Global Advanced Research Journal of Agricultural Science (ISSN: 2315-5094) Vol. 3(11) pp. 379-386, November, 2014.
Available online http://garj.org/garjas/index.htm

Full Length Research Papers

Wastewater treatment and reuse for irrigation green barley fodder in south valley university-Egypt

Rafat Khalaphallah, Mokhles A. Ahmed,(Eman),S.H., Farrag

Department of Agricultural Botany (Microbiology), Faculty of Agriculture, South Valley University, Qena, Egypt.

Accepted 03 November, 2014

The problems of scarcity, shortage and quality deterioration of water, have led to an increased interest in the reuse of treated wastewater in many countries of the world. This study has examined the alternative solution such as the suitable of locally available materials(gravels , fine sand , solar irradiation with plastic polyethylene cover) to treat wastewater samples collected daily from South valley university campus (students residence , students hospital and the university mosque) for irrigation, as well as taking into account the economic aspect . Using alternative water resources such as tertiary treated wastewater is considered very important to produce crops (e.g., barley (Hordeum vulgare L.) due to irrigation water shortage, especially in arid and semi-arid regions like Upper Egypt. The objectives were to investigate the effects of irrigation with treated wastewater (WWt), mixed WW / tap water (WWm) and tap water (TW) on barley fodder yield, quality and microbial load under different conditions. The wastewater samples were filtered and measure of physicochemical parameters (EC, pH, BOD, and COD), micro/ macro nutrients, heavy metals and microbial counts determined over a seven week period. Results indicate the filtration process is effective in reducing the minerals, heavy metals and microorganisms group (total coliforms, E.coli, Staphylococcus aureus and total fungi) levels. Treated wastewater use in irrigation of barley fodder considered as useful alternative disposal method of wastewater without the risk of accumulation of heavy metals in the soil and the maintenance of environment.

Keywords: Wastewater treatment - Wastewater recycling – heavy metals– irrigation green barley fodder - Sand filter –Total fungi

INTRODUCTION

In the last decay, many parts of the world are threatened by water scarcity. In the Middle East the threat of water scarcity is particularly in important as it is an arid and semi arid region with limited fresh water. In many arid and semi-arid countries water is becoming an increasingly scarce resource and planners are forced to consider any sources of water which might be used economically and effectively to promote further development. At the same time, the global warming and population expanding at a high rate, the need for increased food production is apparent. Affected by natural ecosystems as a result of the acceleration of population growth in most countries of the world, and the growing industries and agricultural techniques and the large number of different waste disposal, and which led to the rise of organic and chemical pollution and the spread of pests Among the various

*Corresponding Author's Email: r.shipat@agr.svu.edu.eg

factors for the mediation of water pollution are sewage. The term and sewage to the sewage that contains contaminants Which arise from mixing of different sources of sewage (Leeming et al, 1998) . heavy metals Is treated in wastewater have adverse impacts several of them, it interfere with biological processes used in sewage treatment, causing a decrease in treatment efficiency, accumulate in the sludge and many times causing an increase concentration in the sludge and therefore uses sludge as a fertilizer vegetarian will hurt in the food chain (Abouseeda, 1995,1997). showed numerous studies of the process of digestion anaerobic sludge leads to the production of an acid such as acetic acid,formic acid, hydrogen sulfide, and acidic sludge will lead to the migration of heavy metals into the sewage and thus take its way to the surface and groundwater source principal of fresh water in the world,(Kabata et al.1999, Veeken et al, 1999, Lake et al, 1984). Today, there has be growing concern about the discharge of heavy metals into the Biosphere, because of their cumulative effects on the toxicity of each of the plant, animal, heavy metals in sewage . Most of Wastewater concentration is possible be returned to the biosphere, through the stages of treatments of wastewater and sludge, and this caused the contamination of the food chain. This is the metal of the most dangerous pollutants where that mostly recipe accumulation where accumulate in the bodies of aquatic animals such as fish, birds and plants and up to a human by eating fish that contain cells compounds of these metals, as they have susceptibility to decomposition .

