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 الثالث الصفحات (276-285) 2024م

تأثير الري بمياه الصرف الصحي المعالجة على التوصيل الهيدروليكي

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

Effect of irrigation with treated wastewater on soil hydraulic conductivity

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

تاريخ الاستلام:25-07-2024 تاريخ القبول: 13-08-2024 تاريخ النشر: 04-09-2024

الملخص:
إن الهدف الرئيسي من هذه الدراسة هو دراسة آثار الري طويل المدى بمياه الصرف الصحي المعالجة على التوصيل الهيدروليكي للترب المروية في مشروع الهضبة الخضراء الزراعي، طرابلس – ليبيا والتي ظلت تحت تأثير الري بمياه الصرف الصحي منذ سنة 1970 وقد ابرزت هذه الدراسة أن قيم التوصيل الهيدروليكي تتراوح بين "معتدل" و"سريع إلى حد ما" وهي مستويات نموذجية للتربة قيد الدراسة ذات قوام التربة الرملية والطينية الرملية.
الكلمات الدالة: مياه الصرف الصحي المعالجة، التوصيل الهيدروليكي، معتدل، سريعا إلى حد ما.

Abstract
The main objective of this study is to know the effect of long-term irrigation with treated wastewater (TWW) in hydraulic conductivity of irrigated soils of AL-Hadba EL-Khadra agricultural project, Tripoli – Libya., which has been under the influence of irrigation with wastewater since 1970. This study highlighted that the hydraulic conductivity values Ranging between “moderate” and “moderately rapid which are typical levels for soils under study which have sandy and sandy loam soil texture.
Keywords: treated wastewater (TWW), hydraulic conductivity, moderate, moderately rapid .

INTRODUCTION

The shortage of water and the deterioration of its availability are considered among the biggest challenges facing humans in arid and semi-arid areas in general in order to achieve reliable irrigated agriculture. Due to the geographical location of Libya, the lack of diversity of water sources in it, which is represented by groundwater and a specific number of springs, and the low amounts of rain and their fluctuation from year to year, this makes the expansion of establishing agricultural projects under a sustainable. irrigation system difficult.

Many researchers have studied the effect of wastewater irrigation on irrigated soil properties (Bole et al., 1981; Al-Jaloud et al., 1993, Biwa et al.,1993, sidanlyu et al., 2022 and Friedel et al., 2000). These studies have shown that wastewater irrigation has resulted in both negative and positive effects. Among the soil physical properties that play a role in distinguishing the soil and raising plant growth rates is the hydraulic conductivity (HC), as it affects aeration and water relations with the soil, and thus the extent of the plant's ability to obtain the necessary nutritional elements. It also affects the movement of salts. Salts and nutrients in RW exhibited minor negative effects on the soil-crop systems Sidan Lyu et al. 2022.

Among the soil physical properties that play a role in distinguishing the soil and raising plant growth rates is the hydraulic conductivity (HC), as it affects aeration and water relations with the soil, and thus the extent of the plant's ability to obtain the necessary nutritional elements. It also affects the movement of salts. Jianye Ma et al (2024) concluded that The influence of roots on saturated hydraulic conductivity and Saturated water content was mainly achieved by affecting soil organic matter, not by directly affecting saturated hydraulic conductivity and soil saturated water content and the root density is closely related to saturated hydraulic conductivity (Zhu et al., 2022) and saturated water content (Song et al., 2022). Therefore, the effects of fibrous roots and tap roots on Ks and SW were different, under similar soil properties.

In addition, the hydraulic conductivity of a soil is a measure of its ability to transmit water (Klute & Dirksen, 1986). Jingru et al (2024) reported that measured hydraulic conductivity of hydrophilic porous media was independent of the column outlet condition. However, the measured hydraulic conductivity of hydrophobic porous media was dependent on the column outlet condition.

In a study conducted in Brazil to estimate the hydraulic conductivity of soil under a wastewater irrigation system, the researcher (Robert et al., 2007) concluded that areas irrigated with wastewater showed a decrease in hydraulic conductivity compared to area not irrigated with wastewater (control area) as a result of high Sodium content in irrigation water. It was found that the decrease in hydraulic conductivity was more pronounced in the subsurface layer of soil.

