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Water resources development by applying modern techniques in wastewater treatment and reuse for barley irrigation

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Abstract
The study was to investigate the effects five irrigation water treatments, i.e. wastewater (WW), tap water (TW), wastewater filtered by sand filter (FWW), wastewater filtered by sand filter and treated with nano TiO2 (FNWW) and mix of wastewater filtered by sand filter and treated with nano TiO2 + tap water by 1:1 (TWW mix) for measure irrigation water quality and productivity of barley (*Hordeum vulgare* L.), under Upper Egypt field conditions. The results showed the macro and micro elements were present in higher concentrations in WW compared to TWW. A treated wastewater gave reduction percentage of COD and BOD by 94% and 96%, respectively. Microbial average of treated wastewater faecal coliform(FC) and total coliform (TC) are about 2 X 10^4 and 7 X 10^4 CFU/ml respectively, The concentration of *P. aeruginosa* and *E.coli* about at 4.8 X 10^3 and 2 X 10^3 CFU/ml respectively . The treated waste characteristic level did not reach the maximum allowed level FOA for edible crops. The results indicated the superiority of treated wastewater by sand filter, or by sand filter and nano, or mix wastewater treated with sand filter and nano + tap water by 1:1 for productivity of barley over that irrigated with wastewater.

Keywords: Treated wastewater, barley, wastewater reuse, nutrient minerals, nanoTiO2, sand filter.

Introduction
The use of treated wastewater in agriculture is increasing due to water scarcity, population growth, and urbanization, which all lead to the generation of yet more wastewater in urban areas.. Wastewater reuse in agriculture represents a potentially important alternative for fresh water and save it for drinking and industry water supplies. The use of TWW in agriculture needs to be done with precautions to avoid harming the agricultural soils and to prevent any consumer health risk. Therefore, in Egypt use of treated wastewater in agriculture especially barley crop (Khalaphallah, et al., 2014) reused to treated wastewater in irrigation of barley fodder considered as useful alternative disposal method of wastewater. Wastewater was largely limited to irrigation of

forages and forestry (Nsheiwat, 2007**)**. The popular treatment process for sewage wastewater in Egypt is the use of stabilization pond to separate sewage sludge from WW. The secondary stage is a sand filter stage where most of the organic matter is converted into more stable forms by bacteria **(**khallaphallah, et al. 2014)**.** A nano TiO_2 and sand filter treatment are used to reduce the risks associated with the use of secondary treated effluent mainly microorganisms. Wastewater application in irrigation of crops might result in supplement of nutrients elements in soils. Recent studies have indicated that nutrients from treated wastewater could be benefits to the plant (Luz et al., 2004). Constituting high values for agricultural crops by using low water inputs and high fertilizer efficiencies is one of the methods used in addressing the environmental and resource problems (Sezen et al., 2011). TWW could be arranged with optimum environmental medium for crop growth in order to gain maximum yield and high quality products. Due to the rapidly growth population in Egypt as well as many other countries in the region, the demand for food and livestock products increases, and this becomes a challenge for the animal production sector to meet this rapidly increased demand with the prevailing production conditions (e.g., water shortage). The major constraints on livestock production in Egypt and the other countries in the arid and semiarid regions are the inadequate quantities and poor quality of the produced barley. Achieving a suitable barley production under the prevailing water-scarcity conditions in Egypt and other countries in the region, requires the introduction and implementation of low quality water (treated wastewater) and agricultural techniques which minimize the water consumption and improve yield per unit of water used. One of the modern techniques that are considered important for better water use efficiency as well as for barley production is nano TiO_2 treatment. Barely produced by TWW treatments Types irrigation has a short growth period and requires only a small piece of land for production to take place (Mooney, 2005). It has high feed quality, rich with proteins, fibers, vitamins, and minerals (Leontovich and Bobro, 2005; Al-Karaki and Al-Momani, 2010) with therapeutic effects on animals (Kanauchi et al., 1998; Boue et al., 2003). The use of treated sewage effluents (TSE) for agricultural irrigation is an old and popular practice in agriculture (Feigin et al., 1991). Waste water has been considered as low price fertilizer because of its high nitrogen (N), phosphorus (P) and potassium (K) content (Chaw, et al. 2001). A significant augmentation (3.38 g pot-1 to 8.85 g pot-1) in dry matter yield of barseem (*Trifoliam sp.)* in pots irrigated with sewage WW than GW irrigated pots (Singh, et al.1991). Signifies the essential nutrient elements were supplementation from WW. The field experiments conducted on the use of WW for irrigation to maize, sunflower, groundnut and soybean registered 19.3, 29.9, 5.9 and 4.8% higher grain yield, respectively over fields irrigated with GW (Udayasoorian, et al. 1999). Likewise, a significant increase in barley biomass with municipal WW irrigation application consecutively for 5-years over control, in contrast to lower barley biomass from fields irrigated with WW for consecutively for 10-years has been reported (Rusan, et al. 2007). The current study aimed at to investigate the best type for wastewater treatment, quantity and quality yield, nutrient minerals contents of produced barley using treated wastewater for irrigation and compare with tap water irrigation.

