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Research Article

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The Effect of Reusing Wastewater from Desalination Station in Irrigation on the Growth Parameters of Two Wheat Cultivars (*Triticum aestivum* L.)

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Abstract

This study was aimed to assess the appropriateness of wastewater to irrigate soft and hard wheat crops. to evaluate growth and productivity of wheat crops. The investigation was conducted during the Agricultural season 2021-2022, at Zawia, Libya. The experiment utilized four different water regimes, including: (S1) Irrigation with 100% fresh water (control), (S2): Irrigated with 50% wastewater and 50% fresh water, (S3): Irrigated with 75% wastewater and 25% fresh water, (S4): irrigated with 100% wastewater. Wheat seeds were sowed in November 2021 in plastic pots and harvested at the start beginning of April 2022. The results showed that using wastewater significantly increased growth parameters, in terms of plant height, wastewater supplemented with (S4) resulted in the highest growth (46.5 cm/plant) in hard wheat and 45.12 cm/plant in soft wheat plants. Higher shoot fresh weights (5.5 g/plant), root fresh weights (3.28 g/plant), and root fresh weights (13.12 and 10.22 g/plant) for hard wheat and soft wheat were achieved, respectively, when wastewater was utilized in isolation as opposed to fresh water. In terms of shoot dry weight, irrigation with (S4) resulted in a yield of 2.00 g/plant and 1.42 g/plant, whereas plants irrigated with fresh water produced 0.92 g/plant and 0.82 g/plant, for soft wheat and soft wheat consecutively. The Sodium Adsorption Ratio (SAR) calculated for the study samples is within the low limits for sodium, which ranges from (0-10), as it was in this study from (1.78 to 4.49), all of which are much smaller than the safe value. and without any damage. This means that all water samples analyzed can be used for irrigation. RSC values ranged from-3 to-110 meq/L, all samples are located at the appropriate limits. SAR, RSC of the samples of water indicate that most of the water has no risk of irrigation. The study determined that the utilization of treated wastewater in the irrigation of agricultural crops, while being monitored, lacks economic viability.

Keywords: Wastewater – Desalination water - wheat growth – *Triticum aestivum*.

1. Introduction

Water scarcity is expected to be a major issue in the twenty-first century, as over two-thirds of the global population will reside in countries experiencing high water stress by 2050. The problem will be exacerbated by climate change [1-2]. Additionally, the global irrigation area has more than doubled in the past fifty years [3]. To address the issue of water shortage, various approaches have been devised to preserve water resources and explore alternative sources. [4-5]. For example, irrigation in developing nations often relies heavily on the utilization of wastewater, which represents a compromised solution to address the problem of scarcity of water. [6]. throughout the history of civilizations, wastewater (WW) has been utilized for crop irrigation as a means to sustain agriculture in arid locations. [7-11]. Jiménez et al. (2010) [12] found that wastewater can vary in its composition, from undiluted to diluted, and can be discharged through various urban channels, (such as urban wastewater systems, treated wastewater facilities, and reclaimed or recycled water sources).

Both treated and untreated wastewater can be employed for irrigation, while treated urban wastewater can be utilized indirectly [13]. Wastewater is a dependable and consistent water source that helps reduce expenses on fertilizers. Wastewater flows remain constant regardless of seasons, climatic conditions, or precipitation levels, unlike clean water [14]. However, using wastewater for irrigation has potential hazards to both human health and the environment. The presence of parasitic worms and high concentrations of heavy metals in food has the capacity to promote the spread of diseases. [15]. Untreated wastewater utilized for irrigation can result in soil hardening, pollution of shallow groundwater and accumulation of heavy metals. [16-17]. Several studies suggest that the utilization of wastewater for irrigation might greatly enhance crop yield due to the presence of numerous nutritious constituents in wastewater. [18-20]. In contrast, findings from experiments conducted by Rinaldi et al. (2003) and Begum et al. (2011) [21-22] indicated that wastewater irrigation has a notable adverse effect on agricultural yield production. Wheat (*Triticum aestivum* L.) belongs to Poaceae family and is an essential crop worldwide. It serves as a staple food for almost one-third of the world's population. Wheat is the second most important staple food crop after rice [23]. In Libya, wheat is the main winter cereal crop; Wheat is a staple food and a vital component of the human diet. Therefore, there is a constant need to obtain higher wheat yield to meet the demand of the people [24].