Abu Sharer et al., 1987 also found that the decrease in the hydraulic conductivity of a number of soils in the state of California, USA, when adding water with different concentrations of salts and sodium is due to the collapse of the soil building blocks, which causes a decrease in the size and number of large pores. In addition, the researchers (Kanwar and Ram 1969) also explained that increasing monovalent cations in the soil over divalent cations works to reduce hydraulic conductivity, and increasing potassium also works to reduce the percentage of absorbed sodium ions. Wen zhao et al. (2023) concluded that the average value of soil saturated hydraulic conductivity (Ks) followed the decreasing order of grassland > farmland > forestland. The Ks of grassland decreased gradually with increasing soil depth. The Ks of farmland increased initially and then decreased.

Many researchers have also found that irrigation with treated wastewater has led to a decrease in hydraulic conductivity in clay soil due to clogging of the pores with suspended solids (Load and Ben-Hur, 2010, Bardhan et al., 2016 Taiwo Adeyemo. et al., 2022. Lin Wang et al (2024) reported that irrigation with treated wastewater significantly increases soil salinity and sodicity which leads to a noteworthy increase in soil organic carbon and improves aggregate stability. Nevertheless, the accumulation of organic materials in the soil negatively impacts its permeability and reduces saturated hydraulic conductivity. While, secondary treated wastewater irrigation has less impact on soil structure, probably due to a lower contribution of soil organic carbon from the treated wastewater, resulting in fewer changes in aggregate stability.

The main objective of this study is to evaluate the effect of irrigation with secondary treated wastewater on the soil hydraulic conductivity at the AL-Hadba EL-Khadra agricultural project, Tripoli – Libya.

MATERIALS AND METHOD

Soil samples were collected during the fall agricultural season from three fields in the AL-Hadba EL-Khadra agricultural project) in Tripoli, Libya (Figure 1) at depths of (0-20, 20-40 cm). where Field No 1.was used to grow alfalfa under a permanent irrigation system with treated wastewater, Field No. 2 was cultivated to grow barley under a supplementary irrigation system, while Field No. 3 was not irrigated with waste wastewater and It was taken as a control. All samples under study were analyzed in the laboratories of the Agricultural Research Center / Western Region Branch. The saturated hydraulic conductivity of the soil samples was measured using the constant head method as described by Klute and Dirksen (1986).

Data analysis: -

The results obtained from this study were analyzed using the Statistical Program Minitab14 and a 1-way analysis of variance was carried out to evaluate the differences in soil hydraulic conductivity between fields and between different depths under study were identified (Ryan and Joiner, 2001).

