INT. J. BIOL. BIOTECH., 16 (1): 141-149, 2019.

EFFECT OF CANAL AND UNTREATED DOMESTIC SEWAGE WATER ON THE SOIL CHARACTERISTICS AND YIELD OF COTTON

Qazi Mehmood Ali[1*], Muhammad Ibraheem Keerio[2], Shamsuddin Tunio[2] and Inayatullah Rajpar[2]

[1]*Southern zone Agricultural Research Centre, Karachi University Campus, Karachi, Pakistan*
[2]*Sindh Agriculture University, Tando Jam, Pakistan*
***Corresponding Author:** qazima2001@gmail.com; 021-99261662, 0333-7267278

ABSTRACT

Field experiments for two years during 2013 and 2014 were conducted to study the effect of canal and untreated domestic sewage water on the soil characteristics and yield of cotton, at student farm, Sindh Agriculture University Tandojam. The cotton variety used in the experiment was Haari dost. The study consists of eight treatments with interval of 20 days. Results of analysis of both the treatments revealed that EC, O.M, N, P, K, CO_3, HCO_3, Cl, SO_4, Ca, Mg, Na, K, P, Cd, Pb, Cr, were higher in domestic sewage water as compared to canal irrigation water. pH of experimental field decreased from 7.8 to 7.5 within two consecutive years of domestic sewage water application, whereas increase in EC from 0.86 to 1.39, organic matter from 0.58 to 1.57 %, total Nitrogen from 0.03 to 0.08 %, available Phosphorus from 2.35 to 3.45 $mgkg^{-1}$ and exchangeable Potassium from 180 to 330 $mgkg^{-1}$was increased but the contents found were within permissible limit by FAO and NEQS. Maximum sympodial branches, plant height, productive bolls, boll weight, yield plant^{-1}and ha^{-1} were obtained in T1 followed by T2. The lowest results were recorded in T8. Domestic sewage water can be used for better production of cotton as it increases O.M, Total N, available P and exchangeable K in soil.

Key words: Domestic sewage, soil characteristics, irrigation scheduling, growing period, permissible limit.

INTRODUCTION

Nearly all the agricultural areas of Pakistan are fall in arid and semi-arid climatic zones which are characterized by scanty and low rainfall, high rate of evapo-transpiration and high temperature (GOP, 2006). Under these climatic conditions, artificial irrigation practices are compulsory. Pakistan has worlds' largest gravity flow irrigation system which irrigates more or less sixteen million hectares of agricultural land through water course network, canals and barrages. Per year estimated river flow is 142.3 million acre feet, out of this, 103 MAF is diverted into water courses through canal system (Halcrow, 2003; Anonymous, 2011).

Land and water are natural limited resources but due to unscrupulous and unsystematic utilization, these are diminishing at an alarming status. Now a days, water is becoming the most important limiting natural resource, and to meet the increased demand of agricultural production, more food has to be produced per unit of water available. Hence, its multiple use and re-use is becoming important. In many arid and semi-arid regions where irrigation supplies are insufficient to meet crop water needs, use of sewage water as an alternate supplemental source of irrigation is unavoidable.

Alloway and Ayres (1997) reported that domestic sewage water contains 0.1% suspended, colloidal and dissolved solids of both organic and inorganic nature and 99.9% water. The level of nitrogen, phosphorus and potassium increases in the soil with the application of sewage water. According to Saad *et al.* (2015) dry matter production and yield increased with increase of sewage ratio. In many developing and developed countries, use of municipal sewage water for agriculture purposes is prevalent practice.

In their studeis several researchers have reported the benefits of sewage water irrigation. Epstein *et al.* (1976); USDA (1978); Hassan and Ali (2002) and Hossein *et al*. (2010) reported that sewage water either treated or untreated increases the cation exchange capacity of soil and thus its capacity to retain nutrients. They also reported that sewage water is a good conditioner and a fertilizer, as it contains high nitrogen contents required. According to Chen and Stevenson, (1986); Sommen, (1977) and Mitra and Gupta (2012) irrigation with sewage water can supply all or even more Potassium, Phosphorus and Nitrogen, also valuable micro nutrients that crops require (Panicker, 1995; Nilantha *et al*., 2003).The impact of domestic sewage irrigation on soil may depend on a number of factors such as soil properties, plant characteristics and sources (Mohammed *et al.*, 2014).

Cotton (*Gossypium hirsutum* L.) is an important fiber crop and has economic viability in Pakistan. It is considered the backbone of the national economy due to foreign exchange earnings from the crop.

Keeping in view the importance of impacts of sewage water on soil health and yield of cotton, the present study was designed with the objectives to study the residual effect of domestic sewage water on the soil physico-chemical properties and to determine its effect on cotton yield.