Thus, the aims of this investigation were to comprehend the impact of wastewater. desalination on physiological processes, plant growth, and grain productivity of the wheat crop, and to identify wheat varieties with the highest grain productivity in response to different irrigation treatments. Evaluation of the impact of heavy metal and wastewater content in soil and grain yield.

2. Materials and Methods.

2.1. Treatments.

Current research work was carried out at the Botanical Garden, University of Zawia, Libya during the year 2021-2022. Seeds of two varieties of wheat variety (hard and soft wheat) were sown in November 2021 in plastic pots (10 cm in height and 22 cm in diameter) and harvested at the beginning of April 2022. About 3 kg of soil was added in each pot. The soil was collected from groundwater irrigated area. Each pot was sown with five seeds. Aboveground growth indices including parameters included plant height shoot fresh weights, shoot dry weights, root fresh weights and root dry weights were investigated to evaluate the level of influence of the wastewater on plant growth. Wastewater irrigation with different combinations was used. The wastewater was taken collected from desalination station in at Farookh Mosque in south of Zawia, along with fresh water with different concentrations: S1: Irrigated with 100% fresh water, S2: Irrigated with plus 50% wastewater and 50% fresh water, S3: Irrigated with75% wastewater and plus 25% fresh water, S4: irrigated with 100% wastewater. Experimental design used for this study was randomized block design (RBD).

2.2. Soil and water characteristics

Wastewater and ground water were analyzed for multiple physico-chemical parameters such as electrical conductivity (EC), pH, were determined by EC meter and pH meter [25]. The titration method was used for calculation of (Mg^{+2}, Na^{+}, Ca^{+2}, CO_3, HCO_3) content [26].

2.3. Experimental design and statistical analysis:

The experiments evaluated the effects of two factors using a completely randomized design. There were four replications, with each replication consisting of 16 seeds. The first component, (wheat cultivars), consisted of two categories: hard and soft wheat. The second factor, (wastewater levels), consisted of four levels. (T1: Irrigated with 100% fresh water, T2: Irrigated with 50% wastewater and 50% fresh water, T3: Irrigated with 75% wastewater and 25% fresh water, T4: irrigated with 100% wastewater.). The data was statistically analyzed using IBM SPSS statistics software version 23, 2015. Analyses of variance (ANOVA) were used to determine if there were any significant differences among the wheat types and treatments. To compare the means, a least significant difference test was used at a significance threshold of five percent [27].

3. Results and Discussion

3.1. The impact of treatments on plant height

The findings of plant height indicated that wastewater led to significantly increased the height of wheat plant (hard and soft wheat) compared to control (46.50 cm in hard wheat and 45.12 cm in soft wheat) (Table 1). Resulted in a significant variance in plant height in comparison to the control (39.75 cm in T. Durum, 40.50 cm in T. aestivum). These results are consistent with those documented for foxtail millet. [28], barley [29], wheat [30] and Lucerne [31]. Additionally, the plants that were watered with wastewater exhibited a notably greater plant height compared to the plants that were watered with pure water in both crops. This indicates that output might be enhanced without the need for additional mineral fertilizers. The reason for due to the nutritional content of the treated effluent, which has been shown to fulfill the requirements of plants at different stages of growth, as shown by studies conducted by Gholamali et al., 2011 and Babayan et al., 2012 [31-32]. The leaf count findings also indicated the presence of notable disparities (Fig.1 and Table 1).

