Comparative Study of Soil Fertility under Different Water Resource Irrigation

Javeed Iqbal Ahmad Bhat[1], Zubair Ahmad Dar[1, 2], Azra Amin[1], Gazala Qazi[1]*, Aurosa Amin[3]

[1]Division of Environmental Sciences, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, India, 190025

[2]Department of Mathematical Sciences, Islamic University of Science and Technology, Awantipora, Kashmir, India, 192122

[3] Centre for Biodiversity, Baba Ghulam Shah Badshah University, Rajouri, Jammu & Kashmir, India, 185234

***Corresponding author:** Gazala Qazi

*Email: qazigazala@gmail.com

Abstract

The current study was conducted at the Sher-e-Kashmir University of Agricultural Sciences and Technology, Kashmir using a randomized block design with four treatments: untreated sewage water (T_1), treated sewage water (T_2), ground water (T_3) and Shalimar stream as control (T_4). During the study various soil properties including pH, electrical conductivity (EC), organic carbon, and macronutrient availability (NPK, Ca and Mg) were analyzed before and after irrigation. The outcomes showed significant differences between the treatments. When compared to the other treatments, untreated sewage water (T_1) produced the greatest improvement in soil fertility, with higher levels of accessible Ca, Mg and NPK.

This might be because sewage water's large organic content breaks down and releases nutrients into the land. Although not as much as untreated sewage water, treated sewage water (T_2) also improved the availability of nutrients in the soil. Relatively smaller gains were seen in ground water (T_3) and control water (T_4), with the control having the least impact on nutrient content. These results imply that, with proper management of salinity and other pollutants, sewage water, especially when treated can be used as resource for increasing soil fertility and productivity. The study emphasises how crucial sustainable irrigation techniques are to striking a balance between environmental concerns and nutrient benefits.

Key words: *Soil Fertility, Pollution, Irrigation, Sewage, Organic Carbon*

1. Introduction

Water covers about 71% of the Earth's surface. It is vital for all known forms of the life. On Earth, about 96.5% of the water is found in seas and oceans, 1.7% in ground-water, 1.7% in glaciers and ice caps. Only 2.5% of this water is fresh water and 98.8% of that water is in the form of ice and ground-water and less that 0.3% of all fresh water is in lakes and rivers (Gleick, 1993). On average, 80% of the freshwater withdrawn from rivers and ground-water is used to produce food and other agricultural products (Schaible and Aillery, 2012). Irrigated agriculture is dependent on adequate water supply of usable quality. Water quality concerns have often been neglected because good quality water supplies have been plentiful and readily available (Shamsad and Islam, 2005). This situation is now changing in many areas. Intensive use of nearly all good quality supplies means that new irrigation projects, and old projects seeking new or supplemental supplies, must rely on lower quality and less desirable sources (Cuenca, 1989). Irrigation water quality is related to its effects on soils and crops and its management. High quality crops can be produced only by using high-quality irrigation water keeping other inputs optimal. Characteristics of irrigation water that define its quality vary with the source of water (APHA, 2005). There are regional differences in water characteristics, based mainly on geology and climate.

There may also be great differences in the quality of water available on a local level depending on whether the source is from surface water bodies (rivers and ponds) or from groundwater aquifers with varying geology, and whether the water has been chemically treated. The chemical constituents of irrigation water can affect plant growth directly through toxicity or deficiency, or indirectly by altering plant availability of nutrients (Ayers and Westcot, 1985; Rowe *et al*., 1995). Since most of the freshwater is used for irrigation, understanding the knowledge of irrigation water quality is critical to the management of water for long term productivity. Due to rapid increase in population the water resources are heavily polluted by various toxic metals, which create a danger for all living beings. The need to meet the increasing demands of irrigation and human consumption, the available water resources are getting depleted and the water quality has deteriorated (Joshi *et al*., 2009).

