Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(1): 2207-2213
Received: 13-11-2019
Accepted: 15-12-2019

Nischitha D Gowda
Department of Agronomy, UAHS Shivamogga, Karnataka, India

GK Girijesh
Professor Department of Agronomy, UAHS Shivamogga, Karnataka, India

BC Dhananjaya
Assistant Professor
Dept. of Soil Science
UAHS Shivamogga, Karnataka, India

Corresponding Author
Nischitha D Gowda
Department of Agronomy, UAHS Shivamogga, Karnataka, India

Effect of irrigation with sewage water on performance of groundnut (*Arachis hypogea* L.) and soil properties

Nischitha D Gowda, GK Girijesh and BC Dhananjaya

Abstract
A field experiment to study the "Effect of irrigation with sewage water on performance of groundnut (*Arachis hypogea* L.) and soil properties" was carried out at College of Agriculture, Shivamogga under irrigated condition during summer 2018. The experiment was laid out under randomized complete block design with nine treatments replicated thrice. Irrigable water (IR), treated sewage water (TSW) and untreated sewage water (UTSW) alone and in conjunctive mode in different proportion were used as treatments. Irrigation with untreated sewage water alone has recorded the highest number of pods per plant (20.37), pod weight per plant(14.14 g), pod yield (2534 kg ha^{-1}) because of high nutrient content of untreated sewage water (13.49 ppm of N, 18.94 ppm of P and 19.03 ppm of K) without any toxic and heavy metals. The quality parameters *viz*., shelling percentage (65.19 g), oil content (51.67%) and protein content (25.73%) were also found highest in plots irrigated with untreated sewage water. Soil irrigated with UTSW alone significantly increase soil available nitrogen (295.16 kg ha^{-1}), phosphorous (84.13 kg ha^{-1}) and potassium (128.84 kg ha^{-1}).

Keywords: Irrigation, sewage water, *Arachis hypogea*

1. Introduction
Even though three fourth of earth's surface is covered with water, only three percentage of it is available for the use of mankind. Begum *et al.* (2008) [3] stated that about 95 per cent of the earth's water is in the ocean, four per cent is locked in the polar ice caps and remaining one per cent constitutes in hydrological cycle including ground water reserves. Only 0.1 per cent is available as fresh water in rivers, lakes and streams which is suitable for human consumption. Water is a vital but a severely limited resource in most of developing countries.

The average availability of water is reducing steadily with the growing population, and it is estimated that by 2020, India will become a water-stressed nation. Hence, the use of wastewater has been a common practice, especially in the peri-urban areas (Narin *et al.*, 2013) to meet the challenges of scarce water resource in terms of sustainability, food and income security and environmental safety. However, use of waste water as a supplemental source of irrigation is inevitable for increased agricultural production in many arid and semiarid regions where irrigation supplies are insufficient to meet crop water needs. Further, as these sewage water is good source of plant nutrients and their usage in crop production as an supplimental source of nutrients would help in maintaining soil fertility. Usage of sewage water promotes the concept "Wealth out of waste in order to have green and clean Earth".

An estimated 38,354 million liters of sewage water per day is presently generated in India (Kaur *et al*., 2016). Which accounts for nutrient potential of available sewage in India is more than 33,000 tonnes of N, 700 tonnes, of P and 20,000 tonnes of K $year^{-1}$ (Sreeramulu., 2017) [19]. Land application of sewage water in agriculture may be a more preferred option as it provides an opportunity to recycle the plant essential nutrients and organic carbon (OC) to soil. A huge quantity of waste water is being generated from cities and other industrial areas which is flowing to a river or joined with streams towards the village where most of the people are earning their lively hood through agriculture. The present investigation was taken up to see effect of sewage water usage on performance of summer groundnut and soil properties.

2. Material and Methods
2.1 Experimental system and treatments
Experiment was conducted in summer 2018 to study the effect of irrigation with sewage water on performance of groundnut (*Arachis hypogae*a L.) and soil properties at Agronomy Field Unit, University of Agricultural and Horticultural Sciences, Navile, Shivamogga, Karnataka,

India with nine treatments and three replications The experimental site is situated in Southern Transition Zone of Karnataka situated at latitude 14°0' N to 14º 1' N and 75° 40' E to 75º 42' E longitude with an altitude of 650 meters above mean sea level. The soil of the experimental site is red sandy loam in texture with acidic pH (6.02), low in organic carbon (3.12 g kg^{-1}) and available N (282 kg ha^{-1}), medium in available potassium (122 kg ha^{-1}), whereas, high in available phosphorous (79.64 kg ha^{-1}).

