as criteria for the suitability of water for irrigation purposes.

Evaluating the suitability of water for irrigation is one of the important considerations, so the rate of sodium absorption (SAR) of soil water which provides a reliable estimate of the exchangeable sodium percent (ESP) in soils must be taken into account. Richards (1954) used SAR in place of ESP for diagnosing sodicity problems.

Ran Erel *et al*., (2019) reported that the irrigation of olive (Olea europaea L.) with reclaimed wastewater over eight years, it led to increase ESP of irrigated soil. As a result, negative effects occurred on irrigated soil properties.

Aim of this study is to evaluate the impact AL of the use of secondary treated wastewater for irrigation purposes at -Hadba EL-Khadra agricultural project, Tripoli – Libya on irrigated soil properties.

2-MATERIALS AND METHODS

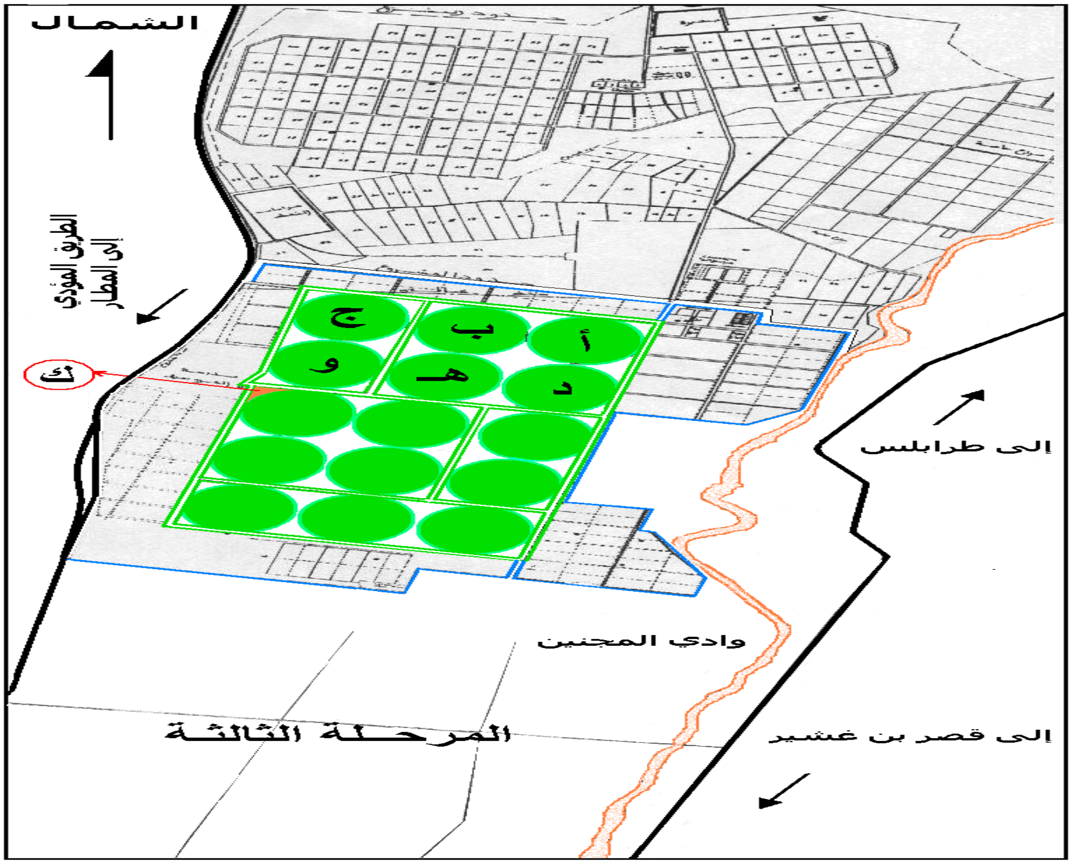
2.1- Study area

This study was conducted on soil samples from AL-Hadba EL-Khadra Agricultural Project, Tripoli – Libya which is located under wastewater irrigation (Map 1). The study area has a Mediterranean climate and the average annual rainfall is 430 mm.