Materials and Methods

The research has been carried out during 2016 at wastewater station of south Valley University, Qena, Egypt. A sand filter system was developed and manufactured at a local workshop used in this study.

The experiment was carried out in a randomized complete block design with four replications.

The different treatments of water irrigation types as follows:

T_1- Wastewater (WW), T_2- tap water (TW), T_3- wastewater filtered by sand filter (FWW), T_4- wastewater filtered by sand filter + treated with nano TiO2 (NWW) and T_5- mix of wastewater filtered by sand filter and treated with nano TiO2 + tap water by 1:1 (TWW mix). The treated wastewater was obtained from the south valley University campus (experimental total area about 500 m^2). Seeds of barely cultivar Giza 2000 were shown in this study. Long tubes pots of 25 cm diameter and 75 cm depth were filled with a 52 kg of a mixture of 1:1 clay and sand.

Representative TWW samples (100 ml) from each treatment were taken in three replicates at and tap water as a control. The nitrogen content was determined using Kjeldahl's method. Samples for the determination of mineral nutrients were prepared using dry ashing method (Schouwenberg and Walinge, 1973). Phosphorus was determined using spectrophotometer (Watanabe and Olsen 1965); potassium and sodium Calcium by flame photometer (Ryan et al., 2001). Total suspended solids (TSS) measure of the turbidity of the water, weigh a piece of filter paper as accurately as possible. Filter a one liter sample of water through the weight filter paper. Allow the filter paper to dry completely. Placing a lamp above the filter paper may help the drying process, but take care in not getting the filter paper too hot. Electric conductivity (EC) is defined as the ability of a solution to conduct electricity and it can be measured by using conductivity meter under 25^{o}C in the range from 0 ~ 2000 µS/cm.

Barley seedlings produced in this study and irrigated with WW were analyzed for presence of microbial pathogens (total faecal coliforms, *E. coli*, and *p aeruginosa*). **BOD and COD** – Biochemical oxygen demand (BOD) is defined as the amount of oxygen used during decomposition of organic material during five day, BOD was measured by glass bottles. Chemical oxygen demand (COD) (Merritt et al., 1999; Maureen et al., 1999). COD was measured by spectrophotometer with 620 nm wave length and high range of COD concentration.

At harvest time, ten fertile stems were taken at random from each pot for measuring number of seeds/plant, total plant weight and seed yield/plant**.**

The data were analyzed by analysis of variance (ANOVA) using SAS statistical software. Treatment means were compared using Duncan's multiple tests (Steel and Torrie, 1980).

Results and Discussion

Irrigation water quality

The analysis of irrigation water used for the various treatments is reported in Table 1. The salinity EC of irrigation water was 1.2 dS/m for TWW and 1.5 dS/m for WW. The pH values were 7.5 for the TWW and 7.7 for the WW. It has been reported that barley can tolerate salinity of water up to 6 dS/m without any impact on seed germination or crop yield (Bagci and Yilmaz, 2003). Macro element and micro element were present in higher concentrations in WW compared to TWW (Table 1). However, similar amounts of P, Mg, and Li were recorded in both WW and TW. The concentrations of these elements are considered lower than those recommended for nutrient solutions in crop production under sand filter systems according to (khalaphallah et al 2014). Barley crop is usually grown with little added fertilizers due to the short period of growth (Al-Karaki and Al-Momani, 2010). The reduction of COD ranging from 500 to 30 mg/l (94%) and BOD from 450 to 20 mg/l (96%) was reported at different wastewater and treated wastewater, respectively. Similar findings were reported by many researchers by using sand filters and activated carbon (Al-Jlil 2009). Compared to the long term effect of WW irrigation, Rusan et al. (2007) reported that N, P, and K, increased significantly in soils as years of WW irrigation increased in the same lands.