Untreated sewage water was collected from the students residential hostels, staff quarters, substantial amount of additional sewage is being produced from different office buildings, laboratories of the College and research wings. The sewage water treatment plant was established in the university to collect the sewage. The collected untreated sewage water will be treated with Sequencing Batch Reactor (SBR) system that has 25 kilo litres per day (KLD) capacity. Irrigable water was collected from the pond situated in university campus and used for irrigation. Treatments comprised irrigable water, treated sewage water and untreated sewage water alone and in conjunctive mode in different proportion in the cyclic form. Treatments consist of irrigable water application (T_1), Treated sewage water application (T_2), Untreated sewage water application (T_3), Irrigable water and treated sewage water applied alternatively (T_4), Irrigable water and untreated sewage water applied alternatively (T_5), Two times Irrigable water application *fb* one time treated sewage water (T_6), Two times Irrigable water application *fb* one time untreated sewage water (T_7), One time Irrigable water application *fb* two times treated sewage water (T_8), One time Irrigable water application *fb* two times untreated sewage water (T_9).

Untreated, treated sewage water and irrigable water samples were analyzed for different physicochemical parameters as per the methods given AOAC Official methods of analysis, 1990. All growth parameters were recorded at 30, 60, 90 DAS and at harvest and yield parameters were recorded at harvest. After each cycle of irrigation and at harvest soil samples were collected and analyzed for chemical properties like pH, EC, organic carbon, available N, P, K and Na. For estimating soil pH, soil and water in the ratio 1:2.5 was used to prepare solution and subjected for potentiometric method; Electrical conductivity of soil was analyzed by using the previously prepared solution and fed to conductivity meter. For soil organic carbon estimation, sieved soil of known quantity was taken, digested with $K_2Cr_2O_7$ and H_2SO_4, subjected for titrimetric analysis by using ferrous sulfate (Walkley and Black, 1934) [21]. Available N of soil was determined by adopting alkaline potassium permanganate method, involving $KMnO_4$, H_2SO_4, boric acid and other chemicals (Subbaiah and Asija, 1956) [20]. Available P_2O_5 of soil was analyzed using Brays method by using Brays No. 1 extractant and activated charcoal and determined by colorimetric method (Jackson, 1973). Available K_2O of soil was determined by flame photometry using ammonium acetate extractant. The sodium of soil was also determined by using Flame photometer method (Jackson, 1973) [10].

Shelling percentage is calculated by taking weight of all the matured pods of ten sample plants. These were hand decorticated to separate the kernels and the weight of the kernels was taken. The ratio of kernel weight to pod weight expressed in percentage was taken as the shelling percent. Oil content of kernels of each treatment was determined by Pulse Nuclear Magnetic Resonance (NMR) technique and expressed as percentage (Tiwary *et al*., 1984). Oil content was multiplied by the kernel yield to obtain the oil yield for each treatment. Oil yield was expressed in kg ha^{-1}. Crude protein content in groundnut seeds was estimated by multiplying nitrogen content of kernel with a factor 6.25.

Five plants were selected at random and labeled in each net plot for recording observations on growth and yield parameters at 30 DAT, 60 DAT, 90 DAT and at harvest. The data was analyzed statistically for test of significance following the procedure described by Gomez and Gomez (1984). The results have been discussed at the probability level of five per cent. The level of significance used in "F" was p=0.05.

3. Results

3.1 Characteristics of Irrigation Water

The pH of water sources varied from 7.30 to 7.79. Highest pH was realised in untreated sewage water (7.79) followed by treated sewage water (7.54). The least was in irrigable water (7.30). The electrical conductivity (EC) of irrigable water (0.54 dS m^{-1}) was found much lower than that of both treated and untreated sewage water (0.92 to 1.33 dS m^{-1}). These recorded variations of different sources again found well within the permissible limits of 3.00 dS m^{-1} as outlined by FAO (1985). The BOD of treated (32.30 meq L^{-1}) and untreated sewage water (73.83 mg L^{-1}). The COD values of different sources of water used varied from 105.32 to 154.08 meq L^{-1}.The total dissolved solids (TDS) in treated (436.83 meq L^{-1}) and untreated sewage water (715.84 meq L^{-1}).