2.2. Soil and water samples

Soil samples were collected from three plots, the first plot (Field 1) was cultivated with alfalfa (Medicago sativa L.) Under permanent irrigation, the second plot (field 2) was cultivated with barely (Hordeium vulgare L.) under supplementary irrigation, and the third plot (field 3) was a fallow and was used as a control. Soil samples from each plot were collected from 0 – 20, 20 – 40, 40 – 60 and 60 – 80 cm depths. Moreover, 5 wastewater samples that used for irrigation were taken to the laboratory for analysis.

Some of the soil chemical properties were measured using standard methods. Exchangeable cations were determined using ammonium acetate extract method while cation exchange capacity using ammonium acetate and sodium acetate extract method (Bower *et al*., 1952, Page *et al*., 1982). In addition, some chemical properties for secondary treated wastewater (irrigation water) were measured too. Moreover, SAR of irrigation water samples and ESP of irrigated soil samples were calculated according to the following equations.



Map (1)- Shows a drawing of the AL-Hadba EL-Khadra agricultural project, including Study fields (A) and (E) with control field (K)

SAR = $\dfrac{Na}{\sqrt{\dfrac{Ca+mg}{2}}}$ where all concentrations are in mill equivalent /l

ESP = $\dfrac{Ex-Na}{CEC}\times 100$ where all concentrations are in mill equivalent / 100 g dry soil.

2.3. Statistical analysis

The results obtained from this study were analyzed statistically using the statistical program (Minitab14). A one-way analysis of variance at a significance level of 0.05. was conducted to evaluate the differences in some characteristics between fields and between different depths (Mead *et al.*, 2003).

3. RESULTS AND DISCUSSION

3.1. Irrigation water properties

From the data presented in table 1 it is clear that irrigation water (wastewater) was nearly neutral in reaction with average pH values of 7.28. In addition, it was classified as C3 – S1 as it has high salinity and low sodium hazard (Richards, 1954).

3.2- Irrigated soil properties.

This study, indicated that the irrigation with wastewater of Electronic conductivity 2.250 dS m^{-1}, TDS 1440 ppm and sodium adsorption ratio of irrigation water (SAR_{iw}) 2.77 $mmol_c^{-1}$ (Table 1) resulted in a significant increase ($p<0.05$) in SAR of soil water ($SAR_{s.w}$) under permanent irrigation (Field 1) compared with $SAR_{s.w}$ under supplementary irrigation (Field 2) and $SAR_{s.w}$ which is not irrigated (Field 3). However, the difference in sodium adsorption ratio of soil water between soils in field 2 and soils in field 3 statistically was not significant.

Table-1- Properties of irrigation water, average values of irrigation water analysis (n=5)

Mean concentration*	parameters	Number
7.284	pH	1
2.250	EC (dS m^{-1})	2
1440	TDS ppm	3
19	Ca^{++} meq/l	4
35.11	Mg^{++} meq/l	5
14.4	Na^{+1} meq/l	6
Nil	CO_3^{-2} ppm	7
256	HCO_3^{-1} ppm	8
443	Cl^{-1} ppm	9
172	SO_4^{-2} ppm	10
2.77	Sodium Adsorbed Rate SAR_{iw} ($mmol_c\ l^{-1}$)	11

(Indira Paudel *et al.* (2018)) reported that the changing in irrigation water quality from treated wastewater to fresh water improved irrigated soil properties and aggregate stability of the soil.

SAR of the soil solution was increased in the wastewater irrigated treatments resulting in a significant ($p<0.05$) increase in ESP which is reaching nearly double that of the control treatment (mean 22.05 % for field No 1, 16.18 % for field No 2) versus mean 7.73 % for field No 3 which is not irrigated (Table 4). Other researchers, Ran Erel *et al.* (2019) were observed similar results.