3.2. Fresh and dry weight

Data associated to shoot and root and root morphology are represented as root fresh weight (RFW), root dry weight (RDW) and are presented in Fig.2. The lowest shoot weight was observed in crop the plants that received S1 irrigation treatments in the case of wheat. The findings of fresh and dry weight indicated that irrigation with treated wastewater were significantly higher ($p \leq 0.05$) than the yields obtained under the control treatment (Table 3). The shoot fresh weight differed significantly between plants irrigated with treated wastewater and fresh water. The plants irrigated with treated wastewater showed higher shoot fresh weight (5.5 and 3.28 g per cultivars respectively) in comparison to plants irrigated by fresh water (S1) (2.5 and 2.15 g per cultivars respectively). At the harvest, dry weights of shoot were comparable in the two cultivars. Fig.2**)**. The reduction in shoot dry weight at harvest was approximately 0.92 and 0.82 g per cultivar for the control treatments with freshwater irrigation (S1). shoot and dry weight was significantly higher in wastewater plants (S3) a threshold of (2.0 and 1.42 g per cultivars respectively). Fig.3 Significant variations were observed in the production of root fresh and dry weight among the various wastewater-irrigated plants. Specifically, plants irrigated with wastewater (S3) exhibited higher root fresh weight (10.72 and 12.55 g) and root dry weight (5.22 and 3.95 g) per plant, respectively, in comparison to plants irrigated with fresh water (S1).

The reduction in fresh and dry weight of root, at the harvest, averaged around (10.27 and 4.52g) and root dry weight (4.27 and 4.52g) per plant respectively) for irrigation with fresh water (S1) in control treatments (fresh water). These outcomes concur with those that were published in the foxtail millet [28], barley [29], wheat [30] and lucerne [31]. The low crop productivity in plants irrigated with tap water may be attributed to insufficient levels of essential nutrients, including nitrogen (N), phosphorus (P), and potassium (K) [33]. Nevertheless, despite the changes in the root structure of crops watered with treated wastewater (TWW), the plants exhibited larger root diameter and an increased presence of fibrous roots, although with a stunted and inhibited look (Fig. 4).

The resultant root growth is consistent with previous research indicating that inhibition of root elongation occurs concurrently with an increase in root diameter [34]. It's possible that the excessive saline level influenced the plants' inadequate root development. Hydroponic systems are linked to salinity stress. stress brought on by low oxygenation and/or a bacterial, fungal, or mold accumulation in the roots of the plants. Nonetheless, since the irrigation streams were regularly replenished and aerated on a weekly basis, there is significant skepticism regarding the link between insufficient oxygenation and the poor root development. When wastewater was used as an irrigation method, barley's agronomic features increased, leading to a 54.3% increase in grain production above conventional irrigation. Samarah et al. (2020) [29] discovered similar results when TWW was applied to different barley varieties, resulting in increased grain yields. The increased combination of nutrients in the TWW is thought to have contributed to the increase in grain output since it promotes crop productivity and growth [35-36]. According to earlier research, irrigation with TWW can raise the yield of fodder [37]. For example, Aghtape et al. (2011) and Elfanssi et al. (2018)[28,38] discovered that TWW irrigation boosted alfalfa (*Medicago sativa*) productivity. Reported that using TWW for irrigation increased the quantity and quality of the feed in foxtail millet (*Setaria italica*). In this research. (Fig. 5).