MATERIALS AND METHODS

Selection of Site

A field experiment was designed at student farm Sindh Agriculture University Tandojam, in the year 2013 and 2014. The experiment site was situated at 25.40 N latitude and 68.69 East longitudes at an altitude of 18 meters above the sea level. The experiment was laid out in randomized complete block design (RCBD) with three replications and eight treatments with plot size of 6m x 5m. The treatments of the experiment were as under.

T1 (irrigation by sewage water during the whole growing period), T2 (irrigation by sewage water at 35, 55 and 75 days, and by canal water at 95, 115 and 135 days), T3 (irrigation by sewage water at 35, 75 and 115 days, and canal water at 55, 95 and 135 days), T4 (irrigation by sewage water at 35, 55 and 115 days, and canal water at 75, 95 and 135 days), T5 (irrigation by canal water at 35, 55 and 115 days, and sewage water at 75, 95 and 135 days), T6 (irrigation by canal water at 35, 75 and 115 days, and sewage water at 55, 95 and 135 days), T7 (irrigation by canal water at 35, 55 and 75 days, and sewage water at 95, 115 and 135 days) T8 (irrigation by canal water during the whole growing period).

Collection of soil samples

The soil of the study area was lying in the category of silt loam textured and was of medium fertility status. Before the start of experiment soil samples were collected from 15 spots within the experimental area at depth of 0-60 cm, these samples were mixed well to form one composite sample and this practice was repeated after harvesting of crop both the years. After harvesting of the crop, soil samples were drawn from each treatment at depth of 0-60 cm for various soil tests viz. soil texture by **(**Bouyoucos Hydrometer method), Ec (dS m^{-1}) by (Digital conductivity meter, Model Hi833), pH by (Digital pH meter, model SP-34 Suntex), O.M (%) by (WalkeIy-Black method), total nitrogen (%) by (Kjedahl method), available phosphorus (mg kg^{-1}) by (AB-DTPA method) and exchangeable potassium (mg kg^{-1}) by (AB-DTPA method).

Collection of domestic sewage and canal water

Three samples each of domestic sewage water and canal water were collected in a clean plastic bottles from septic tank (the source of untreated domestic sewage water for irrigating the experiment) and water course for various water tests viz. pH by (Digital pH meter, model SP-34 Suntex), EC (dS m^{-1}) by (Digital conductivity meter, Model Hi833), CO_3^{2-} (meq L^{-1}) by (HCL Tritration Method), HCO_3^{2-} (meq L^{-1}) by (HCL Tritration Method), Cl (meq L^{-1}) by (Tritration method), SO_4^{2-}(meq L^{-1}) by ($BaCl_2$Titration method), Ca^2+ (meq L^{-1}) by (Tritration method), Mg^2+ (meq L^{-1}) by (Tritration with standard versenate solution), Na^+ (meq L^{-1}) by (Flame photometric analysis), K^+ (meq L^{-1}) by (Flame photometric analysis), P (meq L^{-1}) by (AB-DTPA method), Cd (ppm) by (Digestion technique), Pb (ppm) by (Digestion technique) and Cr (ppm) by (Digestion technique).

Land Preparation

The experimental land was prepared by ploughing once with Moldboard plough followed by harrowing two times in order to prepare a fine seed bed for sowing during both the years. The experimental area was then divided into plots as per proposed lay out plan. The plots were dug up lightly with spade and marked 6 m x 5 m apart. All of phosphorus and half quantity of nitrogen were used at the time of sowing in the forms of triple supper phosphate and urea respectively. The fertilizers were seed dressed at 5 cm away from seed and 4 to 5 cm deep in opened line. The remaining half dose of nitrogen in the form of urea was applied in two split applications i.e. at 2^{nd} and 3^{rd} irrigation after sowing in circumference of 5 cm from the plant.

Sowing of cotton seed

Haari dost, a certified cotton seed was used, and sown by dibbling method. Three seeds were dibbled per spot at distance of 75 cm in the rows and 22.5 cm in plants to ensure even crop stand and to maintain required plant population. Germination was recorded 6 days after sowing and gap filling was done 8 days after sowing and the crop was thinned at 20 days after sowing to ensure stand of one plant per spot after thinning. The irrigations were applied according to the proposed irrigation scheduling. Weeding was done manually by hand three times (20, 45 and 60 DAS) during crop growth.

Statistical Analysis

Data on various parameters recorded from field experiments were statistically analyzed using Statistix 8.1 software programme. The mean values of results were compared by Duncan's Multiple Range test (DMRT) at p = 0.05 (Gomez and Gomez, 1984).

RESULTS

Water samples of canal and domestic sewage water were analyzed to evaluate the suitability of sewage water as a source of irrigation. Results of analysis of both the waters given in Table 1 revealed that, pH of canal water was 7.3 that decreased with addition of domestic sewage water. The pH of domestic sewage water was 6.80.