2. Materials and Methods

A field experiment was conducted at the Experimental Farm of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar campus. Water sources included untreated and treated sewage water from a treatment plant at Hazratbal, Shalimar groundwater and Shalimar stream water (control). The experiment followed a randomized complete block design with five replications

2.1. Treatment details

Number of treatments	4
Treatment details	
T_1	Untreated STP Water
T_2	Treated STP Water
T_3	Ground water
T_4	Shalimar Stream Water (Control)
Number of replications	5
Design of Experiment	Randomized Block Design

2.2. Field operations

The field was ploughed thoroughly, levelled and divided into 20 plots (1 × 1.5 m) with 30 cm wide bunds. Fertilizers (90 kg N, 60 kg P, 60 kg K/ha) were applied, with half of the nitrogen applied 30 days after transplanting. Raised seed beds were prepared, and kale (G.M. Dari) seeds were sown, covered with ash, and watered regularly until germination. Healthy seedlings were transplanted, with a spacing of 30 × 15 cm, placing 12 seedlings per plot. Transplants were watered immediately and irrigated as per treatments after establishment.

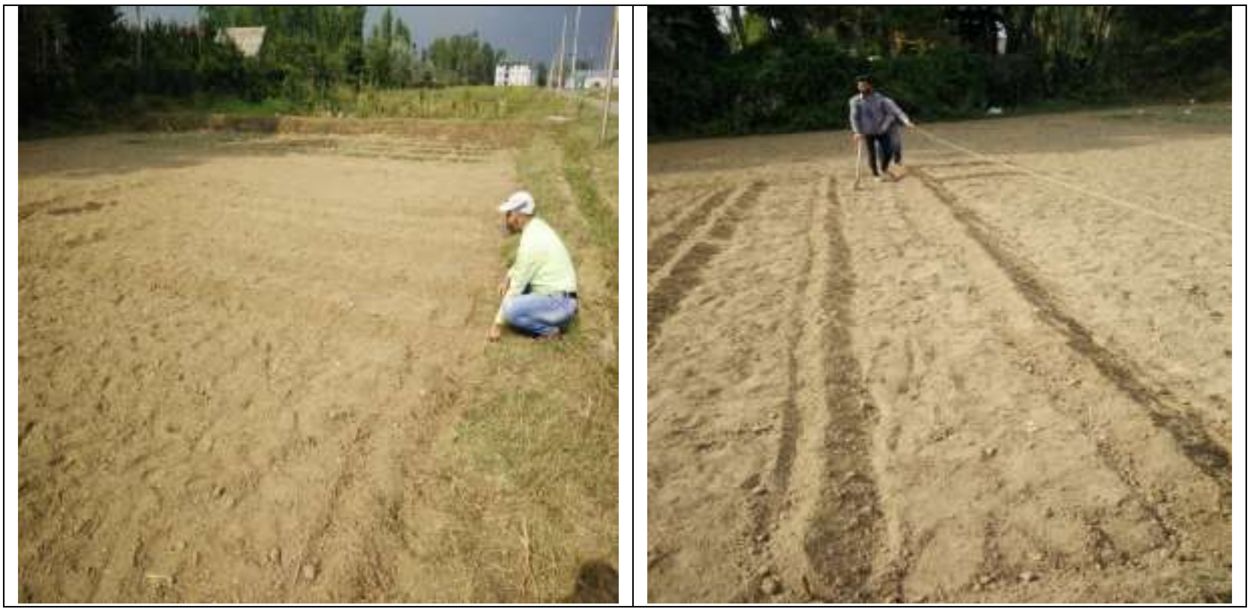

Plate 1: Laying of the experimental field

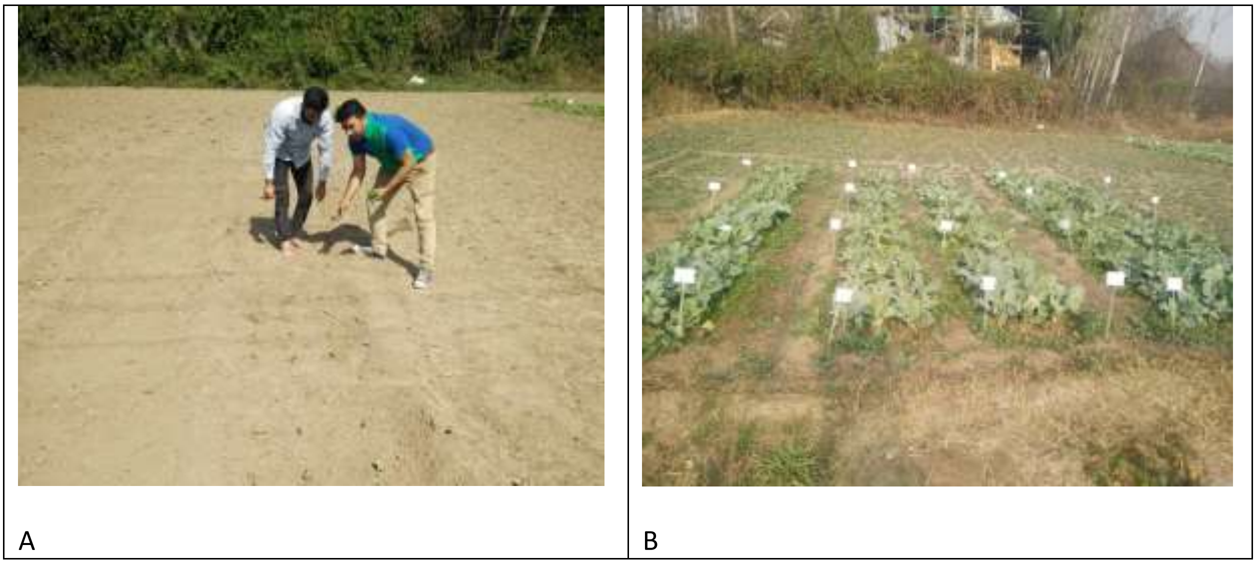

Plate 2: Transplantation of kale seedlings (A) and Crop attaining full vegetative growth (B)

2.3 Soil Analysis

2.3.1 pH and Electrical Conductivity