Table 1. The characteristics of wastewater and treated wastewater used for barley irrigation

Wastewater				Treated Wastewater by sand filter			
Constituent	Mg/L	Constituent	Mg/L	Constituent	Mg/L	Constituent	Mg/L
EC(ds/m)	1. 5	pH	7.9	EC(ds/m)	1.2	pH	7.5
COD	500	N	54	COD	30	N	19
BOD	450	P	10	BOD	20	P	9
TSS	730	No3	350	TSS	40	No3	322
Li	12	SO4	103	LI	7	SO4	88
Mg	30	CL3	125	Mg	17	CL3	23
Na	130	Ca CO3	265	Na	82	Ca CO3	210
Ca	65	K	110	Ca	65	K	105

Microbial analysis

Irrigation with wastewater can represent a major threat to public health (of both humans and livestock), food safety and environmental quality. The microbial quality of wastewater is usually measured by the concentration of the two primary sources of water-borne-fecal coliforms (Ayers et al., 1992). Presence of E. *coli* in irrigation water is used as indicator of fecal pollution as this organism can pose a significant health risks (Dufour, 1997). Howard et al., (2004) reported Concentrations of *P. aeruginosa* in sewage may exceed 10^5 CFUmL^{-1} this agreement with this study. Results of analysis of produced barley seedlings showed no presence of any pathogenic microorganisms. However, in a study conducted by Al-Ghazawi et al. (2008) using the same source of WW for production of barley under field conditions, they found no or low populations of some pathogenic organisms in barley seedlings grown in soil under field conditions (Table 2).

Table 2. Bacteriological tests of wastewater, treated wastewater and tap water

Wastewater types	TC	FC	E.Coli	P, aeruginosa
T_1- WW	$6*10^5$	$2*10^4$	$2*80^4$	$8*10^4$
T_2-TW	$1*10^2$	Not found	Not found	Not found
T_3- FWW	$8*10^2$	$5*10^2$	$5*10^3$	$2*10^2$
T_4- FNWW	$7*10^3$	$2*10^2$	$2*10^2$	$7*10^2$
T_5- TWW mix	$5*10^3$	$2*10^2$	$12*10^2$	3*103

The samples of the aerial part of three varieties of barely were collected in plots and irrigated with treated wastewater for microbiological tests. These tests involve only the enumeration of *Faecal Coliforms* (FC) and *Total Coliforms* (TC) which are signs of germs and fecal contamination (Rusan et al, 2007). Presence of E. coli in irrigation waters is used as indicator of fecal pollution as this organism can pose a significant health risks (Dufour, 1997). Wastewater bacteriological tests of the average are about 2×10^4, 6× 104 and 5×10^3 CFU/ mL, which are the for FC, TC ,E.coli and *P aeruginosa* respectively (Figures 1 and 2).