EC: $dS.m^{-1}$ of canal water was 0.47 that increased with addition of domestic sewage water. The EC: $dS.m^{-1}$ of domestic sewage water was 2.85. CO_3 ($meq.L^{-1}$) of canal water was 0.37 and it was gradually increasing with addition of domestic sewage water. The contents of CO_3 ($meq.L^{-1}$) of domestic sewage water were 0.47. HCO_3 (meq. L^{-1}) in canal water was 1.11 and that were increasing gradually with addition of domestic sewage water. The contents of HCO_3 (meq. L^{-1}) of domestic sewage water were 1.47.

Cl (meq. L^{-1}) of canal water was 1.10 and it was increasing gradually with addition of domestic sewage water. The Cl (meq. L^{-1}) in domestic sewage water was 1.38. SO_4 (meq. L^{-1}) of canal water was 2.60 and it was increasing gradually with addition of domestic sewage water. SO_4 (meq. L^{-1}) of domestic sewage water was 3.69. Ca (meq. L^{-1}) of canal water was 1.40 and it was increasing gradually with addition of domestic sewage water. The Ca (meq. L^{-1}) of domestic sewage water was 1.92.

Mg (meq L^{-1}) of canal water was 0.60 and it was increasing gradually with addition of domestic sewage water. The Mg (meq L^{-1}) of domestic sewage water was 0.81. Na (meq. L^{-1}) of canal water was 1.60 and it was increasing gradually with addition of domestic sewage water. The Na (meq L^{-1}) of domestic sewage water was 2.09.

N of canal water was 3.31 (meq. L^{-1}) and it was gradually increasing with addition of domestic sewage water. The N content of domestic sewage water itself was 6.05 (meq. L^{-1}). P (meq. L^{-1}) in canal water and domestic sewage was 5.31 and 9.18, respectively. Increase was recorded with higher ratios of domestic sewage water applications. K content (meq L^{-1}) of canal water was 1.20 and it was gradually increasing with addition of domestic sewage water. K (meq. L^{-1}) of domestic sewage water was 2.36. Presence of organic matter detected in canal water was 0.57 % and it was recorded increasing gradually with addition of domestic sewage water. The O.M in domestic sewage water was 1.04 %.

Cd ($mgkg^{-1}$) recorded in canal and domestic sewage water was 0.01 and 0.02 respectively. Pb ($mgkg^{-1}$) recorded in canal water was 0.18 and in domestic sewage water was 0.20 that was slightly increasing with addition of domestic sewage water. Cr ($mgkg^{-1}$) recorded in canal water was 0.05 and in domestic sewage water was 0.20. The content was increasing slightly with addition of domestic sewage water.

Table 2 revealed that, soil texture of the experimental field before conducting field experiment was silt loam and the texture of the field did not changed for following two years of the experiment. pH of the experimental field, before experiment was 7.80, it was decreased to 7.60 after the first year of experiment and further decreased to 7.50 after the harvest of the second-year experiment. Before the execution of the experiment, the EC dSm^{-1} of the field was 0.86, which raised to 1.12 and 1.39 for the first and second year of the experiment respectively. O.M %percent in the soil before experiment was 0.58, which was increased to 1.48 in the first year and further increased to 1.57 in the second year of experiment. Total N % in the experimental area was 0.03, which was raised to 0.07 and 0.08 for the first and second year of the experiment respectively. Available P ($mgkg^{-1}$) was recorded as 2.35 in the field before experiment; it was increased to 3.17 in the first year and 3.45 in the second year of the experiment. Exchangeable K ($mgkg^{-1}$) was recorded as 180.00 in the field before experiment; it was raised to 242.00 and 330.00 for the first and second year of the experiment, respectively.

Table 3 indicated that, highest pH (7.80) was recorded in sole canal water irrigation treatment and lowest pH (7.10) was recorded in sole domestic sewage water irrigation treatment in the first year of experimentation. In the second year of the experiment, pH in sole canal irrigation treatment raised to 7.82, while the pH of sole domestic sewage water irrigation treatments was lowered to 7.05. The results also revealed that, with addition of domestic sewage water as irrigation, pH decreases gradually.

The highest EC: (dS. m^{-1}) 1.39 was recorded in sole domestic sewage water treatment and lowest 0.89 was recorded in sole canal water irrigation treatment in the first year. In the second year of experiment it was increased to 1.41 in sole domestic sewage irrigation treatment, in the same way it was also slightly increased to 1.00 in canal irrigation treatment.

The highest O.M 1.48 % was recorded in domestic sewage water irrigation treatment in the first year, which increased to 1.54 % in the same treatment in the second year of experiment. The lowest 0.58% was recorded in the treatment in which sole canal irrigation water was applied in the first year of experiment, which slightly raised to 0.59 next year. It is observed that, organic matter increases with addition of domestic sewage water.