The pH of the soil was measured in a 1:2.5 soil-to-water suspension after intermittent stirring for 30 minutes, using a direct digital pH meter (Jackson, 1973). Electrical conductivity (EC) was determined in the supernatant of the same suspension with a direct digital conductivity meter (Jackson, 1973).

2.3.2 Macronutrient Analysis

Soil available nitrogen was analyzed using the potassium permanganate method (Subbiah & Asija, 1956). Available phosphorus was extracted with 0.5 M $NaHCO_3$ and quantified as described by Olsen *et al*., (1954). Available potassium was extracted using the ammonium acetate method (Jackson, 1973) and measured with a flame photometer.

2.3.3 Micronutrients and Organic Carbon

Available calcium and magnesium were determined using atomic absorption spectroscopy (AAS) from the extract prepared during potassium extraction. Organic carbon was analyzed using the wet digestion method outlined by Walkley and Black (1934).

Statistical analysis:

Using R software, the acquired data was examined using a randomized block design (RBD).

3. Results and Discussion

Composite soil sample of the experimental site was taken before cultivation of crop from a depth of 0-15 cm and analyzed for various physio-chemical properties viz. pH, electrical conductivity, organic carbon and available nitrogen, phosphorus, potassium, calcium, magnesium, zinc, iron, copper, nickel and cadmium by using standard procedures. The initial status of the experimental site has been presented in Table 1. After crop harvesting, the soil samples from each treatment were analyzed for various parameters.