Among the basic cations, Na^+ was dominant in sewage water (14.37 to 17.62 meq L^{-1}) compared to other water sources, which was lower than 40.00 meq L^{-1}a critical value above which water is not safe to use (FAO 1985). The bicarbonate content was also quite low in the different sources of water used (18.81 to 25.23 mg L^{-1}) suggesting that these levels are not toxic.

Irrigable water poses total nitrogen to the extent of 6.18 ppm while that of treated was 10.71ppm. But the total nitrogen in treated (13.49 ppm) sewage water was found higher than the sources mentioned and also exceed the recommended maximum concentration of 10ppm (FAO 1985). The phosphorus content in different sources of water used ranged from 10.29 to 18.94 ppm indicating above the critical concentration of 2.00 ppm. Likewise, the concentration of potassium content (9.46 to 19.03 ppm) in various sources of water was also higher than the critical value (2.00 ppm). This also envisages the richness of essential macronutrients in water sources.

All the heavy metals *viz.*, cobalt, arsenic, boron and nickel were higher in untreated sewage water (0.004, 0.004, 0.035 and 0.004ppm) followed by treated sewage water (0.001, 0.002, 0.017 and 0.002 ppm).Though the heavy metal content in sewage water is negligible and they all are well within the standards of FAO(1985).

Table 1: Chemical composition of irrigable, treated sewage and untreated sewage water

Parameters	Irrigable water	Treated sewage water	Untreated sewage water	FAO Standards
pH	7.30	7.54	7.79	6.5-8.4
EC(dS m^{-1})	0.54	0.92	1.33	0-3
N (ppm)	6.18	10.71	13.49	0-10
P (ppm)	10.29	15.48	18.94	0-2
K (ppm)	9.46	15.55	19.03	0-2
N a(meq L^{-1})	9.19	14.37	17.62	0-40
BOD (meq L^{-1})	24.40	32.30	73.83	10-80
COD (meq L^{1})	105.32	131.82	154.08	30-160
Carbonates (meq L^{1})	5.68	3.34	8.87	0-10
Bicarbonates (meq L^{-1})	36.2	18.81	25.23	0-150
TDS (meq L^{-1})	196.33	436.83	715.84	0-2000
Cobalt (Co) (ppm)	-	0.001	0.004	0.05
Lead (Pb) (ppm)	-	-	-	5.00
Arsenic (As) (ppm)	-	0.002	0.004	0.10
Boron (B) (ppm)	-	0.017	0.035	0-2
Nickel (Ni) (ppm)	-	0.004	0.002	0.20
Chromium (Cr) (ppm)	-	-	-	0.10

3.2 Effect of irrigation with sewage water on soil properties

There was significant change in the soil reaction upon irrigation with sewage water. The highest pH was recorded in plots irrigated with untreated sewage water (6.88) and it is closely followed by one irrigation with irrigable water *fb* twos irrigation with untreated sewage water(6.74). The lowest pH was recorded with irrigable water applied plots (6.28). The electrical conductivity (EC) in sewage irrigated soils was high due to salt content of sewage water of domestic origin. The soil irrigated with untreated sewage water recorded highest EC (0.185 dS m^{-1}) followed by the plots receiving one time irrigable water *fb* two times untreated sewage water (0.178 dS m^{-1}. The organic carbon (OC) content varied slightly due to application of water treatments. Irrigation with untreated sewage water excelled over rest of the treatment by recording significantly higher soil organic carbon of 3.37 g kg^{-1} followed by one time irrigable water *fb* two times untreated sewage water (3.4 g kg^{-1}). Treatment receiving irrigable water recorded (3.11 g kg $^{-1}$).

The treated sewage water and its conjunctive mode of irrigation recorded higher available N, P and K compared to the initial status. Plots receiving irrigation with untreated sewage water recorded highest available N in soil (295.16 kg ha $^{-1}$) closely followed by one time irrigable water *fb* two times untreated sewage water irrigated soil (292.75 kg ha $^{-1}$). Treatment receiving irrigable water recorded lowest (281.02 kg ha $^{-1}$). On the similar lines, available phosphorous and potassium was highest in the treatment receiving irrigation with untreated sewage water alone (84.13 and 128.84 kg ha $^{-1}$respectively) followed by treatment receiving one time irrigable water *fb* two times untreated sewage water (83.01 and 128.23 kg ha $^{-1}$respectively). Plot receiving irrigable water recorded lowest available phosphorous and potassium (73.61 and 121.18 respectively).