Table 3 also depicted that the highest available P (mg.kg^{-1}) 3.17 was recorded in sole domestic sewage water irrigation which was increased to 3.22. The lowest 2.35 was recorded in sole canal water irrigation treatment, which was slightly increased to 2.40 in the same treatment in the second year of the experiment. It was also observed that, with the addition of domestic sewage water, P contents in the soil also increased in all the treatments. Maximum exchangeable K (mg.kg^{-1}) 242.00 was recorded in sole domestic sewage water irrigation treatment, which was increased to 250.80 in the next year of experiment. Whereas minimum 180.00 was recorded in sole canal water irrigation treatment, which was slightly increased to 184.62 in the successive year of the experiment. Increasing trend of Exchangeable K in the experimental field was observed in treatments in which domestic sewage water was used. The highest % of N 0.07 was recorded in the sole domestic sewage water irrigation treatment in the first year of experiment, which was increased to 0.08 in the next year of the experiment. The lowest recorded was 0.03 in the treatment in which sole canal water was applied, and no improvement was recorded in the next year of the experiment.

Table 1. Physicochemical characteristics of canal and sewage water.

Parameters	100% Canal water	100% Sewage water	FAO	NEQS
pH	7.43	6.80	6.5- 8.5	6 - 9
EC (dS.m^{-1})	0.47	2.85	3	NGVS
CO_3 (meq. L^{-1})	0.37	0.47	6	NGVS
HCO_3 (meq. L^{-1})	1.11	1.47	600	NGVS
Cl (meq. L^{-1})	1.10	1.38	1100	1000
SO_4 (meq. L^{-1})	2.60	3.69	1000	1000
Ca (meq. L^{-1})	1.40	1.92	400	NGVS
Mg (meq. L^{-1})	0.60	0.81	60	NGVS
Na (meq. L-^{1})	1.60	2.09	900	NGVS
N (meq. L-^{1})	3.31	6.05	NGVS	NGVS
P (meq. L^{-1})	5.31	9.18	NGVS	15
K (meq. L^{-1})	1.20	2.36	0.2	NGVS
O.M (%)	0.57	1.04	NGVS	NGVS
Cd (mg.Kg^{-1})	0.01	0.02	0.01	0.1
Pb (mg. Kg^{-1})	0.18	0.31	2	0.5
Cr (mg. Kg^{-1})	0.05	0.20	0.1	1

NGVS = no guideline value set.

The results in Table 4 revealed that, sole canal water application produced maximum germination 81.33%and lowest plant height 125.00 cm. Sole domestic sewage water application produced lowest germination 79.50% and highest plant height 130.33cm. The table 4 also indicated that, germination % was higher in treatments in which first irrigation was done with canal water, and germination% was low in treatments in which first irrigation was done with domestic sewage water.

The results of Table 4 also indicated that, maximum numbers of sympodial branches 15.00 were recorded in sole domestic sewage application method, followed by treatment 2, with sympodial branches 12.66. The lowest sympodial branches 10.33 were recorded in sole canal irrigation application treatment.

Productive bolls plant^{-1} as affected by sewage and canal water scheduling were statistically non- significant at 5% probability level. The results revealed that, maximum productive bolls plant^{-1}27.16 were recorded in sole sewage irrigation schedule, persuaded by treatment 2 with productive bolls 26.33. The lowest productive bolls 24.16were observed in treatment, in which sole canal irrigation water was applied.

Table 2. Soil tests before experiment and after harvest of crop each year (2013 & 2014).

Parameters	Soil test before experiment (0-60 cm)	Soil test at 1st year (2013) harvesting (0-60 cm)	Soil test at 2nd year (2014) harvesting (0-60 cm)
SOIL TEXTURE	Silt loam	Silt loam	Silt loam
Sand (%)	15	15	15
Silt (%)	60	60	60
Clay (%)	25	25	25
pH	7.80	7.60	7.50
EC:(dSm^{-1})	0.86	1.12	1.39
OM (%)	0.58	1.48	1.57
Total N (%)	0.03	0.07	0.08
Available P ($mgkg^{-1}$)	2.35	3.17	3.45
Exchangeable K($mgkg^{-1}$)	180.00	242.00	330.00

Table 3. Treatment wise soil test at the time of harvest (0-30 cm).

