University of Thi-Qar Journal of agricultural research

Thi-Qar Journal of agricultural research

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 13, Issue 2 (2024) PP 706-720

https://jam.utq.edu.iq/index.php/main https://doi.org/10.54174/utjagr.v13i1.323

Effect of Treated Water with Aquatic Plant Residues on the Growth Parameters of Wheat (Triticum aestivum L.) in Two Different Soil Textures

[1] Um Al-Banin Ahmed Akeb, [2] Najla Jaber Al-Amiri

Department of Soil Science and Water Resources / College of Agriculture / University of Basra

Email: najla.japer@uobasrah.edu.iq

Abstract

A pot experiment was conducted using Triticum aestivum L. to study the effect of water treated with organic waste from aquatic plants (Azolla, Spirodela, and Lemna) on the growth parameters of wheat. Two types of soil were used: clay loam and sandy loam, within a factorial experiment involving three factors (water treatment type, filter type, and soil texture) with three replicates. Wheat seeds were planted, and the soil was fertilized with nitrogen, phosphorus, and potassium at a uniform level according to the recommended fertilization guidelines for wheat. The pots were irrigated according to the treatments, and after 60 days, the plants were harvested. Dry weight was recorded, and the nitrogen, phosphorus, potassium, sodium, and chloride content in the plant foliage was determined after digesting the plant samples. The results showed that clay loam soil irrigated with water filtered through Azolla had significantly better outcomes compared to sandy loam soil in all studied traits (dry weight, N, P, and K concentrations) and exhibited lower concentrations of sodium and chloride in the plants.

Keywords: ***Saline water, water treatment with aquatic plant filters, wheat growth parameters***

I. Introduction:

Water resources are critical inputs in agricultural production. The scarcity of freshwater resources, especially in arid and semi-arid regions like Iraq, which are characterized by low rainfall and high annual evaporation rates, presents a significant challenge. Expanding and advancing agricultural activities requires substantial amounts of water to ensure food security. Consequently, using drainage and saline well water has been proposed as a solution to develop and rationalize the use of freshwater resources by providing an alternative water source and developing irrigation technologies suited to this alternative water supply to achieve economically viable productivity.

Agricultural production is central to sustainable food supply and meeting living needs. However, numerous biotic and abiotic factors associated with climate change pose a significant threat to sustainable crop production, global food security, and agriculture. Agriculture is the primary and sole consumer of global freshwater resources. Nonetheless, illegal freshwater use and changes in the global hydrological cycle have placed significant pressure on freshwater resources. There is an urgent need for effective and practical strategies to manage crops and soils to enhance Water Use Efficiency (WUE) in agricultural ecosystems. A combination of soil and plant-based factors affects WUE in crop systems; thus, both traditional and modern tools are suggested and effectively applied to increase WUE in various crops (Yerlikaya et al., 2020).

Phytoremediation is a natural, environmentally friendly, and cost-effective technique, offering a 50-80% reduction in conventional treatment costs. It requires less maintenance and fewer specialists and produces less waste that can be recycled. Moreover, a single plant can remove multiple types of contaminants and

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 13, Issue 2 (2024) PP 706-720
https://jam.utq.edu.iq/index.php/main https://doi.org/10.54174/utjagr.v13i1.323

requires less space compared to conventional treatment units, reducing soil erosion and providing green spaces (Doty, 2008).

Aquatic plants serve as bioindicators of water pollution and offer a successful alternative for removing pollutants from aquatic environments (Ingole and Bhole, 2003). They are useful in understanding the complex interaction between organisms' responses to environmental factors and their resistance to the lethal effects of various pollutants.

Torres (1972) confirmed that increasing irrigation water salinity leads to reduced nutrient uptake by plants due to the specific effects of ions from high concentrations of certain ions in irrigation water. This results in increased uptake and accumulation of these ions in plant tissues, thereby decreasing the absorption of other essential nutrients and disrupting the plant's nutritional balance. Pilbeam and Barker (2007) observed that the availability of nutrients in the soil decreases due to nutritional imbalances caused by competition for absorption sites in the roots due to increased soluble salts in irrigation water.

This study was conducted to investigate the effect of water treated with aquatic plants on the growth parameters of wheat.