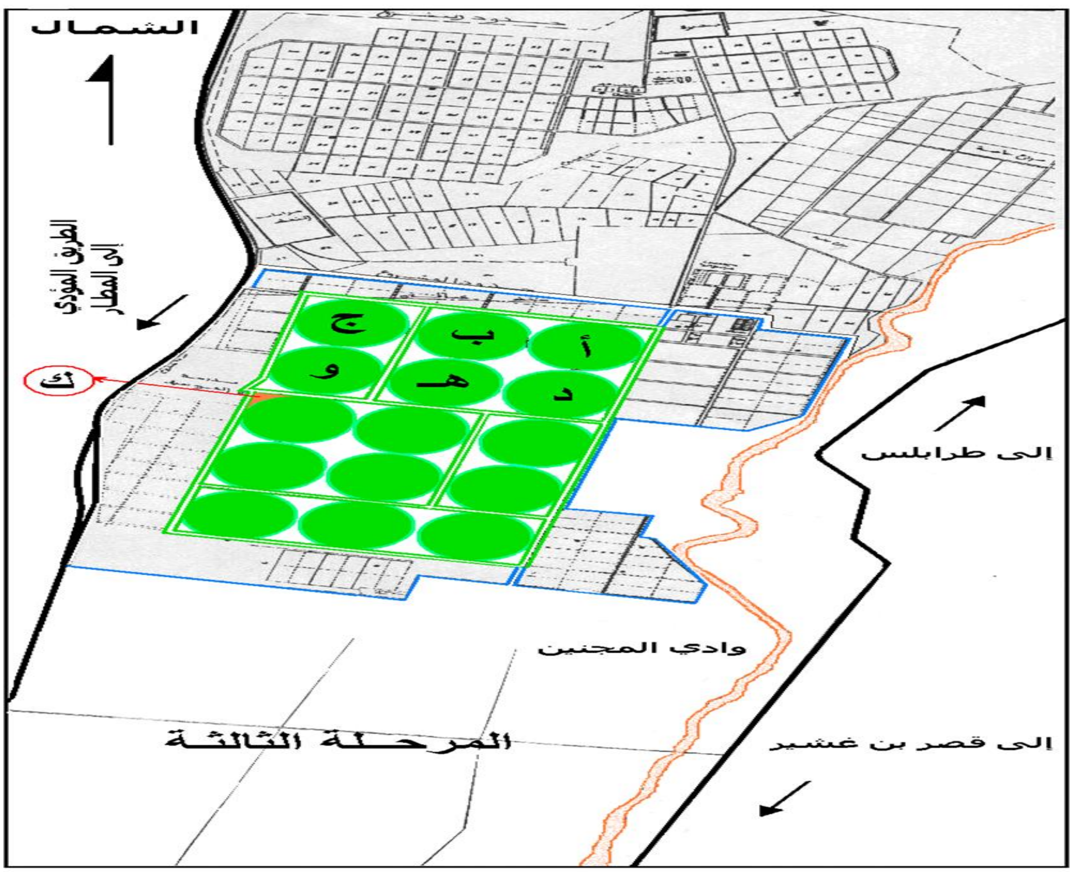

Figure 1- Shows AL-Hadba EL-Khadra Agricultural Project, including study Fields (A ـ أ) and (E ـ هـ) with control field (K ـ ك).

RESULTS AND DISCUSSION

The results of the soil chemical analyzes indicate that the ph. values of all soils in the three fields' falls within the neutral values (7-7.3) and the average electrical conductivity values for soil water extracts were 0.655, 0.720, 0.163 millisiemens/cm for fields number 1, 2, 3 respectively. In addition, the results indicated that the texture of the soil under study were ranged between sandy and sandy loam soil texture. From the data presented in Table 1 and in Figure 1,It was clear that the average hydraulic conductivity values in field (1) were slightly higher in the surface layer (0 - 20 cm), where it was 0.199 cm/min, compared to 0.150 cm/min in the layer (20-40 cm), this decrease in lower layer could be attributed to the increase in physical obstruction processes caused by the trapping of suspended and colloidal materials in the pores of sand grains, in which case they are called physical obstruction)Bouwer & Chaney, 1974, and yan Han et al.,2022) or as a result of permanent irrigation operations and the field not being subjected to plowing operations, or both. Permeability classes and the corresponding ranges of hydraulic conductivity according to (O, Neal, 1952)

Table-1- Description of hydraulic conductivity levels for soil sample collected, (8 samples from the alfalfa field, 8 samples from the barley field, and 4 samples from the control field).

Number of soil samples under study, the value of the hydraulic conductivity (cm/ min) and their level classification.								Depth (cm)	Field number crop
8	7	6	5	4	3	2	1		
0.133 Moderate	0.237 Moderately rapid	0.097 Moderate	0.195 Moderate	0.308 Moderately rapid	0.294 Moderately rapid	0.121 Moderate	0.211 Moderately rapid	0 - 20	(1) alfalfa

0.204 Moderately rapid	0.079 Moderate	0.100 Moderate	0.053 Moderate	0.348 Moderately rapid	0.198 Moderately rapid	0.111 Moderate	0.111 Moderate	20 – 40	
0.431 Moderately rapid	0.237 Moderately rapid	0.225 Moderately rapid	0.109 Moderate	0.084 Moderate	0.076 Moderate	0.161 Moderate	0.350 Moderately rapid	0 – 20	(2) barley
0.431 Moderately rapid	0.310 Moderately rapid	0.172 Moderate	0.212 Moderately rapid	0.054 Moderate	0.089 Moderate	0.123 Moderate	0.368 Moderately rapid	20 – 40	
				0.191 Moderate	0.243 Moderately rapid	0.182 Moderate	0.325 Moderate	0 – 20	(3) control
								20	

				0.306 Modera te	0.303 Modera te	0.298 Moder ate	0.315 Modera te	– 40	

Permeability classes and the corresponding ranges of hydraulic conductivity according to (O, Neal, 1952).