For reuse of wastewater by control planned for alleviates surface water pollution problems and not only conserves valuable water resources but also takes advantage of the nutrients contained in sewage to grow plant. The availability of this additional water near population centers will increase the choice of crops which farmers can grow like as barley fodder (Al Ajmi et al. 2009). The phosphorus and nitrogen content of sewage might reduce or eliminate the requirements for commercial fertilizers. It is advantageous to consider effluent reuse at the same time as wastewater collection; treatment and disposal are planned so that sewerage system design can be optimized in terms of effluent transport and treatment methods. Sewage treatment techniques for effluent discharge to surface waters may not always be appropriate for agricultural use of the effluent.

Most of countries in arid and more arid have included wastewater reuse as an important dimension of water resources planning. Firstly, in the more arid areas such as (Australia and USA) wastewater is used in agriculture, releasing high quality water supplies for potable use. On the other hand, some countries like as (Jordan and the Kingdom of Saudi Arabia) have a national policy to reuse all treated wastewater effluents and have already made considerable progress towards this end. It is generally accepted that, wastewater use in agriculture is justified on agronomic and economic grounds, but care must be taken to minimize adverse health and environmental impacts. Chemical pollution of water pollution and biological pollution are affected in the aquatic environment (flora and fauna and micro-organisms), this study is to provide countries with guidelines for wastewater use in agriculture which will allow the practice to be adopted with complete health and environmental security, and make recommendations necessary to different treatment and improve the work of this study in order to preserve our water sources.

MATERIALS AND METHODS

Site and field Work

The work has been carried out during a period of 7 months starting from october2013 to may 2014 at south valley university, Qena, Egypt. Works included construction of septic pond with a gravel and sand filter treatment system, monitoring the operation of the system and analyzing tap and treated wastewater samples in order to find the characteristics of tap/ wastewater and to assess the performance of the treatment system. The treatment system consists of aerobic pond by screen, gravel filter (depth 20cm), sand filter (depth 60cm) and storage pond cover by plastic polyethylene for keep the solar irradiation (figure.1).

Wastewaters characteristics

Municipal wastewater is mainly comprised of water (99.9%) together with relatively small concentrations of suspended and dissolved organic and inorganic solids. Among the organic substances present in sewage are carbohydrates, lignin, fats, soaps, synthetic detergents, proteins and their decomposition products, as well as various natural and synthetic organic chemicals from the process industries. Table 1 shows the levels of the major constituents of tap water, treated wastewaters and tap/ waste water.

Plant material and Irrigation experiment

Local barley cultivar was selected and used in this study according to the results obtained by Al-Karaki and Al-Momani (2010) that indicated this cultivar out yielded the other tested cultivars for green fodder production under hydroponic conditions. Seeds of barely plant were obtained from the local market of Qena. Seeds were subjected to a germination test to check for their viability before being used; the germination percentage was 95%. Three different water types were irrigated barley fodder: treated wastewater (WWt), tap water (TW), and mixture of equal amounts of WW and TW (WWm). The soil was ploughed

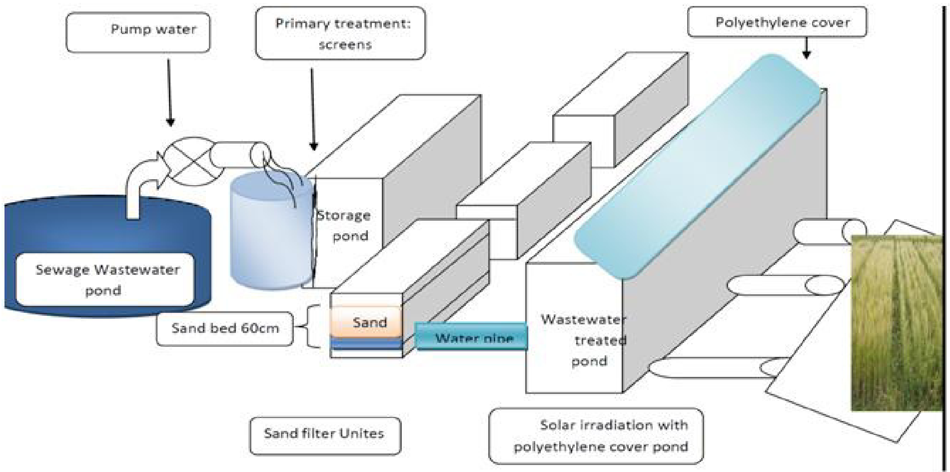

Figure 1. Diagram schematic of sand filter pond and plastic polyethylene cover treatment system