The Treatments in test enhanced the exchangeable sodium content in the soil as compared to initial value of 13.28 mg 100 g^{-1}.Irrigation completely with untreated sewage water has recorded higher (16.23 mg 100 g^{-1}) exchangeable sodium followed by one irrigation with irrigable water *fb* two irrigations with untreated sewage water 16.12 mg 100 g^{-1}. On the other hand, treatment receiving irrigable water recorded lowest sodium content (12.61 mg 100 g^{-1}).

Table 2: Chemical properties of soil as influenced by the irrigation with sewage water

Treatments	pH	EC (dS m^{-1})	OC (g kg^{-1})	N (kg ha^{-1})	$P_2 0_5$ (kg ha^{-1})	$K_2 0$ (kg ha^{-1})	Na (g 100 g^{-1} of soil)
T_1	6.28	0.153	3.11	281.02	73.61	121.18	12.61
T_2	6.51	0.169	3.16	288.11	79.01	125.78	15.15
T_3	6.88	0.185	3.37	295.16	84.13	128.84	16.23
T_4	6.36	0.165	3.17	286.36	77.53	124.33	14.67
T_5	6.67	0.170	3.24	291.91	81.66	127.09	16.08
T_6	6.27	0.164	3.14	284.50	76.99	123.21	14.35
T_7	6.55	0.167	3.22	289.03	79.76	126.18	15.35
T_8	6.45	0.166	3.16	287.76	78.42	124.99	15.08
T_9	6.74	0.178	3.34	292.75	83.01	128.23	16.12
S. Em. ±	0.09	0.00	0.02	0.82	1.12	0.77	0.31
CD ((P=0.05)	0.27	0.01	0.05	2.41	3.35	2.31	0.92

3.3 Effect of irrigation with sewage water on yield and yield parameters of groundnut

The pod yield of groundnut as influenced by the conjunctive use of sewage water revealed that significant variation among different treatments. The highest pod yield of 2534 kg ha^{-1} was realised by giving irrigation with only untreated sewage water throughout its crop cycle. This was significantly superior over irrigating completely with irrigable water (2273 kg ha^{-1}) and the treatment which received two irrigation with irrigable water and one irrigation with treated sewage water (2289 kg ha^{-1}) and on par with rest of the treatments. Similarly, maximum number of pods per plant was obtained with untreated sewage water (20.37) closely followed by one irrigation with irrigable water *fb* two irrigation with untreated sewage water (18.40), irrigation alternatively with irrigable and untreated sewage water (18.37) which are statistically on par. The least number of pods $plant^{-1}$ (14.27) was recorded with irrigation with irrigable water. Further, among the treatments, the highest pod yield plant^{-1} (14.14 g) was obtained in plots which received irrigation with untreated sewage water which was closely followed by 13.96, 13.42 and 13.37 g respectively, recorded with T_9, T_7 and T_5 which are on par with each other and significantly superior over control (11.71 g). However, numerically higher test weight was registered on irrigation with untreated sewage water (34.27 g) closely followed by T_9, T_5 and T_7. The least test weight was observed on irrigation with irrigable water (30.38 g).

The highest total dry matter per plant was realized irrigation with untreated sewage water (37.97 g. This was closely followed by one irrigation with irrigable water *fb* by two irrigations with untreated sewage water (37.04 g) and irrigation alternatively with irrigable and untreated sewage water (5.31 g). However, the treatments T_3> T_9> T_5>T_7>T_2 are numerically in the order of merit. Significantly the least total dry matter (31.24 g plant^{-1}) was obtained with control (irrigation with irrigable water).