Treatments	Soil Texture	pH		EC: (dS. m^{-1})		OM (%)		Available P ($mgkg^{-1}$)		Exchangeable K ($mgkg^{-1}$)		N total (%)	
		2013	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**
(S+S+S+S+S+S)	Silt Loam	7.10	7.05	1.39	1.41	1.48	1.54	3.17	3.22	242.00	250.80	0.07	0.08
(S+S+S+C+C+C)	Silt Loam	7.50	7.44	0.99	1.20	1.21	1.00	2.55	2.99	208.95	215.50	0.06	0.05
(S+C+S+C+S+C)	Silt Loam	7.30	7.25	0.89	1.10	0.76	0.82	2.88	2.84	206.30	212.62	0.04	0.04
(S+S+C+C+S+C)	Silt Loam	7.30	7.26	0.89	1.10	0.78	0.82	2.58	2.84	201.60	211.89	0.04	0.04
(C+C+S+S+C+S)	Silt Loam	7.28	7.23	1.00	1.20	0.80	0.84	2.64	2.98	211.50	214.75	0.04	0.04
(C+S+C+S+C+S)	Silt Loam	7.30	7.25	1.11	1.21	0.81	0.84	2.58	2.98	215.60	218.50	0.04	0.04
(C+C+C+S+S+S)	Silt Loam	7.20	7.18	1.21	1.25	1.25	1.21	2.88	3.00	222.40	225.75	0.06	0.06
C+C+C+C+C+C)	Silt Loam	7.80	7.82	0.89	1.00	0.58	0.59	2.35	2.40	180.00	184.62	0.03	0.03

S = Sewage water and C, canal water.

Table 4. Effect of sewage and canal irrigation scheduling on agronomic parameters.

Treatment	Germination %	Plant Height (cm)	Sympodial plant^{-1}	Productive Bolls plant^{-1}	Boll weight plant^{-1} (g)
(S+S+S+S+S+S)	79.50a	130.33a	15.00 a	27.16a	3.36a
(S+S+S+C+C+C)	80.16a	130.17a	12.83 ab	26.33a	3.13b
(S+S+C+C+S+C)	80.50a	129.67ab	12.66 ab	25.83a	3.04bc
(C+C+S+S+C+S)	81.16a	129.67ab	12.33 b	25.16a	3.02bc
(S+C+S+C+S+C)	80.50a	127.33a-c	11.33 b	25.00a	2.99bc
(C+S+C+S+C+S)	80.83a	126.33a-c	10.83 b	24.83a	2.97c
(C+C+C+S+S+S)	81.16a	125.50bc	10.83 b	24.50a	2.95c
(C+C+C+C+C+C)	81.50a	125.00c	10.33 b	24.16a	2.89c
Prob:	ns	ns	ns	ns	**
S.E	0.84	1.41	0.84	1.44	0.05
LSD (5%)	1.19	1.99	1.19	2.04	0.07

ns (non-significant). Figure followed by similar letter are not significantly different at p = 0.05.

Table 5. Effect of sewage and canal irrigation scheduling on physiological and yield parameters.

Treatment	Total Dry Matter (g)	Ginning Out Turn	Yield Plant^{-1} (g)	Yield ha^{-1} (Kg)
(S+S+S+S+S+S)	199.03a	35.00a	69.23a	3876.9a
(S+S+S+C+C+C)	189.80b	34.83ab	61.87ab	3465.0ab
(S+S+C+C+S+C)	182.07c	34.66ab	57.53b	3221.8b
(C+C+S+S+C+S)	180.02cd	34.66ab	56.55b	3167.3b
(S+C+S+C+S+C)	179.37cd	34.50ab	55.41b	3103.3b
(C+S+C+S+C+S)	178.75cd	34.16ab	55.35b	3099.7b
(C+C+C+S+S+S)	177.80cd	34.00ab	54.92b	3075.7b
(C+C+C+C+C+C)	174.25d	33.83b	54.04b	3026.7b
Prob:	**	n.s.	*	*
S.E	1.91	0.34	2.94	164.99
LSD (5%)	2.71	0.48	69.23a	3876.9a

n.s (non-significant). Figure followed by similar letter are not significantly different at p = 0.05.

Table 4 also showed that maximum boll weight 3.36 g were recorded in sole sewage application method, followed by treatment 2 which gained the boll weight of 3.13 g. The results also indicated that, minimum boll weight 2.89 g was recorded in sole canal irrigation application treatment. Total dry matter as affected by sewage and canal water scheduling was highly significant at 5% probability level. The results exhibited that, maximum TDM (g) 199.0 was recorded in sole sewage irrigation schedule, persuaded by treatment 2 with, TDM 189.80 and lowest 174.25 g was observed in treatment, in which sole canal water was applied (Table 5).