Table 1: Initial status of experimental site

Particulars	Initial status
Soil pH	7.2
Electrical conductivity(dSm^{-1})	0.20
Organic carbon (%)	0.68
Available nitrogen (kg ha^{-1})	190.87
Available phosphorus (kg ha^{-1})	18.75
Available potassium (kg ha^{-1})	130.55
Available calcium (mg/kg)	473.95
Available magnesium (mg/kg)	120.2

3.1 pH, electrical conductivity and organic carbon

Data in Table 2 revealed that pH of soils irrigated with untreated sewage water and treated sewage water were lower (7.04 and 7.13 respectively) as compared to soil treated with Shalimar stream water (7.40), whereas high value of pH was recorded in ground water treated soils (7.47). Electrical conductivity of soils irrigated with untreated sewage water, treated sewage water and Ground water was higher (1.76, 1.45 and 0.55 dSm^{-1} respectively) as compared to soils treated with Shalimar stream water (0.25 dSm^{-1}). Analysis of data revealed that organic carbon content in soils irrigated with untreated sewage water, treated sewage water and Ground water was maximum (1.26%, 1.15% and 0.96% respectively) whereas, minimum organic carbon content was recorded in the soils treated with control (0.94%) as is evident in Table 2.

Table 2: Effect of different sources of irrigation water on pH, electrical conductivity & organic carbon content in soil

Parameters / Treatments	pH	E.C(dSm^{-1})	Organic carbon (%)
T_1:Untreated sewage water	7.04	1.76	1.26
T_2:Treated sewage water	7.13	1.45	1.15
T_3:Ground water	7.47	0.55	0.96
T_4:Shalimar stream (Control)	7.40	0.25	0.94
C.D. ($p \leq 0.05$)	0.029	0.021	0.020
SE(d)	0.013	0.009	0.009
*Initial status	**7.2**	**0.20**	**0.68**

3.2 Available nitrogen, phosphorus and potassium in kg/ha

The data in Table 3 reveals that the available nitrogen of soils irrigated with untreated sewage water, treated sewage water and ground water was higher (290.69 kg ha^{-1}, 270.24 kg ha^{-1} and 218.41 kg ha^{-1} respectively) as compared to the soils irrigated with control (198.54 kg ha^{-1}).The perusal of data in Table 3 indicates that available phosphorus was found maximum in soils irrigated with untreated sewage water, treated sewage water and Ground water (30.04 kg ha^{-1}, 23.93 kg

$ha^{-1}$and 22.70 kg ha^{-1} respectively) whereas, the minimum content of available phosphorus (21.46 kg ha^{-1}) was recorded in control water irrigated soils.

Table 3: Effect of different sources of irrigation water on available nitrogen, phosphorus and potassium content (kg/ha) in soil

Parameters / Treatments	Available nitrogen	Available phosphorus	Available potassium
T_1: Untreated sewage water	290.69	30.04	278.64
T_2: Treated sewage water	270.24	23.93	251.99
T_3: Ground water	218.41	22.70	189.58
T_4: Shalimar stream (Control)	198.54	21.46	183.22
C.D. ($p \leq 0.05$)	4.010	1.280	0.080
SE(d)	1.82	0.58	0.036
*Initial status	**190.87**	**18.75**	**130.55**

Available potassium content of soils irrigated with untreated sewage water, treated sewage water, Ground water and Shalimar stream water (control) was 278.64, 251.99, 189.58 and 183.22 kg ha^{-1} respectively (Table 3). From the data, it was observed that maximum available potassium content was recorded in the untreated sewage water irrigated soils whereas control water irrigated soils recorded lowest content of available potassium.

3.3 Available calcium and magnesium

The perusal of data in Table 4 indicates that available calcium was recorded highest in soils irrigated with untreated sewage water, treated sewage water and Ground water (516.29 mg/kg, 510.24 mg/kg and 494 mg/kg respectively), whereas, the lowest content of available calcium was recorded in control water irrigated soils (483.62 mg/kg). The data in Table 4 displays that the available magnesium content was recorded maximum in soils irrigated with untreated sewage water (132.24 mg/kg) followed by treated sewage water (130.65 mg/kg) and ground water (127.35 mg/kg), whereas, the lowest was recorded in soils irrigated with control (125.55 mg/kg).