Table 3: Yield and yield parameters of groundnut as influenced by irrigation with sewage water

Treatments	Pod yield (kg ha^{-1})	Pods plant^{-1}	Pod weight per plant (g)	Test weight (g)	Total dry matter accumulation per plant (g)
T_1	2273	14.27	11.71	30.38	31.24
T_2	2324	18.29	12.97	32.63	34.14
T_3	2534	20.37	14.14	34.27	37.97
T_4	2292	16.33	12.49	31.13	32.31
T_5	2442	18.37	13.42	23.61	35.31
T_6	2289	14.53	11.92	30.76	31.41
T_7	2368	18.33	13.37	33.20	34.83
T_8	2303	15.80	12.35	31.70	32.53
T_9	2489	18.40	13.96	34.01	37.04
S. Em. ±	56.84	0.80	0.45	3.20	0.84
CD (P=0.05)	170.41	2.38	1.33	NS	2.51

3.4 Effect of irrigation with sewage water on quality parameters of groundnut

treatment T_3 (irrigation with untreated sewage water) estimated significantly higher oil content (53%) in groundnut, but it remained statistically at par with the treatments T_9 (one irrigation with irrigable water *fb* two irrigations with untreated sewage water), T_5 (Irrigation alternatively with irrigable and untreated sewage water), T_7 (Two irrigations with irrigable water *fb* one irrigation with untreated sewage water) and T_2 (Irrigation with treated sewage water). Irrigation with irrigable water throughout crop cycle registered significantly lower oil content (46.30%) except T_6 and T_8 with which it is on par.

The result showed that irrigation with untreated sewage water significantly higher oil yield of groundnut (893.11 kg ha^{-1}) over rest of the treatments except T_9 (843.14 kg ha^{-1}), T_5 (807.51 kg ha^{-1}) and T_7 (778.74 kg ha^{-1}). The least oil yield was obtained from irrigation with irrigable water (620.11 kg ha^{-1}).

The results revealed that the treatment T_3 (irrigation with untreated sewage water) estimated significantly higher protein content (25.73%)over others except T_9(one irrigation with irrigable water *fb* two irrigations with untreated sewage water) (25.57%), T_5 (Irrigation alternatively with irrigable and untreated sewage water) (25.27%), T_7 (Two irrigations with irrigable water *fb* one irrigation with untreated sewage water) (25.20%) and T_2 (irrigation with treated sewage water) (24.90%) which is on par.

Table 4: Quality parameters of groundnut as influenced by irrigation with sewage water

Treatments	Shelling percentage (%)	Oil yield (kg ha^{-1})	Protein content (%)
T_1	58.77	620.11	23.17
T_2	63.98	746.12	24.90
T_3	66.57	893.11	25.73
T_4	60.95	654.50	24.07
T_5	64.84	807.51	25.27
T_6	60.24	658.65	23.27
T_7	64.52	778.74	25.20
T_8	62.38	707.48	24.30
T_9	64.47	843.14	25.57
S.Em.±	3.13	39.19	0.34
CD (P=0.05)	NS	117.49	1.05

4. Discussion

4.1 Characteristics of Irrigation Water

The different sources of water (untreated sewage water, treated sewage water and irrigable water) used for the study showed variability in possessing chemical properties (Table 1). The pH status of three different sources of water used was three waters fall within the slightly alkaline range. (7.29 to 7.78), which is within the safe limit of 6.50 to 8.40 as suggested by FAO (1985). The electrical conductivity (EC) of irrigable water (0.54 dS m^{-1}) was found much lower than that of both treated and untreated sewage water(0.92 and 1.33 dS m^{-1}, respectively).These recorded variations of different sources again found well within the permissible limits of 3.00dSm^{-1}as outlined by FAO (1985). The highest BOD and COD was found in untreated sewage water (73.82 and 154.08 meq L^{-1} respectively) and treated sewage water (32.30 and 131.82 meq L^{-1}, respectively) compare to irrigable water (24.40 and 105.32 meq L^{-1}, respectively) due to suspended organic colloids but found lower than the recommended maximum concentration of 10-80 meq L^{-1} and 160 meq L^{-1}, respectively (FAO 1985). The total dissolved solids (TDS) in untreated (715.84 meq L^{-1}) and treated (436.83 meq L^{-1})

sewage water though varied but did not cross the recommended maximum concentration of 2000.00 mg L^{-1} for irrigation water as per the criteria of FAO (1985). Untreated sewage water has highest carbonate and bicarbonate content (8.87 and 25.23 meq l^{-1}, respectively) followed by treated sewage water (3.34 and 18.81 meq l^{-1}, respectively). The soap chemicals used and suspended particles of food remnants from kitchen waste may have contributed to the highest values of TDS and HCO^{3-}. (Abegunrin *et al.* (2013) [1].