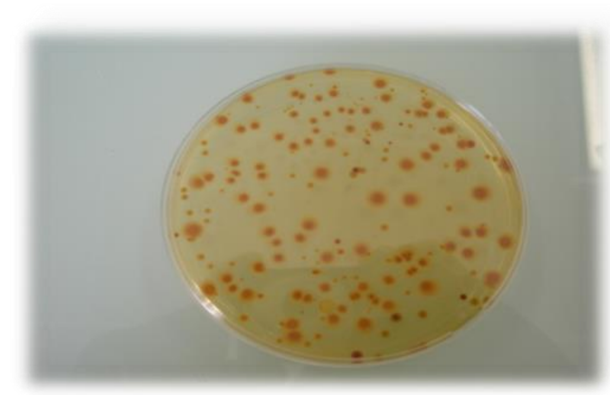

Figure 1. *Escherishia coli* colonies on TTC7 media

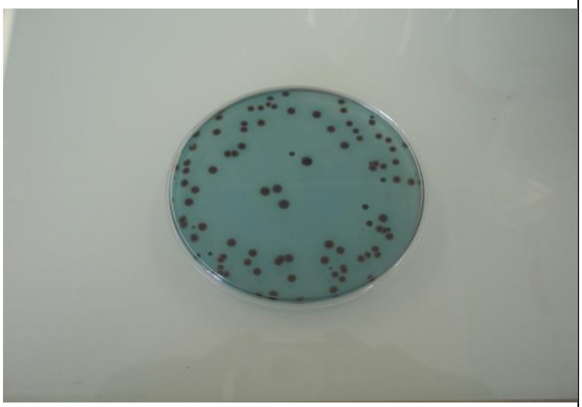

Figure 2. *Pseudomonas aeruginosa* colonies on TTC7 media

These results confirm the results obtained from the irrigated grass by three disinfected treated wastewater which has a concentration of TC between 4×10^2 and 8×10^3CFU/ml. However, FC and anaerobic sulfite-reducers are below than 2 x10^2 CFU/ml as well as *P aeruginosa* that are absent in 25 grams, but the faecal coliform microorganisms are greater than 3×10^7 CFU/g (Table 2). This is consistent with the results of (Chaw, et al. 2001) in which it was announced that lettuce plants irrigated with the treated wastewater are more altered toward the end of the harvest than plants irrigated with fertilized water. This alteration may be due to the abundance of total coliform bacteria (5.1×10^5 CFU/g) as the barley grows at ground level and can be easily contaminated by the bacterial group. Therefore, we can conclude that the disinfection has been successful from a microbiological point of view. However, it affects the germination and growth of barley plants by their intake of sodium and chloride ions, which increases the salinity of the treated wastewater.

Barely productivity

The results in Table 3 indicated that irrigation with tap water (TWW) or irrigation with mix of wastewater filtered by sand filter and treated with nano TiO2 + tap water by 1:1 (TWW mix) gave the highest values of number of seeds/plant, total plant weight and seed yield/plant without significant differences between them. The minimum and significantly number of seeds/plant (10.215), total plant weight (2.635 g) and seed yield/plant (0.432 g) were recorded in irrigation with wastewater (WW) than other treatments. The results obtained by (Rusan, et al. 2007), (Singh, et al.1991) and (Udayasoorian, et al. 1999).

Table 3. Effect of irrigation with different wastewater treated on number of seeds/plant, total plant weight and seed yield/plant of barley.

Treatments	Number of seeds/plant	Total plant weight (g)	Seed yield/plant (g)
T_1- WW	10.215 c*	2.635 d	0.432 d
T_2-TW	23.059 a	3.607 a	1.005 a
T_3- FWW	19.278 ab	3.227 bc	0.781 b
T_4- FNWW	16.604 b	3.069 c	0.631 c
T_5- TWW mix	19.625 ab	3.359 ab	0.885 ab

*Means within column with the same letters are not significantly different at 5% level.

Conclusions

Treated wastewater (TWW) is a feasible source for irrigation of barley. The current study shows the superiority of treated wastewater by, sand filter, or by sand filter and nano, or mix wastewater treated with sand filter and nano + tap water by 1:1 for productivity of barley over that irrigated with wastewater. This indicated that TWW is a good source of nutrients needed for plant growth to promote high yields. The microbial load in the barley irrigated with TWW was apparent, yet below FAO accepted limits (FAO 1992). The use of WW in sand filter systems may reduce the risk of microbial load in the soil.

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References

Al- Jlil, S. A. 2009. COD and BOD reduction of domestic wastewater using activated sludge, sand filters and activated carbon in Saudi Arabia," Biotechnology, 8, 4,. 473–477

Al-Ghazawi, Z., J. Amayreh, L. Rousan and A. Hijazi. 2008. Wastewater reuse for agriculture pilot project at Egypt University of Science and Technology. In: I. Al Baz, R. Otterpohl and C. Wendland (Eds.). 284-297. Efficient Management of Wastewater: its treatment and reuse in water scarce countries. Springer-verlag, Berlin, Germany.

Al-Karaki G.N., Al-Momani N. 2010. Evaluation of some barley cultivars for green fodder production and water use efficiency under hydroponic conditions. Jordan J. Agri Sci .

Ayres R.M., Stott R., Mara D.D., Lee L.D. 1992. Wastewater reuse in agriculture and the risk of intestinal nematode infection. Parasitol. Today 8:32-35.

Bagci S.A., Yilmaz A.E.H. 2003. Determination of the salt tolerance of some barley genotypes and the characteristics affecting tolerance. Turk. J. Agric. For. 27:253-260.

Boue, S., T. Wiese, S. Nehls, M. Burow, S. Elliott, C. Carterwientjes, B. Shih, J. McLachlan and T. Cleveland. 2003. Evaluation of the estrogenic effects of legume extracts containing phytoestrogens. J. Agric. Food Chem. 51(8):2193-9.