Table 4: Effect of different sources of irrigation water on available calcium and magnesium content (mg/kg) of soil

Parameters / Treatments	Calcium	Magnesium
T_1: Untreated sewage water	516.29	132.24
T_2: Treated sewage water	510.24	130.65
T_3: Ground Water	494	127.35
T_4: Shalimar stream (Control)	483.62	125.55
C.D. ($p \leq 0.05$)	2.324	0.034
SE(d)	1.05	0.015
*Initial status	**473.95**	**120.2**

In the present study the available nitrogen, phosphorous, potassium, calcium and magnesium content in the soil improved due to application of untreated sewage water and treated sewage water (Table 3-4) as compared to other water resources. Increase in available nitrogen could be due to the fact that the decomposition of sewage organic matter in soil released nitrogen in available forms. Basumatary and Bordoloi (1992) and Boruah and Nath (1992) found that layer of organic matter significantly improves the retention of potassium in the soils. Investigations, including long and short- term studies, showed that soil fertility increases as a consequence of the application of wastewater (Bernal *et al.*, 1993; Chakrabarti, 1995; Navas *et al.*, 1998; Friedel *et al.*, 2000). Wastewater application not only increased organic matter and nitrogen contents of soils, but also decreased pH which caused increase in availability of phosphorous and micronutrient content (Mohammad, 1986; Mohammad and Mazahreh, 2003). The same results were reported by Mancino and Pepper (1992) and Abedi-Koupai *et al.* (2006). They found that the total nitrogen and available phosphorous concentrations increased significantly in sewage water irrigation treatment compared to other treatments. Similar results were noticed by Khaskhoussy *et al.* (2013) who investigated the effect of treated sewage water on soil and corn crop in which he found that the irrigation with treated waste water significantly increased the soil electrical conductivity, major element contents as sodium, chlorine, calcium, magnesium and fertilizer elements like nitrogen, phosphorous and potassium. Earlier, Angin *et al.* (2005) have also reported that irrigation with raw sewage water increased soil organic matter, nitrogen and concentration of major cations. These findings are in line with those of Kiziloglu *et al.* (2008) and Alghobar and Suresha (2017).

Conclusion

From the present study, it can be concluded that the sewage water is enriched in nutrients and heavy metal pollution is within safe limits hence sewage water can be used for irrigation purposes after stabilization.It can thus be suggested that both untreated/treated waste water can be used to irrigate kale or other vegetables with a continuous monitoring of the effluent quality to avoid contamination.

Acknowledgment
The authors express their heartfelt gratitude to the Division of Environmental Sciences, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, for providing the necessary facilities and support to conduct this study.

Funding
This research received no specific grant from any funding agency.

Conflict of Interest
Authors have no conflict of interest and nothing to disclose.