Methods:

Soil Sample Preparation:

Property	Unit of Measurement	Burjassia Soil	Karma Ali Soil
Soil pH (1:1)		7.79	7.86
Electrical Conductivity (Ece)	dS/m	2.46	3.33
Total Solid Carbonates	g/kg	112	336.2
Cation Exchange Capacity (CEC)	cmol/kg	2.05	13.06
Organic Matter	g/kg	0.28	4.08
Ca++	mmol/L	15.53	18.2
Mg++		3.2	11.32
Na+		11.5	17.33
K+		0.2	1.36
Cl-		17.2	25.61
SO4_2		10.32	14.15
HCO3_		1.6	4.71
CO3__		0	0
Soil Fractions			
Clay	g/kg	766	70.3
Silt		101.9	489.3
Sand		132.1	440.4
Texture		Sandy Loam	Clayey Silt

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 13, Issue 2 (2024) PP 706-720
https://jam.utq.edu.iq/index.php/main *https://doi.org/10.54174/utjagr.v13i1.323*

soil type was sandy loam from the agricultural field in Al-Zubair, classified as Sand, Mixed, Typically Torripasmments, Hyperthermic, Calcareous, Active (Al-Atab, 2008). The second soil type was clay loam from Al-Qurna district (Al-Sharsh area), classified as Fine Silty, Mixed, Typically Torripasmments, Hyperthermic, Calcareous, Active. The samples were air-dried, and gravel and debris were removed, then sieved through a mesh with a 2 mm aperture. Subsequently, some preliminary chemical and physical properties of the two soils were determined, as detailed in Table (1).

Chemical and Physical Properties of the Soil Before Planting:

Table 1: Some Chemical and Physical Properties of the Studied Soils Before Planting

Soil pH was measured in a 1:1 soil-to-water suspension according to the method described by Page et al. (1982) using a pH meter model (JENWAY 3505) after calibrating the device with standard solutions. Electrical conductivity was measured in a saturated soil paste extract using an EC meter model (JENWAY 4510) at a temperature of 25°C. Organic carbon was estimated using the method described by Walkley and Black in Page et al. (1982) with potassium dichromate in the presence of concentrated sulfuric acid. The remaining dichromate was then titrated with (1N) ammonium ferrous sulfate, and organic matter was calculated using the following formula:

%OrganicMatter=%OrganicCarbon×1.724\% Organic Matter = \% Organic Carbon \times 1.724%OrganicMatter=%OrganicCarbon×1.724

Total carbonate content was estimated using the back-titration method for excess acid with (1N NaOH) using phenolphthalein as an indicator and (1N HCl) as described by Jackson (1958). Cation exchange capacity (CEC) was estimated using the method proposed by Papanicolaou (1976) described in Page et al. (1982), with (1N CaCl2) as the saturation solution and (1N NaNO3) as the extraction solution. Cations and anions were measured in the saturated soil paste extract as described by Page et al. (1982). Calcium ions were determined by titration with (Na2-EDTA (0.01 N)) using the murexide indicator. Magnesium was also determined by titration with (Na2-EDTA (0.01 N)) using the EBT indicator, with calcium determined by difference, as described in Page et al. (1982). Sodium and potassium ions were measured using a flame photometer model JENWAY pFP7. Chloride ions were determined by titration with silver nitrate (0.05 N AgNO3) using potassium chromate (5% K2CrO4) as an indicator. Sulfates were estimated by the turbidimetric method using a spectrophotometer model (UVD 3200) at a wavelength of 490 nm, as described in Page et al. (1982). Carbonate and bicarbonate ions were estimated using the pH-Alkalinity method described in Page et al. (1982). The soil particle size distribution was determined using the pipette method as described by Black (1965).

Soil moisture at field capacity was measured by placing the soil in experimental containers with 3 replicates, moistening slowly to saturation, covering with polyethylene to prevent evaporation until excess water was drained, then a sample from each replicate was taken to determine the moisture content at field capacity, as described in Sutcliffe (1979).