Chaw, R., and Reves, A. S., 2001, Effect of waste water on Menthe piperita and Spinaceal oleraceae., J. Environ. Biol., 51, 131-145

Dufour A.P. 1977. Escherichia coli: The Fecal Coliform. In: A.W. Hoadley and B. J. Dutka (Eds.). pp. 48-58. Bacterial Indicators / Health Hazards Associated with Water. American Society for Testing and Materials

FAO. 1992. Wastewater quality guidelines for agricultural use. In: Pescod, M.B. (Ed) Wastewater treatment, and use in agriculture – FAO irrigation and drainage paper 47. Rome, Italy. pp 25-35.

Feigin, A., Feigenbaum, S. and Limoni, H. 1981. Utilization efficiency of nitrogen from sewage effluent and fertilizer applied to corn plants growing in a clay soil. Journal of Environmental Quality, 10, 284-287.

Feigin, A., Ravina, I. And Shalhevet, J. 1991. Irrigation with treated sewage effluent: management for environmental protection. Berlin: Springer-Verlag, 224p.

Howard, I., Espigares, E., Lardelli, P., Martin, J.L., Espigares, M., 2004. Evaluation of microbiological and physicochemical indicators for wastewater treatment. Environ. Toxicol. 19 (3), 241–249.

Kanauchi O, T. Nakamura, K. Agata, K. Mitsuyama and T. Iwanaga. 1998. Effects of germinated barley foodstuff on dextrin sulfate sodium-induced colitis in rats. J. Gastroenterol. 33(2):179-88.

Leontovich, V. P. and M. A. Bobro. 2005. Technology of continuous growing of hydroponic fodder. Russian Agric. Sci. 33:239-241.

Luz E. de-Bashana, Yoav Bashan (2004) Recent advances in removing phosphorus from wastewater and its future use as fertilizer (1997–2003). Water Research 38, 4222–4246.

Maureen, A.M., Fox, S., and Pennell, J., 1999, Environmental Engineering Handbook, [e-book]. CRC Press LLC, p. 1399.

Merritt, F.S., Loftin, M.M. and Ricktts J.T 1999. Standard Handbook for Civil Engineering: Environmental Engineering, McGraw-Hill Co., INC., P 72.

Mooney, J. 2005. Growing cattle feed hydroponically. Meat and livestock Australia. p.30.

Nsheiwat, Z. B. 2007. Wastewater use in Jordan: an introduction. Wastewater Reuse –Risk Assessment, Decision-Making and Environmental Security. pp. 73–79.

Khalaphallah R., Mokhles A. Ahmed, (Eman), S.H.,Farrag (2014) Wastewater treatment and reuse for irrigation green barley fodder in south valley university-Egypt. Glo. Adv. Res. J. Agric. Sci. 3(11): 379-386

Rusan, M. J. M., Hinnawi, S., Rousan, L., 2007, Long term effect of waste water irrigation of forage crops on soil and plant quality parameters., Desalinization 215, 143-152.

Ryan J, Estefan G and Rashid A 2001 Soil and plant analysis laboratory manual, 2nd edition. National Agricultural Research Center (NARC). Islamabad, Pakistan. pp. 135-136.

Schouwenberg, V. and Walinge J. C. 1973. Methods of analysis for plant material. Agric. Univ. Wageningen, The Netherlands.

Sezen, S. M, G. Celikel, A. Yazar, S. Tekin and B. Kapur. 2011. Effect of irrigation management on yield and quality of tomatoes grown in different soilless media Emir. J. Food Agric.. 23 (1): 80-94.

Singh, R. P., Singh, V., and Shukla, A. K., 1991. Yield and heavy metal contents of Berseem as influenced by sewage water and refinery effluent., J. Ind. Soc. Soil Sci., 39, 402-404

Steel RGD, Torrie JH. 1980. Principles and procedures of statistics, 2nd ed McGraw-Hill, New York.

Udayasoorian, C.; Devagi, P.; Ramaswami P. P. 1999. Case study on the utilization of paper and pulp mill effluent irrigation for field crop. In: Proceedings of Workshop on 'Bioremediation of Polluted Habitats', p. 71-73.

Watanabe, F. S. and S. Olsen. 1965. Test of an ascorbic acid method for determining phosphorus in water and NaHCO3 extract for soil. Soil Sci 21:677–678.