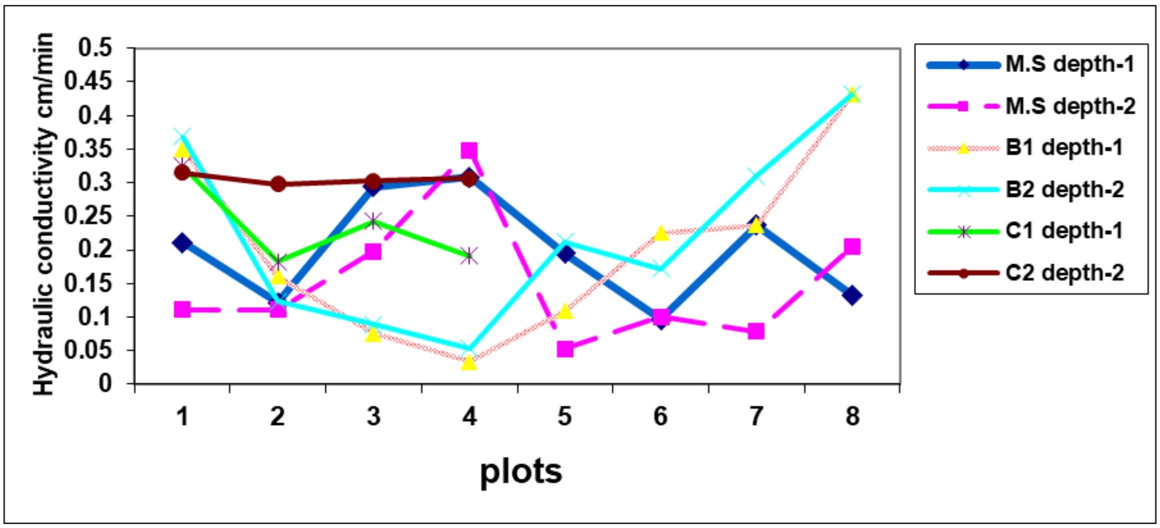

Figure 1– Ranges of soil hydraulic conductivity for three fields under study under two depths (0 –20 cm) and (20–40 cm). (M.S =Field of Medicago Sativa L., B1 and B2 = field of Hoodlum Valgare L, C1 and C2 = control field).

In addition, there were somewhat similarity in the average hydraulic conductivity values in field (2) and field (3), and that average was increase in layer (20 – 40) cm from 0.209 cm/min to 0.219 cm/min and from 0.235 cm/min to 0.306 cm/min in fields (2) and (3) respectively. This is might be due to the similar nature of the soil texture, which may be a confirmation sign for this. According to these results, it can be confirmed that there was a correlation between hydraulic conductivity and soil texture in the three fields. In addition, the results indicated that there was no good correlation between the hydraulic conductivity and some chemical and physical soil properties, including the percentage of organic matter and the percentage of exchangeable sodium, as well as

Bulk density, while there was a good correlation between the hydraulic conductivity of the soils under study and clay percentage where the value of the correlation coefficient reached (r = 0.54). In addition, the results of the statistical analysis indicated that there were no significant differences in hydraulic conductivity between the layers in one field or among the rest of the layers in the three fields. This is could be attributed to the decrease and convergence of the average values in the study sectors in the fields under study.

RECOMMENDATIONS

1-The necessity of paying attention to wastewater (as a non-traditional source) and adopting it as part of the water resources available in Libya to compensate for the shortage of surface water and exploiting it in the fields of agriculture, industry, and others as a water resource after being treated in treatment plants.

2-The necessity of conducting periodic measurements and analyzes of wastewater used in agricultural fields and comparing these results with local and international specifications.

3- The necessity of conducting periodic measurements and analyzes of the soil of agricultural projects and expanding the scope of the analyzes to include analyzing the soil in terms of its contamination with heavy metals and others, and comparing these results with local and international specifications.

4- Limiting the flow of untreated wastewater into seawater to maintain clean water and protect marine wealth.

5- Encouraging researchers and making room for them in Libya to delve into the areas of analysis related to development projects and educating citizens by conducting intensive research and studies.

REFERENCES

-Abu-Sharar, T.M., Bingham, F.T. & Rhoades, J.D. 1987. Reduction in hydraulic conductivity in relation to clay dispersion and disaggregation. Soil Science Society of America Journal 51, 342-346.

-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.