Table 1. Major constituents of wastewater

Parameters	Unit	TW	WWt	WW
EC	**dS/m**	0.5	1.15	1.5
BOD	**Mg/l**	-	10	480
pH	-	7.4	7.8	7.63
COD	**Mg/l**	-	25	1120

Figure (2) Image of barley plant at two week age

using plough twice more prior to broadcasting barley seeds using disk plough. Plot size was 1 x 2 m using three irrigation treatments (TW = tap water irrigation, WWt = treated wastewater irrigation and WWm, = treated wastewater irrigation with a 1:1 mixture of TW and wastewater as shown in Figure 2.

Table 2. Mineral nutrients concentration in barely green fodder under irrigated with different water types

Samples			Macro Elements(mg/g)			Micro Elements(ppm)			
			N	P	K	Zn	Mn	CU	Fe
ww			55	8	23	26	6	12	198
TW			32	10	15	18	2	4	121
WWt			52	6	13	24	3	6	127
WWm			32	7	17	24	2	5	177

Mesurement and analysis

Measure of Vegetative growth

A fresh plant samples (about 150 grams) from every treatment were taken at 45day, oven-dried at 70°C for 48 hours, weighed, and stored for chemical analysis. To study the nutritional value of produced fodder, proximate analysis for collected samples was conducted and crude protein, crude fat and dry matter contents were determined according to the procedures of AOAC (2000).

Crude fiber was determined using acetyl tri-methyl ammonium bromide and 1N H_2SO_4 (Robertson and Van Soest, 1981).

Number of total fungi and pathogenic bacteria

Wastewater, soil and barley plant Rhizosphere were analyzed for presence of microbial pathogens (total coliforms, E. coli, staphylococcus aureus, and total fungi). The presence of *E.coli* in a water sample will often but not always mean that other pathogens are also present. It is easier to measure *E.coli* concentrations and assume that this represents a group of similar pathogens than to measure concentrations of individual pathogens. Detection of studied microorganisms was determined in this study. (1). Number of bacteria was detected on the general purpose culture medium Nutrient Agar No. 2 (Czech Republic Media). Incubation temperature for mesophilic bacteria was 37 °C, incubation time was 24 hours. Incubation temperature for psychrophilic bacteria was 20 °C for 72 hours. All types of colonies were enumerated.(2). Number of total fungi (including yeasts and filamentous species of moulds) was estimated on the general cultivation medium for fungi potato diox Agar. Plates were incubated at 25 °C for 48–72 hours. All types of colonies were enumerated.(3). Presence of faecal indicators was detected by total coliforms enumeration on m-FC agar (Merck, Germany). Plates were incubated at 44 °C for 24 hours. Blue colonies of faecal coliforms were enumerated.

Mineral nutrient analysis

Representative wastewater and fresh green fodder samples (100ml, 150 g) from each treatment were taken in four replicates at 40 days, oven-dried at 70°C for 48 hours, ground to pass a 0.5 mm sieve, and stored for chemical analysis. 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 by flame photometer (Ryan et al., 2001), Ca, Mg, Mn, Zn and B by Atomic Absorption Spectrometer. Some nutritional elements (N, P, K, Ca, Mg, Zn, Na, and B) for various irrigation waters were also analyzed.

Determination of heavy elements

Barley plants sample were collected at age three weeks , from three treatment in addition to the control and dried in an oven temperature of 70 C for 48 hours and after drying milled models were taken it 0.5 g of dry matter in Baker and conducted by the digestive processes using sulfuric acid, nitric and perchloric acid by 2 : 1: 1, respectively, for a period ranging from (4-2) taking into account the complete coverage of the samples and the size to 50 ml with distilled water (APHA, 1998), was estimated concentrations of each of (Cd, Ni, Pb and Cr) atomic absorption spectrometer device and through the curve the standard for each element can be found in concentrations of metals through the application of the equation is expressed in unit mg / kg(ppm) dry.