The average cation exchange capacity for soils irrigated and not irrigated with wastewater were relatively low (7.40, 7.74 and 7.36 meq/100g dry soil) for permanent, supplementary wastewater irrigated soils and for not irrigated soils respectively

The average cation exchange capacity (CEC) of the irrigated and not irrigated soils under study were relatively low (7.40, 7.74 and 7.36 meq/100g dry soil) for permanent, supplementary wastewater irrigated soils and for not irrigated soils respectively. These low CEC values could be attributed to the low organic matter and clay content of the irrigated and not irrigated soils (Table 4). In contrast, several researchers stated that long term wastewater irrigation rises organic matter content and CEC of irrigated soils (Sánchez–González *et al.*, 2017; Ganjegunte *et al.*, 2018).

3. 3- Exchangeable cations

About 15.13 % of the exchangeable cations on the exchange sites of the soil in field (1) accounted for exchangeable calcium, for field (2) was 14.21 % and 5.29 % for field (3) which is not irrigated. The increase in exchangeable calcium under wastewater irrigation treatments (permanent and supplementary irrigation) statistically were significant ($p<0.05$).

In addition, the increase in exchangeable calcium under wastewater irrigation treatment might be due to a high concentration of soluble calcium in irrigation water. (Kiziloglu *et al.* 2008) reported that the irrigation of cauliflower and red cabbage plants grown with primary treated wastewater treatment leads to an increase in soil salinity, organic matter, exchangeable Na^+, K^+, Ca^{++}, Mg^{++}, of irrigated soil. A significant decrease in soil solution electrical conductivity, Na^+ and Cl^- concentration, sodium adsorption ratio (SAR), exchangeable sodium percentage were found after change of irrigation water quality from treated wastewater to fresh water (Indira Paudel *et al.* 2018).

Exchangeable potassium accounted for 17.9 % of exchangeable cation on the exchange sites of the permanent wastewater irrigated soil (Field 1), 22.1%, of the supplementary wastewater irrigated soil (Field 2) and 25.13 on the exchange sites of not irrigated soil (Field 3), which used as a control. However, statistically, there were no significant differences in exchangeable potassium concentration between fields and between different layers within the same field. These results might be due to the mineral composition of the project's soil.

Table-2- Mean concentration values of exchangeable cations for soil samples in the three fields on the depths level.

Exchangeable cations (meq / 100g dry soil)				depth (cm)	Field – No
Mg^{++}	Ca^{++}	K^+	Na^+		
1.18 (a)	0.98 (a)	1.37 (a)	0.737 (a)	20-0	Alfalfa (1)
1.39 (a b)	1.04 (a b)	1.27 (a b)	0.62 (a b)	20-40	
1.55 (a b c)	1.12 (a b c)	1.40 (a b c d)	0.67 (a b c)	40-60	
1.58 (a b c d)	1.34 (a b c)	1.28 (a b c d)	0.74 (a b c d)	60- 80	

1.74 (a b c d)	1.48 (a b c)	1.66 (a b c d)	1.23 (a b c d)	20-0	barley (2)
1.38 (a b c d)	1.13 (a b c)	1.51 (a b c d)	0.92 (a b c d)	20- 40	
1.25 (a b c d)	0.93 (a b c)	1.66 (a b c d)	0.79 (a b c d)	40- 60	
1.06 (a b c d)	0.86 (a b c)	1.74 (a b c d)	0.81 (a b c d)	60- 80	
1.97 (a b c)	0.48 (a b c)	1.88 (a b c d)	0.75 (a b c d)	20-0	control (3)
0.54 (a b)	0.29 (a b)	1.91 (a b c d)	0.58 (a b c d)	20-40	
0.53 (a b)	0.33 (a b)	1.68 (a b c d)	0.51 (a b c d)	40- 60	
0.55 (a b)	0.39 (c)	1.96 (a b c d)	0.58 (a b c d)	60- 80	

Table-3- Mean concentration values of exchangeable cations for soil samples at the level of the three fields

* Exchangeable cations (meq / 100 g)				Field- No
Mg^{2+}	Ca^{2+}	K^{+}	Na^{+}	
1.43 (a)	1.12 (a)	1.33 (a)	0.69 (a)	Alfalfa (1)
1.15 (a)	1.10 (a)	1.64 (a)	0.94 (a)	Barley (2)
0.89	0.39	1.86 (a)	0.61 (a)	Control (3)

*- Means in the same column and that have the same letter after them are not significantly different at ($p<0.05$).