Irrigable water poses total nitrogen to the extent of 6.18 ppm while that of untreated was 13.19 ppm. But the total nitrogen in treated (10.71 ppm) sewage water was found higher than the sources mentioned and also exceed the recommended maximum concentration of 10ppm (FAO 1985). The high N content in sewage water could be due to presence of considerable amount of suspended organic compounds which undergo decomposition anaerobically resulting in more accumulation of ammonical nitrogen (Kharache *et al*., 2011).

The phosphorus content in different sources of water used ranged from 10.29 to 18.94 ppm indicating above the critical concentration of 2.00 ppm. Likewise, the concentration of potassium content (9.46 to 19.03 ppm) in various sources of water was also higher than the critical value (2.00 ppm). This also envisages the richness of essential macronutrients in water sources.

All the heavy metals *viz.*, cobalt, arsenic, boron and nickel were higher in untreated sewage water (0.004, 0.004, 0.035 and 0.004ppm) followed by treated sewage water (0.001, 0.002, 0.017 and 0.002 ppm).Though the heavy metal content in sewage water is negligible and they all are well within the standards of FAO (1985). It was observed that lead and chromium were not traceable but others were found to be in much low concentration and below the permissible limit of FAO (1985). This clearly indicates that intended sewage water will not lead to contamination of soil and as well non-toxic to plants thereby human and animal health.

4.2 Effect of irrigation with sewage water on soil properties

The soil texture consisted of 80% sand, 16% silt and 4% clay, classified as sandy loam, according to the USDA classification. The soil properties as influenced by conjunctive use if sewage water was shown in Table 2. Soil reaction in the sewage water irrigated soils varied from slightly acidic to alkaline ranging from 6.27 to 6.88 (Table 2). The variation in soil pH might be attributed by different factors like leaching action of water, soil nature and mechanical composition. The plot receiving one irrigation with irrigable water *fb* two times with untreated sewage water recorded highest pH of 6.88. Thereby, different treatments increased pH value as compare to initial value 6.02. The higher pH values could be ascribed to the large quantity of salts present in sewage effluents (Bhat *et al.*, 2011) [5]. Irrigation completely with untreated sewage water had recorded highest electrical conductivity (0.185 dS m^{-1}). High EC in soils irrigated with sewage water could be ascribed to the large amount of ionic substances, soluble salts and salt content of sewage water. This is line with the findings of Rana *et al.* (2010) [16].

The organic carbon (OC) content varied slightly due to application of water treatments. The organic carbon content in the soils ranged from 3.11 to 3.37 g kg^{-1} (Table 1). Significantly higher soil organic carbon of 3.37 g kg^{-1} at harvest was recorded in plots irrigated with untreated sewage water completely. This is attributed to addition of organic matter (high BOD in sewage water) through sewage water. It was reported that sewage application to soils is a carbon building and soil quality sustaining practice due to rapid decomposition of organic compounds present in sewage (Rahmani, 2007) [15].

The untreated sewage water and its conjunctive mode of irrigation recorded higher available N, P and K compared toother treatments. Untreated sewage water irrigation has recorded significantly higher available nitrogen (295.16 kg ha^{-1}) over others except one irrigation with irrigable water *fb* two irrigations with untreated sewage water (292.75 kg ha^{-1}). The lowest was noticed in plots irrigated completely with irrigable water (281.02 kg ha^{-1}). On the similar lines, available phosphorous and potassium was highest in the treatment receiving irrigation completely with untreated sewage water (84.13 and 128.84 kg ha^{-1} respectively) followed by treatment receiving one irrigation with irrigable water *fb* two irrigations with untreated sewage water (83.01 and 128.23 kg ha^{-1} respectively). This was corroborated with the findings of Harshitha *et al*., (2018) [13]. The Treatments in test enhanced the exchangeable sodium content in the soil as compared to initial value of 13.28 mg 100 g^{-1}. Irrigation with untreated sewage water alone has recorded higher sodium content of 16.23 mg 100 g^{-1} soil followed by one irrigation with irrigable water *fb* two irrigations with untreated sewage water (16.12 mg 100 g^{-1} soil). The higher sodium content in sewage irrigated soils was due to detergents present in sewage effluent which accumulate on the surface soil.

4.3 Effect of irrigation with sewage water on yield and yield parameters of groundnut

The sewage water contained considerable amount of nutrients which are considered essential for maintaining the soil fertility as well as for enhancing the plant growth and productivity. Sewage water in general proved beneficial in increasing the plant growth characteristics and dry matter accumulation was higher in plants receiving it as a source of irrigation water either alone or in conjunctive mode compared to those receiving irrigable water (IW). The effect of sewage water irrigation on growth and yield parameters of groundnut has been given in table 3.