Statistical analysis of variance for ginning out turn (GOT) were non-significantly different at 5 % probability level. The results exhibited that, highest GOT (35.00) was recorded in sole domestic sewage water irrigation scheduling treatment, followed by treatment 2, which produced (34.83) GOT. The lowest GOT (4.00 and 33.83) were recorded in treatment in which canal water was solely applied for irrigation

Statistical analysis of variance for yield plant^{-1} and yield ha^{-1} were significantly different at 5% probability level. The results in table 5 indicated that, yield plant^{-1}(g) and yield ha^{-1}(kg) 7.33, 69.23 and 3876.9, respectively were recorded in sole sewage water irrigation scheduling treatment, followed by treatment 2, yield plant^{-1} (61.87) and yield ha^{-1} (3465.00). The minimum yield $plant^{-1}$ and yield ha^{-1}54.04 g and 3026.7 kg, respectively were recorded in treatment in which canal irrigation water was applied solely.

DISCUSSION

Sewage water, with proper management, usually produces a water of suitable quality that can be used for irrigation purposes with minimum impacts on human health or the environment (Qishlaqi*et al.,* 2008; Hofstedt, 2005). According the results of water analysis, it was indicated that all the critical parameters viz: soil pH, EC, Total Nitrogen, Available Phosphorus, Exchangeable Potassium, CO_3, HCO_3, Cl, SO_4, Ca, Mg, Na, K, P, Cd, Pb and Cr in both types of water (domestic sewage and canal water) were in permissible limit of NEQS,2005; FAO, 1993). Generally, domestic sewage effluent contained more nitrogen, phosphorus, and potassium compared to those found in canal water (Salms, 2004; Abedi and Najafi; 2001; Alloway and Ayres, 1997). Heavy metals (Cd, Pb and Cr) were more in domestic sewage water as compared to canal water, but were in permissible limits of FAO and NEQS. The results are in agreement with Hussein *et al.* (2010) and in contradiction with Al-Enezi e*t al.* (2004) who reported that untreated wastewater contains heavy metals (Cu, Zn, Pb, Cd, Cr, Ni) which are not only toxic to human health but also pollutes the environment. The results also indicated that, domestic sewage water is rich in organic matter (Weber *et al.*, 1996; Munir *et al.* (2007) and other plant nutrients. The results are in accordance with Khurana and Singh (2012), O'Riordan *et al*. (1983) and Hossein *et al*. (2010) who reported that high content of nitrogen, phosphorus and potassium in sewage water strengthens its high manural value for field crops and irrigating with sewage water could add enough N, P, K and S to meet the nutrient requirement of the crops.

The results also indicated that organic matter in domestic sewage water 1.04 as compared to 0.57 in canal irrigation water. The results were in agreement with O'Riordan *et al*. (1983), Ramesh (2003), Antil and Narwal (2008), Sashikanth (2010), Hossein *et al.* (2010) and Kharche *et al.* **(**2011) who proved that the effect of continuous irrigation with sewage water on soil properties like organic carbon was high as compared to soils irrigated with normal water, as domestic sewage water contains 40-50% organic carbon.

It is reported that most crops give higher than potential yields with wastewater irrigation. Several researchers have documented the effects of effluent application on cotton yield and fiber quality (Bieloral *et al.*, 1984; Day and McFayden,1984; Oron and DeMalach, 1987, Papadopoulos and Stylianon, 1998; Alves *et al.*, 2006).

Results showed that crop irrigated with domestic sewage water significantly affected the boll weight (g), yield $plant^{-1}$ and yield ha^{-1}at $P< 0.05$. The significant increase in above mentioned parameters may possibly be due to the quantity of nutrient elements (N, P and K) and organic matter in domestic sewage water is more than that in freshwater and applying domestic sewage water is a type of fertigation which results in increases in cotton yield. The results agree with Alikhasi *et al.* (2012); Silva *et al.* (2009) and Boquet *et al.* (2004) who examined parameter of growth and development of cotton plants when irrigated with wastewater and well water and observed that the height of plants irrigated with wastewater had always been above the well water irrigated plants. Similar results were reported by Tsakou *et al.* (2001) who reported faster development and significant root and shoot biomass production of cotton (*Gossypium hirsutum* L.) grown on sludge-amended soil.

Respecting to higher cotton yield in sewage water treatments (Table 5) the results agree with Saad *et al.* (2015); Alikhasi *et al.* (2012); Silva *et al.* (2009) and Bezerra *et al*. (2008) who examined parameter of growth and development of cotton plants when irrigated with wastewater and well water and found that highest cotton yield was achieved when cotton crop was irrigated with sewage water. Similar results also supported by Tsadilas and Vakalis (2003) who reported that in the case of cotton, wastewater use, increased significantly the agricultural income in comparison to the canal water and gave about 64% higher agricultural income over control treatment.

Conclusion

It may be concluded that the domestic sewage water may be used for irrigation of crop to increase crop yield and to save canal water for other purposes.

REFERENCES

Abedi, M.J and P. Najafi (2001).*Wastewater treatment and use in agriculture.* Report of Iranian National Committee on Irrigation and Drainage, pp. 240.