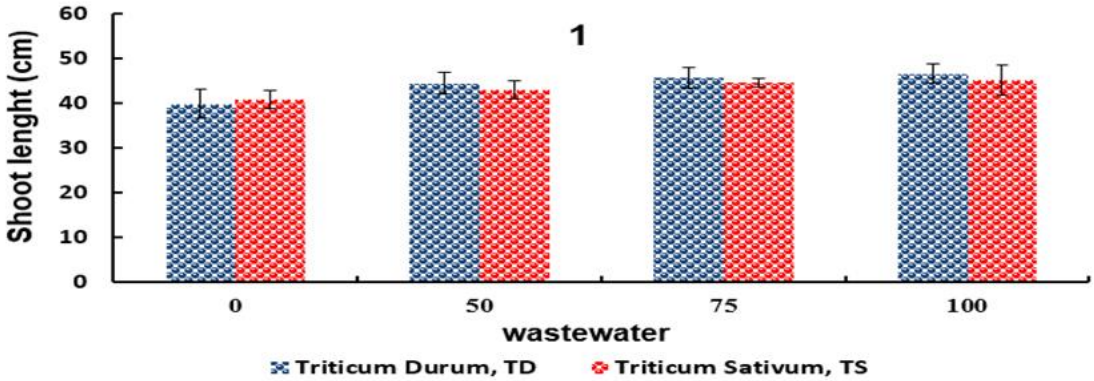

Figure 1: Shoot length (cm) of wheats grown under the impact of irrigation with the wastewater for 4 months. Each value is the meaning of 4 replicates ± SE.

Table 1: Effects of treated municipal wastewater on wheat growth characteristics**.**

Irrigation treatment		Shoot length (cm.)	Shoot Fresh Weight (g)	Root Fresh Weight (g)	Shoot Dry Weight (g)	Root Dry Weight (g)
		Triticum Durum				
S1	Irrigated with 100% Fresh water	39.75±3.33[a]	2.50±0.32[a]	10.72±2.65[a]	0.92±0.17[a]	4.27±0.32[a]
S2	Irrigated with 50% wastewater and 50% Fresh water	44.25±2.43[b]	3.80±0.40[b]	11.92±0.86[ab]	1.42±0.51[ab]	5.20±0.32[a]
S3	Irrigated with 75% wastewater and 25% Fresh water	45.62±2.30[bc]	5.03±1.02[c]	12.82±1.87[b]	1.82±0.91[ab]	5.17±0.32[a]
S4	irrigated with 100% wastewater	46.50±2.10[ab]	5.50±0.63[c]	13.12±0.94[c]	2.00±0.69[ab]	5.22±0.32[a]
		Triticum Sativum				
S1	Irrigated with 100% Fresh water	40.75±2.10[ab]	2.15±2.65[a]	12.55±1.86[bc]	0.82±1.03[a]	4.90±0.32[a]
S2	Irrigated with 50% wastewater and 50% Fresh water	42.87±1.96[abcd]	2.40±0.86[a]	11.90±2.89[ab]	1.25±0.97[a]	4.52±0.32[a]
S3	Irrigated with 75% wastewater and 25% Fresh water	44.50±0.87[abc]	3.15±1.87[ab]	11.47±0.43[ab]	1.32±0.49[a]	4.62±0.32[a]
S4	irrigated with 100% wastewater	45.12±3.34[a]	3.28±0.94[aab]	10.22±1.32[a]	1.42±0.43[ac]	3.95±0.32[a]

There are data indicating a decrease in both root elongation and cell division in vegetable crops such as Lettuce-Paris Islands Cos [39], tomatoes [40], and vicia [41].

Water Quality Indicator for Irrigation Purpose

Mean values of EC (dSm^{-1}) among four treatments ranged from 42 to 1509. The values of Ca^{+2} and Mg^{+2} (mg/L) in four treatments were (8-73). The values of Mg^{+2} (mg/L) in four treatments were (9-70). The values of Na^{+} ranged from 5 to 38 mg/L). The value of Na^{+} was lowest in Treatment-I while highest in treatment-T4. Concentration of HCO_3 (mg/L) in all treatments ranged from 14 to 33. (Table 3)

Sodium Adsorption Ratio (SAR)

Sodium is the primary parameter of importance when evaluating the appropriateness of groundwater for irrigation. High levels of sodium ions in groundwater are unsuitable for agricultural irrigation. In groundwater enriched with sodium (Na), the soil will discharge magnesium ions (Mg2+) and calcium ions (Ca2+) into the groundwater. At the same time, sodium ions (Na+) will be attracted and held onto the soil due to cation exchange processes. In contrast, Na+ ions will be discharged from cation exchange sites, whereas Ca2+ ions will be adsorbed in groundwater that has a high concentration of Ca2+. Furthermore, the combination of sodium with chloride and carbonate leads to the formation of salty and alkaline soils, which are detrimental to the development of plants [42].