The pod yield of groundnut varied significantly among sewage water treatments. The .highest pod yield of groundnut (2534 kg ha^{-1}) was realized on irrigation with untreated sewage water (T_3) which was statistically superior over irrigation with irrigable water alone, conjunctive use of irrigable water and treated water at 2:1 (2289 kg ha^{-1}) and 1:1 ratio (2292 kg ha^{-1}) and 1:2 ratio (2303 kg ha^{-1}) and on par with rest of the treatments. The higher yield was mainly attributed to higher number of pods $plant^{-1}$ (20.37), pod weight per plant (14.14 g) and test weight (34.27 g), the factors considered to have direct influence on pod yield. Higher yield and yield component values on irrigation with untreated sewage water was due to additional supply of plant nutrients and more nutrients uptake by the crop.

Higher pod yield might be due to the positive effect of sewage water irrigation on soil physical, chemical, biological properties and better translocation of photosynthetic to sink *i.e.*, pod and indirect effect on yield through other yield components. This is in accordance with the findings of Singh *et al*., (1991) [18] and Gladis (2000) [7]. A positive response of yield with sewage water irrigation was also recorded in pearl millet and sorghum by Katoria *et al*. (1981) [11].

The highest total dry matter per plant was realized on irrigation with untreated sewage water (37.97 g). This was closely followed by one irrigation with irrigable water *fb* two irrigations with untreated sewage water (37.04 g). Higher total dry matter in the treatments which receives untreated sewage water either alone or in conjunctive mode is due to higher nutrient composition in sewage water particularly N, P, K and nitrogen promotes vegetative growth through cell elongation apart from cell division and expansion. Potassium controls opening and closing of stomata and involved in meristem tic growth, regulates translocation of photosynthetic and activate several enzyme while phosphorus plays a fundamental role in synthesis of ATP during photosynthesis. It brings significant increase in dry weight of plants. Similar findings had also been reported by (Reddy *et al*., 1998 and Bharose *et al*., 2011) [4].

4.4 Effect of irrigation with sewage water on quality parameters of groundnut

Irrigation with untreated sewage water found significantly superior over rest of the treatments by recording the highest protein content of 25.73 per cent. The next best treatment was conjunctive use of irrigable and untreated sewage water at 1:2 ratios (25.57%). The protein content of kernel being essentially a manifestation of its nitrogen content, the higher 'N' content in kernel is directly related to the available soil nitrogen and uptake by plants. Further, higher N uptake manifested with combined application of RDF and sewage water and higher kernel yield in these treatments caused for the higher protein yield. The findings are in agreement with early work of Iqbal *et al*. (2012) [9] in chickpea.

It was observed that shelling percentage of groundnut varied from 66.57 per cent to 58.77 per cent and did not differ significantly. However, irrigation with untreated sewage water (66.57%) registered numerically higher shelling percentage was closely followed by T_9 (65.47%), T_5 (64.84%) and T_7 (64.52%). The least shelling percentage was observed on irrigation with irrigable water (58.77%). The result showed that irrigation with untreated sewage water gave significantly higher oil yield of groundnut (893.11 kg ha^{-1}) except T_9 (843.14 kg ha^{-1}), T_5 (807.51 kg ha^{-1}) and T_7 (778.74 kg ha^{-1}). The least oil yield was obtained from irrigation with irrigable water (620.11 kg ha^{-1}) Oil yield is the product of oil content and kernel yield. Hence the higher oil yield in these treatments is due to higher seed yield and oil content. Similarly, Zaki and Shaaban, (2015) reported that irrigation with sewage water in sunflower has recorded higher oil content than well water.

5. Conclusion

It is concluded from the study that irrigating with untreated sewage water alone throughout the crop growth, lead to increase in available nutrient status of the soil (296.16, 84.13, 128.84 kg NPK ha^{-1}) along with higher pod yield of 2534 kg ha^{-1} in groundnut. Even conjunctive use of irrigable and untreated sewage water at 1:2 ratios was the next best treatment**.** In addition yield increase, higher protein content and oil yield was also obtained. Irrigation with domestic sewage water or in conjunctive mode, it is possible to save 3.5 lakh ha cm of water and 8,73,840 ha additional of area can be brought under irrigation.