RESULTS AND DISCUSSION

Characteristics and quality of Irrigation water

The characteristic of irrigation water used for the various treatments is reported in Table 1. The salinity of irrigation water was 0.5 dS/m (tap water) and 1.15 dS/m (WW). The pH values were 7.4 for the tap water and 7.63 for the WW. It has been reported that hydroponically grown barley can tolerate salinity of water up to 6 dS/m without any impact on seed germination or crop yield (Bagci and Yilmaz, 2003).Nitrogen, K, Na, Cl and Zn were present in higher concentrations in WW compared to tap water (Table 1). However, similar amounts of P, Mg, and B were recorded in both WW and TW. The concentrations of these elements

Table3. The concentrations of heavy metals in treated wastewater used for irrigation.

Water type	Heavy metals (ppm)			
	Ni	**Pb**	**Cd**	**Cr**
WWt	**0.0053**	**0.0091**	**0.004**	**0.006**
TW	**0.0004**	**0.00032**	**0.0003**	**0.00021**
WW	**0.033**	**0.072**	**0.02**	**0.043**
Safe limits in plant according to FAO (1992).*	1.5	5	0.2	20

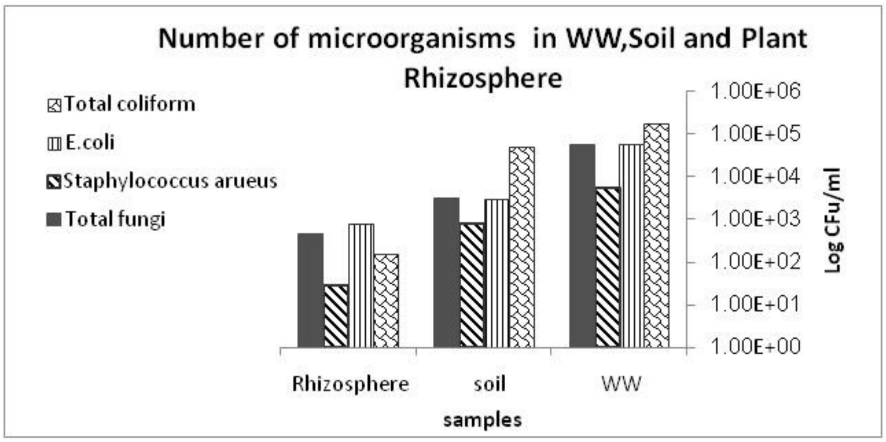

Figure 3. Number of microorganism in soil and field grown barley irrigated with wastewater (WW).

are considered lower than those recommended for nutrient solutions in crop production (e.g., vegetables) under hydroponic systems according to Benton (2005). Hydroponic green fodder is usually grown with no or little added fertilizers due to the short period of growth (Al-Karaki and Al-Momani, 2010). However, Al-Karaki and Al-Hashimi (2010) recommended that no need to use fertilizer for green barley fodder production under hydroponic conditions, when they found that chemical fertilization at 10% or 20% of Hoagland's solution had no significant effects on barley green fodder yield.

To know the potential risk of heavy metals in irrigation water to plants and hence animals and human beings, it is necessary to evaluate their concentrations in WW. The heavy metal concentrations of WW and TW used in this study are presented in Table 3. Although the nickel, cadmium, chromium, and lead contents in WW are much higher than those in TW irrigation waters, the levels of these elements in WW are lower than the acceptable levels set for irrigation water for crop production according to FAO guidelines (FAO, 1992). The results in table 3 showed the values of the heavy elements in the water samples for wastewater curd Pb concentration was of 0.072 ppm , after treatment was a concentration of 0.0091 ppm, and this means that this element was not exposed to the amount of change and treatment vital in the various basins, on the contrary, rose slightly in some basins, and also shows in Table 3., the results of approximating well as for Cadmium(Cd) where the water source of a concentration of 0.02 ppm in WW and the concentration for wastewater treated(WWt) was 0.004 ppm. Chromium (Cr) there is a fluctuation simple in values between basins to collect samples inflows Cr concentration 0.043 ppm and outflows a concentration of 0.006 ppm .