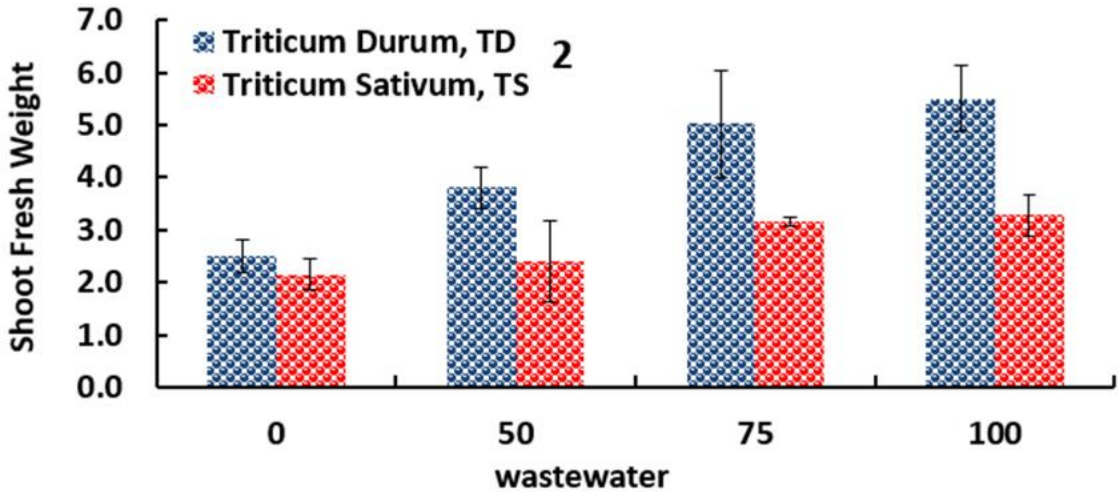

Figure 2: Fresh weight of shoot (g) of wheat grown under the impact of irrigation with the wastewater for 4 months. Each value is the mean of 4 replicates ± SE.

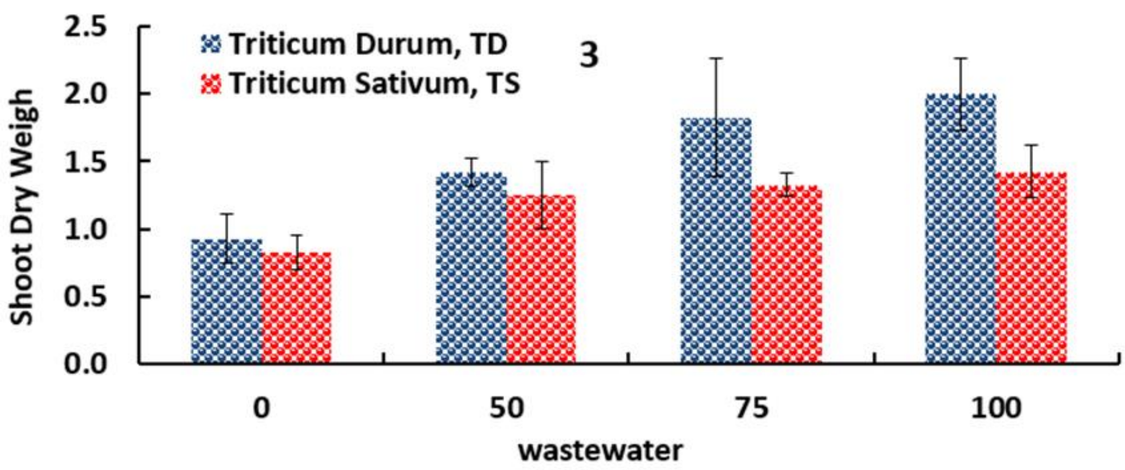

Figure 3: Dry weight of shoot (g) of wheat grown under the impact of irrigation with the wastewater for 4 months. Each value is the mean of 4 replicates ± SE.