6. References

1. Abegunrin TP, Awe GO, Idowu DO, Onigbogi OO, Onofua OE *et al.* Effect of kitchen wastewater irrigation on soil properties and growth of cucumber (*Cucumis sativus*), J. S. Sci. and Environ. Manag. 2013; 4(7):139-145.
2. AOAC. Official Methods of Analysis, 15th ed. Association of Official Analytical Chemists, Washington DC, 1990; 1213.
3. Begum A, Harikrishna S, Khan I. Chemical composition of rain water in south Bangalore, Karnataka. Rasayan j Chem. 2008; 1(4):856-861.
4. Bharose R, LAL SB, Thomas T, David AA. Response of different level of sewage and tubewell irrigation water on growth, yield and nutrient uptake of onion crop (*Allium cepa* L.) at Allahabad. Int. bi-ann. J Agric, 2011.
5. Bhat MA, Long term effect of sewage water irrigation on heavy metal accumulation on soils and crops. J Indian Soc. Soil Sci. 2011; 59(1):97-100.
6. FAO, Water quality for agriculture RS, Ayers DW, Westcot. Irrigation and Drainage Paper 29 Rev. 1. FAO, Rome, 1985, 174.
7. Gladis R, Bose MSC, Fazlullaha-khan AK. Wastewater irrigation and N and P fertilization on HCN and NO_3 content of fodder. Madras Agric. J. 2000; 86:250-255.
8. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research, 2nd Edn. John Wiley and Sons, New York, USA, 1984.
9. Iqbal HT, Faheem A, Babalola OO, Arif I. Growth, Photosynthesis and yield of chickpea as influenced by urban wastewater and different levels of phosphorus. Int. J of Plt. Res. 2012; 2(2):6-13.
10. Jackson ML. Soil chemical analysis, (Ed.). Prentice-Hall of India Pvt. Ltd., New Delhi, 1973.
11. Katoria VB, Singh P, Malik BS, Sharma HC. Effect of irrigation and nitrogen on the yield and quality of pearl millet and maize for summer fodders. Har. Agri. Uni. J Res. 1981; 11:100-102.
12. Kharche VK, Desai VN, Pharande AL. 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 Indian. Soc. Soil Sci. 2011; 59(2):177-184.
13. Harshitha M, Prasanthi A, Naidu MVS, Hemalatha S. Impact of Urban Sewage Water on Soil Properties in Guravarajupalle Village of Renigunta Mandal of Chittoor District in Andhra Pradesh, India, Int. J Curr. Microbiol. App. Sci. 2018; 7(9):3764-3769.
14. Narain V, Khan SAM, Sada R, Singh S, Prakash A. Urbanization, peri-urban water (in)security and human wellbeing: a perspective from four south Asian cities. Water Int. 2013; 38:930-940.
15. Rahmani HR. Use of industrial and municipal effluent water in Esfahan province, Iran, Sci. Res. Essay. 2007; 2(3):84-88.
16. Rana L, Dhankhar R, Chhikara S. Soil characteristics affected by long term application of sewage water. Intl. J. Environ. Sci. 2010; 4(3):513- 518.
17. Reddy MAN, Ramachandra R, Reddy YTN, reddy NS, Anjappa M, Reddy R. Effect of organic and inorganic source of N, P, K on growth and yield of pea. *Legume Research*. 1998; 21(1):57-62.
18. Singh RR, Singh V, Shukla AK, Singh V. Yield and heavy metal contents of berseem as influenced by sewage water and refinery effluent. J Indian soil sci., 1991; 39:402-404.
19. Sreeramulu US, Reuse of municipal sewage and sludge in Agriculture. Scientific Publishers, http://www.ais.unwater.org, 2017.

20. Subbaiah BV, Asija GL. A rapid procedure for the estimation of available nitrogen in soils. Curr. Sci. 1956; 25:259-260.
21. Walkley A, Black CA. An examination of Degtijar off method for determining soil organic matter and proposed modification of the chromic acid titration method. Soil Sci. 1934; 37(1):29-34.
22. Zaki SS, Shaaban MM. Impact of treated sewage water irrigation on some growth parameters, yield and chemical composition of sunflower (*Helianthus annuus* L.) plants. Int. J Chem. Tech Res. 2015; 8(9):114-122.