Microbial quality in produced fodder

Microbial and chemical contamination of grey water poses a potential risk to human health (Dixon et al., 2000). Filtration processes remove most microorganisms from wastewater. Irrigation with wastewater can represent a major threat to public health of 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 waters is used as indicator of fecal pollution as this organism can pose a significant health risks (Dufour, 1997). The results in figure.3 showed analysis of rhizosphere barley fodder found no or low populations of some pathogenic microorganisms (Table 3). This according with a study

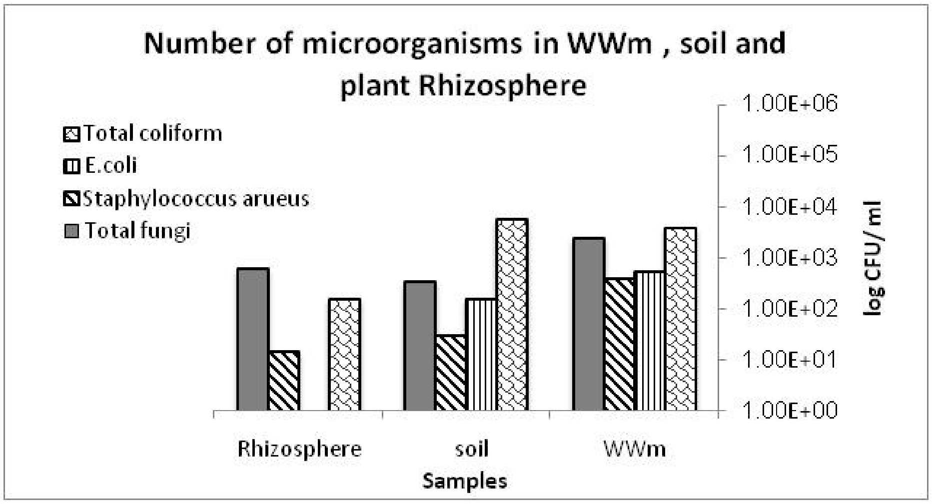

Figure 4. Number of microorganism in soil and field grown barley irrigated with treated wastewater mixed with tap water (WWm).

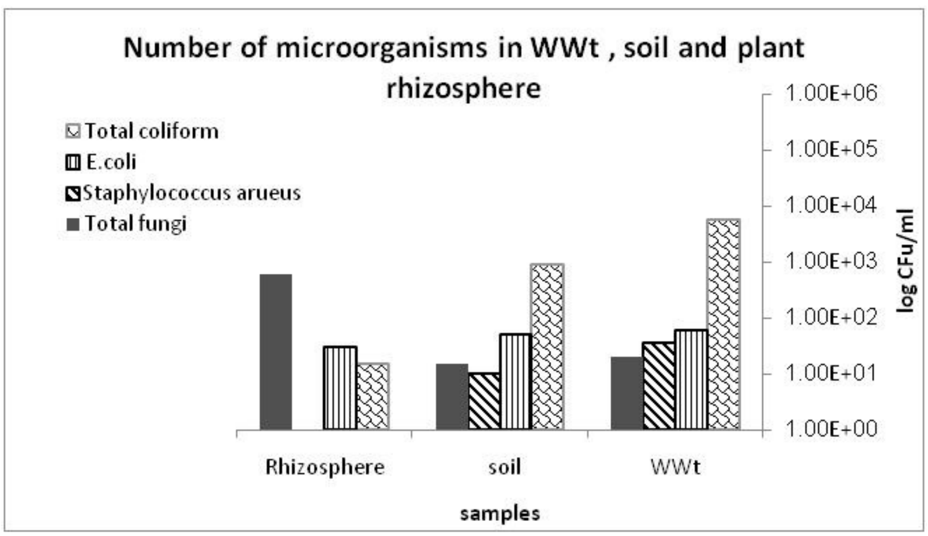

Figure 5. number of microorganism in soil and field grown barley irrigated with treated wastewater (WWt).