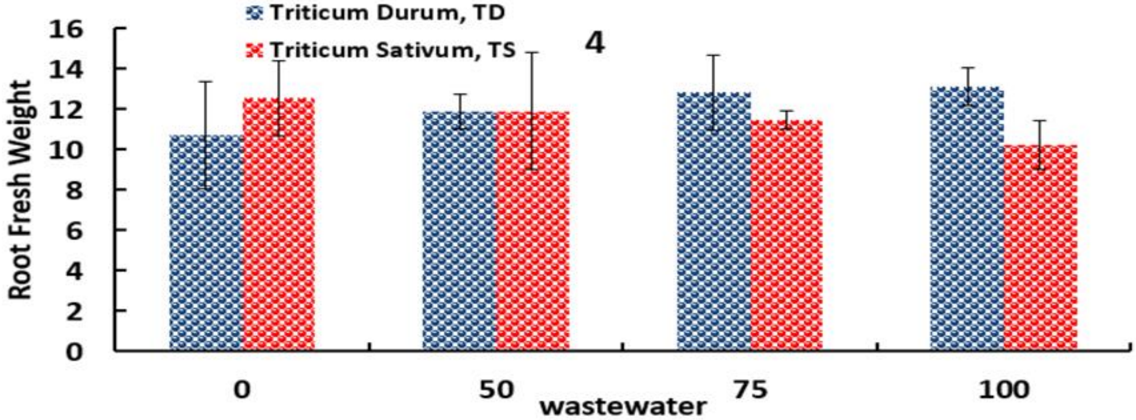

Figure 4: Fresh weights of root (g) of wheat grown under the impact of Irrigation with the wastewater for 4 months. Each value is the meaning of 4 replicates ± SE.

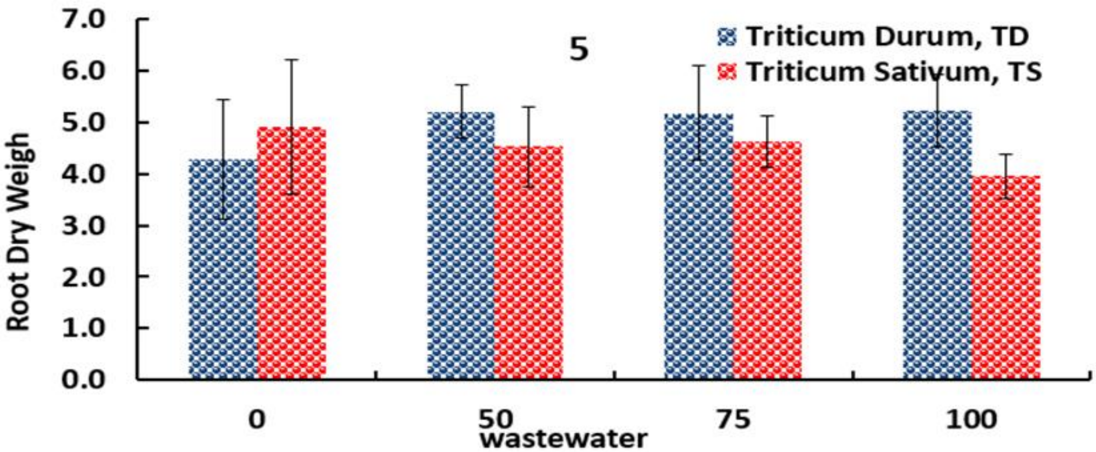

Figure 5: Dry weights of root (gm) of wheats grown under the impact of irrigation with the wastewater for 4 months. Each value is the meaning of 4 replicates ± SE.