3.4 - Exchangeable Sodium Percent (ESP)

The Exchangeable Sodium Percent on the soil exchange sites of field No (1) under permanent irrigation and field No (2) under supplementary irrigation were significantly increased by the average of 22.05, 16.18 % respectively compared with ESP on the soil exchange sites of field No (3) which is a control by the average 7.73 % (Table 4). The highly increased in ESP under permanent and supplementary irrigation might be attributed to the high sodium content in irrigation water. Many workers elsewhere have reported that the sodicity has been shown to increase as the SAR of irrigation water increase (Paliwal and Grandhi. 1976, Al-Jaloud *et al.*, 1993). Through the results obtained from the current study, it is clear that the use of this type of wastewater for irrigation purposes since 1970 to irrigate alfalfa (Medicago sativa L.) and barely (Hordeium vulgare L.) has not had any negative effects that prevent its use.

Table-4 - Mean concentration values of SAR, ESP and CEC for soil samples on the level of the three fields

SAR ($mmol_c\, l^{-1}$)	ESP (%)	CEC *Meq/100g*)(	depth (cm)	Crop & Field number
5.59 (a)	16.99 (a)	7.88 (a)	20-0	alfalfa (1)
4.82 (a)	18.12 (a b c d)	7.39 (b)	20-40	
4.37 (a b)	24.65 (a b c d)	7.21 (a b c)	40-60	
3.59 (a b c)	28.45 (a b c d)	7.11 (a b c d)	60- 80	
2.77 (b c d)	25.28 (a b c d)	7.98 (a b c d)	20-0	barley (2)
3.02 (b c d)	16.32 (a b c d)	7.49 (a b c d)	20- 40	
2.94 (c d)	11.33 (a b c d)	7.72 (a b c d)	40- 60	
2.87 (c d)	11.79 (a b c d)	7.78 (a b c d)	60- 80	
2.37 (c d)	8.83 (a b c d)	6.61 (b c d)	20-0	control (3)
1.95 (c d)	7.89 (a b c d)	7.61 (a b c d)	20-40	
1.73 (c d)	6.85 (a b c d)	7.57 (a b c d)	40- 60	
2.00 (c d)	7.35 (a b c d)	7.66 (a b c d)	60- 80	

* ESP (%)	CEC (meq/100g)	Crop & Field number
22.05 (a)	7.40 (a)	alfalfa 1
16.18 (a)	7.74 (a)	barley 2
7.73	7.36 (a)	control 3

* - Means in the same column and that have the same letter after them are not significantly different at ($p<0.05$).

4- CONCLUSION

From this study we can conclude that the exploitation of secondary treated wastewater for irrigation purposes for more than 50 years in AL-Hadba EL-Khadra Agricultural Project, Tripoli – Libya did not have negative effects on the characteristics of the irrigated soil that would prevent it from being exploited.

5- REFERENCE

1- Al-Jaloud, A. A., Hussain, G., Al-Saati, A. J. & Sheikh, K. (1993). "Effect of wastewater on Plant Growth and Soil Properties", Arid Soil Research and Rehabilitation 7, 173 – 179.

2- Blumenthal, U.J., Mara,D D., Peasey, A., Palacios ,G.R., Stott,R. 2000. Guidelines for the Microbiological Quality of Treated Wastewater in Agriculture: Recommendations for Revising WHO Guidelines; Bulletin of the World Health Organization, pp. 78-98.