Al-Enezi., G.M.F. Hamoda and N. Fawzi (2004). Ion exchange extraction of heavy metals from wastewater sludges. *J. Environ. Sci. Health*, 39(2): 455-464.

Alikhasi, M., M. Kouchakzadeh and E. Baniani (2012). The effect of treated municipal wastewater irrigation in non-agricultural soil on cotton plant. *J. Agr. Sci. Tech.*, 14: 1357-1364.

Alloway, B.J and D.C. Ayres (1997). *Chemical Principles of Environmental Pollution.* 2nd Edn. Chapmann and Hall Inc. London, UK., pp: 208-211.

Alves, W.W., C.V. Azevedo., C.B. Rogaciano., D.N. José and E.M. Napoleão (2006). Effect of treated wastewater, nitrogen and phosphorus on quality of the brown fiber cotton. American Society of Agricultural and Biological Engineers, Annual Meeting.

Anonymous (2011). Government of Pakistan, Ministry of Economic Affairs and Statistics,

Statistics Division. "Overall Water Availability". *Pakistan Statistical Year Book 2011*. http://www.pbs.gov.pk/sites/default/files/other/yearbook2011/AGRIC./1-15.pdf.

Antil, R.S and R.P. Narwal (2008). Influence of sewer water and industrial effluents on soil and plant health. In: *Groundwater resources: Conservation and management*, V.D. Puranik, V.K. Garg, A. Kaushik, C.P. Kaushik, S.K. Sahu, A.G. Hegde, T.V. Ramachandarn, I.V. Saradhi & P. Prathibha, (Ed.), 37-46, Department of Environmental Science and Engineering, GJU Science and Technology Hisar, India.

Bezerra, M.A., R.E. Santelli., E.P. Oliveira., L.S. Villar and L.A. Escaleira (2008). Response surface methodology (RSM) as a tool for optimization in analytical chemistry. *Talanta.*76: 965-977

Bieloral. H., I. Vaisman and A. Feigin (1984).Drip irrigation of cotton with treated municipal effluents: *J of Environ.Qual*., 13(2): 231-234.

Boquet,D.J., R.L. Hutchinson and G.A. Breitenbeck (2004). Long term tillage, cover crop and nitrogen rate effects on cotton: plant growth and yield components. *Agron. J.,* 96: 1443–1452.

Chen, Y. and F.J. Stevenson (1986). Soil organic matter interactions with trace elements. *The role of organic matter in modern agriculture.* Chen, Y and Y. Avnimellech (Eds.). Martinus Nijhoff Publishers, Dordrocht, The Netherlands, pp: 73-116.

Day, A.D. and J.A. McFayden (1984). Yield and quality of cotton grown with wastewater. *Biocycle*, 25(3): 35-37..

Ensink, H.J.J., H.W Van der., Y. Matsuno., S. Munir and M.R. Aslam (2002). *Use of untreated wastewater in peri-urban agriculture in Pakistan: risks and opportunities.* Research Report 64, International Water Management Institute.

Epstein, E., J.M. Taylor. and R.L. Channey (1976). Effect of sewage sludge applied on soil on some physical and chemical properties. *J. Environ. Qual.,* 5: 422-426.

FAO (1993). *Wastewater management for agriculture*, RENA Technical Bulletin Series, Cairo, Egypt.

Gomez, K.A. and A.A. Gomez (1984). *Statistical Procedures for Agricultural Research* (2ed.) John wiley and sons, NewYork, 680p.

Government of Pakistan (2006). *Pakistan Agricultural Census Report.* Pakistan Census Organization, Islamabad.

Halcrow (2003). *Exploitation and regulation of fresh groundwater—main report*. ACE-Halcrow JV Consultants, Gulberg III, Lahore, Pakistan.

Hassan, M.U. and N. Ali (2002). Potential for Blue-Gray Water Trade-offs for Irrigation in Small Towns of Pakistan: A Case Study of Farmers'Costs and Benefits in Haroonabad.*The Pakistan Development Review*, 41:2 (Summer 2002) pp. 161–177.

Hofstedt, C (2005). *Wastewater use in Agriculture in Andhra Pradesh, India: An evaluation of irrigation water quality in reference to associated health risks and agricultural suitability.* M.Sc thesis, Deptt: of Soil Science, Swedish University of Agric. Sci. Ulls vag, 17, SE 756 51 UPPSALA.

Hossein, H.D., M. Manshouri and H.A. Farahani (2010). The effect of irrigation by domestic waste water on soil properties.*Journal of Soil Science and Environmental Management*, 1 (2): 030-033.

Kharche, V. K., V. N. Desai and A, L. Pharande (2011). Effect of sewage irrigation on soil properties, essential nutrient and pollutant element status of soils and plants in a vegetable growing area around Ahmednagar city in Maharashtra. *J. Ind. Soc. Soil Sci*., 59 (2): 177-184.