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.

Figure 2 shown there is a marked decrease of the numbers (total coliforms, E.coli and staphylococcus arueus) in treated wastewater compared with untreated wastewater, notes that the lowest number of total coliforms was 1.5E10-1.5E10^2, E.coli was 3.0E10-1.5E10^2 and staphylococcus was 1.0E10 -1.5E10, the number of total fungi reached the lowest value 1.5E10-1.5E10^2. Also the results showed there is a discrepancy between the numbers of bacteria and fungi, is due to the different thermal range for each of them , fungi 20-30˚ C and bacteria 30-37˚C , in this study use of the sun's rays in the presence of a cover of plastic polyethylene.

Figures (4,5) shown that effect of wastewater on microbial contamination of the root system of barley(Rhizosphere plant) during the growing season and was bacterial contamination of plants irrigated with untreated wastewater larger than the bacterial content of the plant, which has been irrigated with exchange and tap water , the plants were irrigated with treated wastewater less contaminating bacterial of treatments previous. The results show a lack of bacterial content in the root system (rhizospher) compared to soil bacterial content, due to the

Table 4. Characteristic and quality barley fodder produced and irrigated with wastewater, treated wastewater and tap water

Water type	Crude Protein%	Crude Fat%	Crude fiber %	Dry matter%	Carbohydrate soluble%
WW	28	5.2	22	18.1	23.2
WWt	24.2	5.5	21	17.5	21.5
TW	23	5.7	18	16.6	18

soil consider as a filter to reduces arrival of micro-organisms to layers which the plant absorbs its food, the number of fungi refers to abundance soil- borne fungi, Aspergillus sp, Penicillum sp. , Alternaria Sp. Fusarium Sp. and Helminthosporium Sp.

The results indicate that the present water treatment system in this study may raise the value of water for reused to plant irrigation. The level of micro-organisms was allowable level to irrigate fodder plants.

Characteristics and quality barley fodder

The analysis for the produced barley dry fodder showed higher contents of crude protein, crude fiber, crude fat, dry matter and soluble carbohydrate in fodder which irrigated with wastewater, on the other hand lower contents with other types of water (Table 4). The protein content in barley fodder reached about 28.4% irrigated with WW, while the values of barley fodder irrigated with WWm and TW were 24.2% and 23%, respectively (Table 4). For the crude fat and crude fibre contents in barley fodder reached about 5.2% and 22% respectively for WW. But with WWt were 5.5% and 21% respectively. The values of soluble carbohydrate in dry fodder ranged between 21.5-23.2% for WWt and WW. Owens (2009) reported that the lower values of acid fiber (<30%) in the fodder are considered of good nutritional values. The findings related to produce green fodder in this study indicated that irrigation with WW or WW mix may have no adverse effect on health or performance of grazing animals. It offers good use of treated wastewater to increase farmers' benefits. Proximate chemical analyses indicated that barely fodder may probably be superior in some aspects to field grown alfalfa hay used mainly as a source of roughage for livestock in Egypt and the countries of region. Al-Karaki and Al-Momani (2010) reported that hydroponic barley fodder has higher crude protein values and less fiber content than field grown alfalfa forages. Dry matter content in the produced fodder in this study ranged between 16.6% and 18.1%, and these values are not significantly different between different barley fodders irrigated with different water types.

CONCLUSIONS

Wastewater was efficiently treated with aerobic bond; wastewater treated is a feasible source for irrigation of produced barley fodder. The present study shows WW irrigated fodder barley > that irrigated with tap water in several aspects related to quality of the barley crop. Microbial content in the wastewater after treatment much less than the content in the wastewater pre-treatment which shows the efficiency of treatment process. The accumulation of heavy metals in the fodder irrigated with WW was apparent, yet below FAO accepted limits. WW is a good source of nutrients needed for plant growth to promote high yields. The use of WW in irrigation after treated may reduce the risk of heavy metal accumulation in the soil for a long time. Wastewater disposal after treated is a best practice compared to direct disposal into ground water.

ACKNOWLEDGMENTS

The authors wish to thank the Postgraduate sector at South Valley University for funding this project research.

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