An agricultural experiment was conducted in the greenhouse of the Soil and Water Resources Department / College of Agriculture / University of Basrah using soil with the properties mentioned in Table 1. The soil was ground and sieved through a 4 mm mesh to test the efficiency of treated water with Azolla, duckweed, and water lentils, selected based on laboratory results for wheat growth and vegetative biomass. The soil was placed in plastic pots with 3 kg of air-dry soil. Wheat seeds (Triticum aestivum L.) variety Baheeth 22 were used and fertilized according to the recommended fertilization practices for

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 13, Issue 2 (2024) PP 706-720
https://jam.utq.edu.iq/index.php/main https://doi.org/10.54174/utjagr.v13i1.323

wheat. Wheat seeds were sown at 10 seeds per pot on (2022-12-20), then watered with tap water and arranged randomly, covered with a nylon cover to encourage germination. After germination, thinning was done to 7 plants per pot. After ten days of germination, irrigation was done with treated water passing through filters, equivalent to field capacity for each pot, maintaining moisture with periodic weighing of pots and replenishing moisture with the same type of water for each treatment. The experiment continued for 60 days.

Plants were harvested 60 days after sowing at a height of 2 cm from the soil surface to avoid contamination. They were then washed with distilled water to remove soil and debris, placed in paper bags, and dried in an incubator at 70°C until constant weight was achieved, and the dry weight of the plants was recorded. The dry plant samples were digested using the method proposed by Cresser and Parsons (1979), then total nitrogen in the digest solution was determined using a steam distillation apparatus as described in Page et al. (1982). Phosphorus was measured using a spectrophotometer at a wavelength of 700 nm. Potassium and sodium in the digest solution were determined using a flame photometer. Chloride was measured by titration with silver nitrate (0.01 N $AgNO_3$) using potassium chromate (5%) after adjusting the acidity of the extract (Karla, 1998).

The agricultural experiment was designed using a Completely Randomized Design (C.R.D) with three replicates. Data were analyzed statistically by analysis of variance and using the Least Significant Difference (L.S.D) test for comparing treatment means (Al-Rawi and Khalaf Allah, 1980), with SPSS Ver.22 for statistical analysis.

II. Results and Discussion:

1. Dry Weight of Wheat Vegetative Biomass:

Examining the results from Table (2), which shows the dry weight of wheat plants irrigated with treated water passing through Azolla, duckweed, and water lentil filters, planted in clayey-loamy and sandy-loam soils, reveals variable effects of the treated water on dry biomass production. The results show that plants irrigated with water passing through the Azolla filter recorded the highest dry biomass production, amounting to 6.85 g pot^{-1}, which was significantly different from the dry weights recorded for plants irrigated with water passing through the duckweed and water lentil filters, which were 6.02 and 5.51 g pot^{-1}, respectively.

Additionally, clayey-loamy soil showed higher dry biomass production, recording 7.24 g pot^{-1}, compared to sandy-loam soil, which recorded 5.02 g pot^{-1}. Notably, the highest dry weight recorded for clayey-loamy soil irrigated with Shatt al-Arab water passing through the Azolla filter was 9.60 g pot^{-1}. This result was significantly different from the same soil irrigated with Shatt al-Arab water passing through the duckweed and water lentil filters, which recorded 8.43 and 7.87 g pot^{-1}, respectively. These values were superior to the control treatment with irrigation water, which recorded 5.34 g pot^{-1}.

On the other hand, sandy-loam soil irrigated with Shatt al-Basra water passing through the water lentil filter recorded a dry weight of 4.4 g pot^{-1}, which was not significantly different from the dry weight recorded for sandy-loam soil irrigated with tap water, which was 4.11 g pot^{-1}.

These findings highlight the effective role of the filters used in the study—Azolla, duckweed, and water lentil—in treating saline and polluted water from Shatt al-Basra and Shatt al-Arab, which are considered unsuitable for agriculture based on international irrigation water standards. Phocaides (2001) confirmed that increased salinity in irrigation water causes salt accumulation in the soil, leading to a cumulative effect of salts, especially in the root zone. This results in increased osmotic pressure, reducing water and nutrient availability, which negatively