Khurana, M.P.S and P. Singh (2012). Waste water use in crop production: A Review. *Resources and Environment*, 2(4): 116-131.

Kiziloglu, F.M., M. Turan., U. Sahin., Y. Kuslu and A. Dursun (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.

Mitra, A and S.K. Gupta (2012). Effect of sewage water irrigation on essential plant nutrients and pollutant element status in a vegetable growing area around Calcutta. *Journal of Indian Society of Soil Science*, 47: 99-105.

Mohammed A. Alghobar., L. Ramachandra and S. Suresha (2014). Effect of Sewage Water Irrigation on Soil Properties and Evaluation of the Accumulation of Elements in Grass Crop in Mysore City, Karnataka, India. *American Journal of Environmental Protection.* 3 (5): 283-291. doi: 10.11648/j.ajep.20140305.22.

Munir, J.M., S. Rusana., Hinnawi and L. Rousan (2007). Long term effect of wastewater irrigation of forage crops on soil and plant quality parameters. *Desalination*, 215: 143-152.

NEQS (2005). National Environmental Quality Standards for municipal and liquid industrial effluents.

Nilantha. H., T. Weaver., A. Hicks and L. Campbell (2003). Irrigating cotton with treated sewage. *The Australian Cottongrower*, 24 (3): 41.

O' Riordan, E.G., V.A. Dodd., H. Tunney and G.A. Fleming (1983). The chemical composition of sewage sludges. *Ireland Journal of Agriculture Research*, 25: 239-49.

Oron. G and Y. DeMalach (1987). Response of cotton to treated domestic wastewater applied through trickle irrigation. *Irri Sci.,* 8(4): 291-300.

Panicker, P. V. R. C. (1995). Recycling of Human Waste in Agriculture and Aquaculture: In *Recycling of Wastes in Agriculture*, Tandon, H.L.S. (Eds.). Fert. Dev. Consultation Org., New Delhi, India, pp: 68-90.

Papadopoulos. I and Y. Stylianous (1988). Trickle irrigation of cotton with treated sewage effluent.. *J. Environ Quality*, 17(4): 574-580. 207.

Qishlaqi, A., F. Moore and G. Forghani (2008). Impact of untreated wastewater irrigation on soils and crops in Shiraz suburban area, SW Iran. *Environmental Monitoring and Assessment.* 141(1-3):257-273.

Ramesh, M (2003). *Soil and water resource characteristics in relation to land disposal of sewage effluents and suitability of sewage water for irrigation.* M.Sc. *(Ag.)* Thesis. Acharya N.G. Ranga Agricultural University, Hyderabad, India.

Saad, A.M., G.M. Marwa., M.A Bayoumi., M.G. Zoghdan and R.A. El-Dissoky (2015). Sustainable safe reuse of drainage water in agriculture at North delta soils, *Egypt. Journal of Chemical and Pharmaceutical Research,* 7(5):1033-1043.

Salma (2004). *Environmental impacts of wastewater irrigation*. Msc thesis. Faculty of Agricultural Engineering and Technology University of Agriculture, Faisalabad.

Sashikanth (2010). *Evaluation of pesticide residues in soil, water and crop along the course of river Musi, Hyderabad.* M.Sc (Ag) Thesis, Acharya N.G. Ranga Agricultural University, Hyderabad.

Silva, G.M., S. Alcantara., D.V. Pérez., R.A. Almeida., J.C. Polidoro and W. Bettiol (2009). Chemical changes and heavy metal partitioning in an oxisol cultivated with maize (*Zea mays*L.) after 5 years disposal of domestic and industrial sewage sludge. *Water, Air, and Soil Pollution,* 203: 3-16.

Sommen, L.E (1977,). Chemical composition of sewage sludge and analysis of their potential use as fertilizer. *J. Environ. Qual*., 6: 225-235.

Tsadilas, D.C and P.S. Vakalis (2003). Economic benefit from irrigation of cotton and corn with treated wastewater. *Water Science and Technology, Water Supply*. 3 (4): 223–229.

Tsakou, A., M. Roulia and N.S. Christodoulakis (2001). Growth of cotton plants (*Gossypium hirsutum*) as affected by water and sludge from a sewage treatment plant: I. Plant phenology and development. Bull Environ Contam. *Toxicology*. 66: 735–742.

USDA (1978). *Improving soils with organic wastes*. Office of the Secretary of Agriculture.

Weber, B., Y. Avnimelech and M. Juanico (1996). Salt enrichment of municipal sewage - new prevention approaches in Israel, *Environ. Manage.*, 20 (4): 487-495.

(*Accepted for publication December 2018*)