3- Bower, C.A., Reitemeier, R.F. & Fireman, M. 1952. Exchangeable cation analysis of saline and alkali soils. Soil Science 73, 251-261.

4- FAO. 1994. Water Quality for Agriculture. FAO Irrigation and Drainage Paper 29. Revision, Rome, Italy, p. 174.

5- Ganjegunte, G., Ulery, A., Niu, G., Wu, Y. 2018. Organic carbon, nutrient and salt dynamics in saline soil and switchgrass (Panicum virgatum L.) irrigated with treated municipal wastewater. Land Degrad ,Dev. 29 (1), 80–90.

6- Indira Paudel, Asher., Bar-Tal. Guy, J. Levv., Nativ Rotbarl. 2018.. Treated wastewater irrigation: Soil variables and grapefruit tree performance. Agricultural Water Management 204, 126–137.

7- Kalavrouziotis, I.K., Kokkinos, P., Oron, G., Fatone, F., Bolzonella, D., Vatyliotou, M., Varnavas, S.P. 2015. Current status in wastewater treatment, reuse and research in some Mediterranean countries. Desalin. Water Treat 53, 2015–2030.

8- Kiziloglu, F.M., Turan, M., Sabin, U., Kuslu,V. 2008. Effects of untreated and treated wastewater irrigation on some chemical properties of cauliflower (Brassica olerecea L. Var. botrytis). And red cabbage (Brassica olerecea L. Var. rubra) grown on calcareous soil in Turkey. Agricultural Water Management 95, (6) 716-724.

9- Mead, R.N., Curnow, R.N. & Hasted, A.M. 2003. Statistical Methods in Agricultural and Experimental Biology. 3rd Edition. Chapman and Hall/ CRC Press.

10- Page, A.L., Miller, R.H., Keeney, D.R. 1982. Methods of soil analysis, part 2. Chemical and microbiological properties. Amer. Soc. of Agron, Madison, Wisconsin, USA.

11- Paliwal, K.V. & Gandhi, A.P. 1976. Effect of Salinity, SAR, Ca: Mg ratio in irrigation water and soil texture on the predictability of exchangeable sodium percentage. Soil Science 122, 85-90.

12- Qadir, M., Wichelns, D., Sally, LR., McCornick, PG., Drechsel, P., Bahri. A., Minhas, P.S. 2010. The Challenges of Wastewater Irrigation in Developing Countries. Agric. Water Manage 97(4) 561-568.

13- Ran Erel., Amir Eppel., Uri Yermiyahu., Uri Yermiyahu. 2019. Long term irrigation with reclaimed wastewater. Implications on nutrient management, soil chemistry and olive (Olea europaea L.) Performance. Agricultural Water Management 213, 324 – 335.

14- Richards, L.A. 1954. Diagnosis and Improvement of Saline and Alkali Soils. Agriculture Handbook No.60. USDA.

15- Robert. S., Ayers. 1977. Quality of Water for Irrigation. Journal of the Irrigation and Drainage Division 103, 135-154.

16- Sánchez-González, A., Chapela-Lara, M., Germán-Venegas, E., Fuentes-García, R., del Río-Portilla, F., Siebe, C. 2017. Changes in quality and quantity of soil organic matter stocks resulting from wastewater irrigation in formerly forested land. Geoderma 306, 99–107.

17- Scot,C.A., Faruquie, N.I., Reschid-Sally,.L. 2004. Wastewater Use in Irrigated Agriculture: Management Challenges in developing countries. Waste Water Use in Irrigated Agriculture: Confronting The Livelihood and Enviromental Realities. Edited by C.A.Scott, N.I.Faruquie. and L. Reschid- Sally.

18- U. S. Salinity Laboratory Staff. 1954. In Diagnosis and Improvement of Saline and Alkali Soils. L.A. Richards (ed). Agriculture Handbook, No. 60, USDA, Washington, D.C.