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 13, Issue 2 (2024) PP 706-720
https://jam.utq.edu.iq/index.php/main *https://doi.org/10.54174/utjagr.v13i1.323*

affects dry biomass production. This is consistent with findings by Al-Zubaidi (1992), who noted that salts have a qualitative effect on plants, causing antagonism between elements like potassium and sodium, which affects nutrient availability. Mandal et al. (1999) observed that Azolla contributes to increased photosynthesis by releasing organic compounds extracellularly, enhancing oxidation, reducing reduction, and supplying the soil with organic matter, thereby affecting nutrient availability and improving physical and chemical soil properties. Sbedi and Shrestha (2015) confirmed that Azolla has the ability to precipitate certain ions such as calcium and magnesium, which increases soil aggregation stability and positively impacts soil physical, chemical, and fertility properties. Brouwer et al. (2015) and Raja et al. (2012) highlighted Azolla's contribution to soil fertility through the provision of organic matter rich in nutrients during its decomposition. Furthermore, Al-Essa (2012) and Farid (2016) emphasized the importance of soil texture in plant growth due to differences in soil properties, noting the high regulatory capacity of clayey soils to maintain nutrient supply during the growing season compared to sandy soils.

2. **Nitrogen Content in Wheat Plants:**

The data in Table (3) and the supplementary statistical analysis (1) illustrate the effect of treated water passing through various filters on the nitrogen content in the dry matter of wheat plants grown in clayey-loamy and sandy-loam soils. The results align with those observed for dry matter production, as seen in Table (15).

Notably, wheat plants irrigated with water treated through the Azolla filter exhibited the highest nitrogen concentration in dry matter, measuring 1.48%. This was significantly higher compared to nitrogen levels in plants irrigated with water treated through the duckweed filter (1.10%) and water lentil filter (1.00%). This finding is consistent with Parashuramulu et al. (2013), who noted that Azolla is rich in protein and amino acids, with a protein content of 25-35% and is also nutrient-rich.

Egyptian et al. (2008) suggested that some ions have the ability to exchange between plants and solutions due to biosorption, allowing the bio-mass to release certain ions back into the aqueous medium.

Shatt al-Arab water showed superior nitrogen content compared to Shatt al-Basra water. The clayey-loamy soil consistently outperformed the sandy-loam soil. Specifically, clayey-loamy soil irrigated with Shatt al-Arab water recorded the highest nitrogen content at 1.69%. The highest nitrogen content in wheat dry matter was found in plants irrigated with Shatt al-Arab water filtered through Azolla, reaching 1.81%, which significantly differed from other treatments due to the interaction between filter type and water source.

The highest nitrogen concentration, 2.35%, was observed in the clayey-loamy soil irrigated with Shatt al-Arab water and filtered through Azolla. Conversely, the lowest nitrogen content, 0.93%, was recorded in sandy-loam soil irrigated with Shatt al-Basra water and filtered through water lentil. Control treatments with tap water recorded nitrogen contents of 0.97% and 0.66% for clayey-loamy and sandy-loam soils, respectively.

These results indicate that all types of treated water and soil types yielded better results compared to the control with tap water. This suggests successful performance of most filters in purifying contaminated water, which aligns with the findings of Maktouf et al. (2018), who observed that duckweed effectively improves water quality and contains significant amounts of nitrogen, phosphorus, and potassium, which meet plant nutrient needs. Similarly, Guneidi et al. (2016) found that water lentil is a source of protein with high capacity to remove nitrate,

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 13, Issue 2 (2024) PP 706-720
https://jam.utq.edu.iq/index.php/main *https://doi.org/10.54174/utjagr.v13i1.323*

ammonium, and phosphate from contaminated water, supporting the effectiveness of Azolla, duckweed, and water lentil in enhancing nitrogen availability.

3. **Phosphorus Content in Wheat Plants:**

Table (4) and the supplementary statistical analysis (1) present phosphorus content in the dry matter of wheat plants irrigated with water passing through various filters and grown in clayey-loamy and sandy-loam soils. The experimental factors, including filter type, treated water type, and soil type, did not significantly affect phosphorus values, despite Azolla, duckweed, and water lentil filters recording phosphorus concentrations of 0.112%, 0.097%, and 0.082%, respectively. These were higher compared to the control treatments, which recorded phosphorus concentrations of 0.08% and 0.05% for clayey-loamy and sandy-loam soils, respectively.