Table 2: Two-way ANOVA showing the effect of the main factors (irrigation with the wastewater and cultivars) and their interaction of wheats. at the first harvest (4 months from application of Irrigation).

Variable and source of variation	f	F	P	Variable and source of variation	f	F	P
Shoot length				**Shoot DW**			
Cultivars	1	1.009	0.325	Cultivars	1	4.226	0.051
Wastewater	3	4.178	0.016	Wastewater	3	5.894	0.004
Cultivars × Wastewater	3	1.159	0.346	Cultivars × Wastewater	3	1.671	0.200
Shoot FW				**Root DW**			
Cultivars	1	3.912	.060	Cultivars	1	0.620	0.439
Wastewater	3	5.258	.006	Wastewater	3	0.082	0.969
Cultivars × Wastewater	3	4.100	.018	Cultivars × Wastewater	3	0.445	0.723
Root FW							
Cultivars	1	0.234	0.633				
Wastewater	3	.035	0.991				
Cultivars × Wastewater	3	0.626	0.605				

After signing the values of electrical conductivity and the percentage of sodium adsorption on the American salinity chart, it became clear that the sample (S1) fell within (C1-S1) fell within the type (C2- S1) water of medium salinity with low sodium concentration, this water can be used in most types of soil and for most crops, and it may require some washing operations to grow crops that are highly sensitive to salts such as citrus. While the sample (S3-S4) fell within the type (C3-S1) water of high salinity, low sodium concentration, therefore, this type of water should only be used in soil that does not suffer from layering problems of any kind, which usually hinder the movement of water for efficient washing, and crops sensitive to salinity should be avoided (Fig.6). Water loss following irrigation is typically attributed to the mechanisms of evaporation and evapotranspiration. Therefore, the soil solution becomes more concentrated, leading to the formation of precipitates consisting of Ca^{2+} and Mg^{2+} mixed with CO_3^{2-} and HCO_3^- [43]. Simultaneously, the proportion of Na^+ ions increase, leading to elevated levels of Na^+ content in the soil solution. This, in turn, results in an increase in the SAR (Sodium Adsorption Ratio) and the amount of exchangeable Na^+ ions present in the soil solution [44]. If the concentration of carbonates exceeds that of alkaline earths, the combination of Na^+ with the remaining carbonates after precipitation will result in the formation of $NaHCO_3$, which may have an impact on soil structure [45]. Figure 7 displays the findings of residual sodium carbonate (RSC) represented as the difference between the concentration of carbonates and the concentration of alkaline earths [42, 46].

$$RSC = (HCO_3^- + CO_3^{2-}) - (Ca^{2+} + Mg^{2+})$$

TA denotes the total alkalinity concentration (as $CaCO_3$), and all concentrations of parameters are denoted in milligrams per liter. When the pH is between 6 and 8, the concentration of OH− is negligible in comparison to the values of other parameters, at which point it is less than 10−3 mg/L. [46]. The classification of irrigation water was determined by its RSC values, with values less than 1.25 being considered appropriate, values between 1.25 and 2.5 being considered marginal, and values more than 2.5 being considered unsuitable [47]. According to the data, the RSC values varied from -3 to -110. This suggested that exceeded carbonates had led to a slight sodium hazard (Table 4).

Table 3: Soil analysis result for physical and chemical characteristics.