References
1. Abedi-Koupai, J., Mostafazadeh-Fard, B., Afyuni, M., & Bagheri, M. R. (2006). Effect of treated wastewater on soil chemical and physical properties in an arid region. *Plant Soil and Environment, 52*(8), 335.
2. Alghobar, M. A., & Suresha, S. (2017). Evaluation of metal accumulation in soil and tomatoes irrigated with sewage water from Mysore city, Karnataka, India. *Journal of the Saudi Society of Agricultural Sciences, 16*(1), 49–59.
3. Angin, I., Yaganoglu, A. V., & Turan, M. (2005). Effects of long-term wastewater irrigation on soil properties. *Journal of Sustainable Agriculture, 26*(3), 31–42.
4. APHA. (2005). *Standard methods for the examination of water and wastewater* (21st ed.). American Public Health Association.
5. Ayers, R. S., & Westcot, D. W. (1985). *Water quality for agriculture* (Vol. 29). Food and Agriculture Organization of the United Nations.
6. Basumatary, A., & Bordoloi, P. K. (1992). Forms of potassium in some soils of Assam in relation to soil properties. *Journal of Indian Society of Soil Science, 40*(3), 443–446.
7. Bernal, M. P., Roig, A., & Garcia, D. (1993). Nutrient balances in calcareous soils after application of different rates of pig slurry. *Soil Use and Management, 9*(1), 9–14.
8. Boruah, H. C., & Nath, A. K. (1992). Potassium status in three major soil orders of Assam. *Journal of Indian Society of Soil Science, 40*(3), 559–561.
9. Chakrabarti, C. (1995). Residual effects of long-term land application of domestic wastewater. *Environment International, 21*(3), 333–339.
10. Cuenca, R. H. (1989). *Irrigation system design: An engineering approach*. Prentice Hall.
11. Friedel, J. K., Langer, T., Siebe, C., & Stahr, K. (2000). Effects of long-term wastewater irrigation on soil organic matter, soil microbial biomass, and its activities in central Mexico. *Biology and Fertility of Soils, 31*(5), 414–421.
12. Gleick, P. H. (1993). *Water in crisis: A guide to the world's fresh water resources*. Oxford University Press.
13. Jackson, M. (1973). *Soil chemical analysis*. Prentice Hall of India.
14. Joshi, D. M., Kumar, A., & Agrawal, N. (2009). Assessment of the irrigation water quality of river Ganga in Haridwar district. *Rasayan Journal of Chemistry, 2*(2), 285–292.
15. Khaskhoussy, K., Hachicha, M., Kahlaoui, B., Messoudi-Nefzi, B., Rejeb, A., Jouzdan, O., & Arselan, A. (2013). Effect of treated wastewater on soil and corn crop in the Tunisian area. *Journal of Applied Science Research, 9*(1), 132–140.
16. Kiziloglu, F. M., Turan, M., Sahin, U., Kuslu, Y., & Dursun, A. (2008). Effects of untreated and treated wastewater irrigation on some chemical properties of cauliflower (*Brassica oleracea L. var. botrytis*) and red cabbage (*Brassica oleracea L. var. rubra*) grown on calcareous soil in Turkey. *Agricultural Water Management, 95*(6), 716–724.
17. Mancino, C. F., & Pepper, I. L. (1992). Irrigation of turfgrass with secondary sewage effluent: Soil quality. *Agronomy Journal, 84*(4), 650–654.
18. Mohammad, M. J. A. M. (1986). The effect of S and H_2SO_4 application on the availability of Fe, Mn, and Zn in calcareous soils (Doctoral dissertation). Washington State University.
19. Mohammad, M. J., & Mazahreh, N. (2003). Changes in soil fertility parameters in response to irrigation of forage crops with secondary treated wastewater. *Communications in Soil Science and Plant Analysis, 34*(9–10), 1281–1294.
20. Navas, A., Bermúdez, F., & Machín, J. (1998). Influence of sewage sludge application on physical and chemical properties of Gypsisols. *Geoderma, 87*(1–2), 123–135.
21. Rowe, D. R., & Abdel-Magid, I. M. (1995). *Handbook of wastewater reclamation and reuse*. CRC Press.
22. Schaible, G., & Aillery, M. (2012). *Water conservation in irrigated agriculture: Trends and challenges in the face of emerging demands*. Economic Research Service.
23. Shamsad, S. Z. K. M., & Islam, M. S. (2005). Hydrochemical behavior of the water resource of Sathkhira Sadar of southwestern Bangladesh and its impact on the environment. *Bangladesh Journal of Water Resource Research, 20,* 43–52.
24. Subbiah, B. V., & Asija, G. L. (1956). A rapid procedure for the estimation of available nitrogen in soil. *Current Science, 25,* 259–260.
25. Walkley, A., & Black, I. A. (1934). An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science, 37*(1), 29–38.