-Bardhan, G., Russo, D., Goldstein, Levy, G. 2016. Changes in the hydraulic properties of a clay soil under long – term irrigation with treated wastewater. Geoderma 264, 1-9.

-Biwa, M.S., Josan, A.S., Choudhary, O.P. 1993. Effect of frequency of sodic and saline-sodic irrigations and gypsum on the buildup of sodium in soil and crop yields. Irrigation Science 14, 21-26.

-Bole, J.B., Carefoot, J.M., Chang, C. and Oosterveld, M. 1981. Effect of wastewater irrigation and leaching percentage on soil and ground water chemistry. Journal of Environmental Quality 10, 177-183.

-Friedel.J.k., Langer 7 C. Siebe 7 K. Stahr. 2000. Effects of long-term waste water irrigation on soil organic matter, soil microbial biomass and its activities in central Mexico Biol Fertil Soils 31:414–421.

-Jianye Ma, Zhiqiang Min, Zhanbin Li, Peng Li. 2024. Effect of mixed plant roots on saturated hydraulic conductivity and saturated water content of soil in the loess region Agricultural Water Management 295.

-Jingru He, Gaoxiang Huang, Mingjun Ding, Peng Wang, Hua Zhang, Zhongfu Wang. 2024. Surface tension effects on the hydraulic conductivity of hydrophobic porous media. Geoderma.

-Kanwar, J. S. & Ram, D. 1969. "K+ and Mg++ in irrigation water and their effects on the physico-chemical properties of soil. Indian Society of Soil Sci J 17, 2: 217 – 226.

-Klute, A. & Dirksen, C. 1986. Hydraulic conductivity and diffusivity: laboratory methods. In: Klute, A. (ed). Methods of Soil Analysis. Part 1, 2nd edition. American Society of Agronomy, Inc. Madison Wisconsin. pp. 687-734.

-Lado.M. & Ben-Hur, M. 2010. Effects of irrigation with different effluents on saturated hydraulic conductivity. Of arid and semiarid soils. Soil. Sci. Soc Am J 74, 23-32.

-Lin Wang, Guillaume Blanchy, Wim Cornelis, Sarah Garr. 2024. Changes in soil hydraulic and physio-chemical properties under treated wastewater irrigation: A meta-analysis. Agricultural Water Management Agricultural Water Management 295.

-O, Neal, A.M. 1952. A key for evaluating soil permeability by means of certain field clues. Soil. Sci. Soc Am.Proc.16, 312-315.

-Roberta, A. B., Goncalves, Marcos, V. F., Thomas, V. G., Paulo, L. L., Celia, R. M., Yves. L., Carlos, T. S. & Adolpho, J. M. (2007). "Hydraulic Conductivity of a Soil Irrigated with Treated Sewage Effluent". Agricultural Water Management 88, 119 – 131.
-Ryan, B. & Joiner, B.L. 2001. Minitab Handbook. 4th Edition. Duxbury Thomson Learning, Pacific Grove, CA., pp. 464.
-Sidan Lyu , Laosheng Wu, Xuefa Wen, Jing Wang and Weiping Chen. 2022. Effects of reclaimed wastewater irrigation on soil-crop systems in China, Science of The Total Environment volume 813.
-Song, T., An, Y., Wen, B., Tong, S., Jiang, L. 2022. Very fine roots contribute to improved soil water storage capacity in semi-arid wetlands in Northeast China. Catena 211,
-Taiwo Adeyemo, ISAAC Kramer, GUY, j. LEVY, yair MAU. 2022. Salinity and sodicity can cause hysteresis in soil hydraulic conductivity. Geoderma, Volume 413, 115765.
- yan Han, Qing Wang, Weitong Xia, Jing Liu, Jiaqi Wang, Yating Chen. 2022. Experimental study on the hydraulic conductivity of unsaturated dispersive soil with different salinities subjected to freeze-thaw Journal of Hydrology 583.
- zhao, Minghui W, Cuibai, C, Laiming, H. 2023. Variations, controls and predictions of soil saturated hydraulic conductivity under different land use types in the alpine region of Tibet, China. Geoderma 35.
- Zhu, P., Zhang, G., Zhang, B., 2022. Soil saturated hydraulic conductivity of typical revegetated plants on steep gully slopes of Chinese Loess Plateau. Geoderma 412,