Irrigation treatment	pH	EC dSm^{-1}	Na mg/L	Ca mg/L	Mg mg/L	CO3 mg/L	HCO3 mg/L
S1	7.02	42	5	8	9	0	14
S2	7.15	542	9	27	34	0	21
S3	7.28	1046	23	41	57	0	27
S4	6.74	1509	38	73	70	0	33

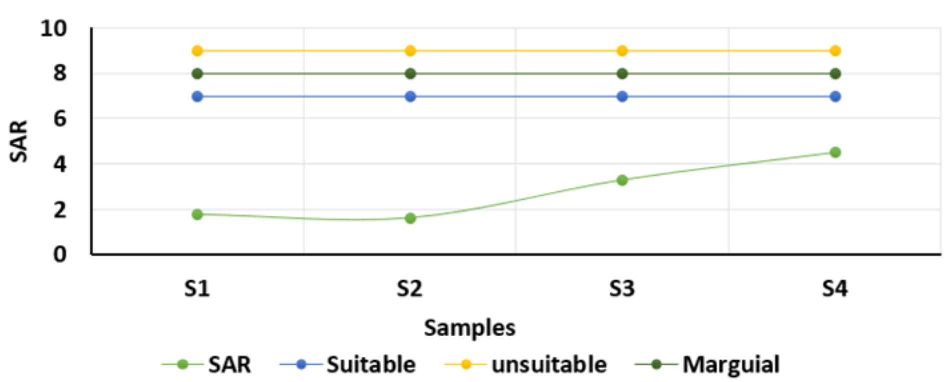

Figure 6: Variation of Sodium adsorption ratio (SAR) for samples.

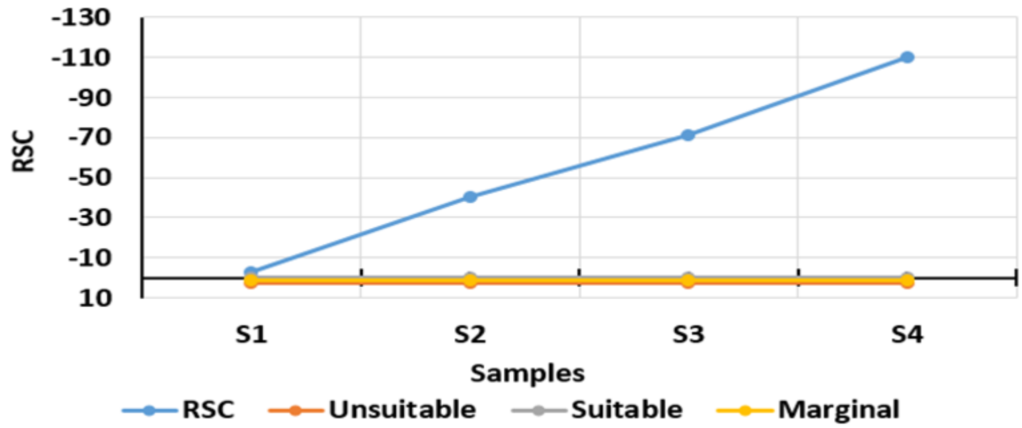

Figure 7: Variation of Residual Sodium Carbonate (RSC) for samples.

Table 4: The calculated results of SAR, RSC (meq/l)

Irrigation treatment	SAR	RSC
S1	1.78	-3
S2	1.63	-40
S3	3.29	-71
S4	4.49	-110

4. Conclusions

Wastewater is significantly used for agricultural irrigation as a replacement for freshwater to combat the worldwide water shortage. Wastewater irrigation has significantly mitigated water scarcity situations in several places of the world. This research provides novel perspectives on the significance of using wastewater irrigation in agricultural cultivation. The heterogeneous crop yield effect of effluent irrigation was elucidated. Untreated wastewater irrigation may cause a multitude of environmental and health-related issues via the soil and crops. Implementing appropriate treatment and irrigation methods may provide significant advantages while mitigating potential hazards. With prudent management, may guarantee these advantages while mitigating dangers. The use of wastewater for irrigation positively influenced the growth and productivity of wheat, while the application of disinfectant did not have any adverse effects on the crop output. The absence of phosphorus and total nitrogen buildup in the soil suggests that the plant fully used the nutrients provided by the wastewater for its growth. It should be noted that the existing research mostly focuses on the immediate impacts of using wastewater for irrigation on crop production. The long-term effects on soil fertility remain inadequately investigated and should be prioritized as a significant area of future study.

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