Xiaoyun and Xingyunan (2015) reported that aquatic plants can remove up to 96.1% of total phosphorus in water, reducing nutrient enrichment in lakes and rivers. This is consistent with Maktouf et al. (2018), who found that duckweed removed 85.71% of phosphorus from water, and Guneidi et al. (2016), who demonstrated that water lentil also effectively removes phosphorus from contaminated water. The lack of significant differences in phosphorus content among treatments may be due to the inherent phosphorus deficiency in the soils used.

4. **Potassium Content in Wheat Plants:**

From Table (4) and the supplementary statistical analysis (1), it is evident that potassium content varied with filter type. Azolla-filtered water produced the highest potassium values in plants, measuring 1.32%, though it was not significantly different from the duckweed-filtered water, which recorded 1.20%. Both were significantly higher than the water lentil-filtered water, which had a potassium content of 1.04%. Clayey-loamy soil demonstrated higher potassium levels, recording 1.39%, compared to sandy-loam soil, which recorded 0.97%.

Wheat plants in clayey-loamy soil irrigated with Shatt al-Arab water showed the highest potassium concentration at 1.41%, with the highest recorded value of 1.65% in plants irrigated with Shatt al-Arab water through the Azolla filter. The lowest potassium content, 0.75%, was found in sandy-loam soil irrigated with Shatt al-Basra water and filtered through the water lentil. Control treatments with tap water recorded potassium concentrations of 0.23% and 0.12% for clayey-loamy and sandy-loam soils, respectively.

The lack of significant interaction among experimental factors (filter type, soil type, and water source) suggests that while the filters effectively increased nutrient availability, their influence on potassium content varied.

5. Sodium Content in Plants:

The results in Table (5) and the supplementary statistical analysis (1) show the sodium content in wheat plants after irrigation with treated water filtered through Azolla, duckweed, and water lentil. The filters differed in their ability to remove sodium from the water, which is reflected in the sodium content of the plants.

Duckweed showed the highest sodium content in plants, at 0.90%, which was significantly higher than the sodium content from Azolla and duckweed filters, which recorded 0.84% and 0.87%, respectively. This reflects the higher efficiency of Azolla and duckweed in removing sodium from the water, while the water lentil was less efficient, resulting in higher sodium content in the plants.

Clayey-loamy soil consistently showed higher sodium content (1.34%) compared to sandy-loam soil (0.40%). This is due to clayey-loamy soil's lower retention of nutrients and its overall deficiency in nutrients, leading to higher availability of sodium to the plants. When irrigated with Shatt al-Basra water, clayey-loamy soil recorded a sodium concentration of 1.62%, while sandy-loam soil recorded 0.73%.

The highest sodium content (1.64%) was found in clayey-loamy soil irrigated with Shatt al-Basra water filtered through water lentil, significantly differing from other treatments. The control treatment had a sodium content of 0.81% for the same soil. These results are consistent with GEMS (1997), which highlighted the ability of aquatic plants to remove calcium, magnesium, sodium, and potassium ions from contaminated water through their biomass. Karimi et al. (2005) noted that increased sodium and chloride accumulation can lead to imbalances in cell ion content, affecting plant health, as sodium competes with potassium and calcium for uptake.

6. Chloride Content in Plants:

Table (6) and the supplementary statistical analysis (1) demonstrate the effect of the experimental treatments on chloride content in the dry matter of wheat plants. The type of filter had a significant effect on chloride concentration. Water lentil showed the highest chloride concentration at 1.20%, significantly different from Azolla and duckweed filters, which recorded 0.98% and 1.02%, respectively. This aligns with the efficiency of these filters in removing chloride, where water lentil was the least efficient, resulting in higher chloride content in plants.

Shatt al-Arab water recorded a chloride concentration of 1.08%, higher than Shatt al-Basra water, which had 1.05%. Clayey-loamy soil had a higher chloride concentration (1.27%) compared to sandy-loam soil (0.87%).

The interaction between soil type and water source was significant, with clayey-loamy soil irrigated with Shatt al-Basra water showing the highest chloride content at 1.36%, compared to sandy-loam soil irrigated with the same water, which had 0.75%. When irrigated with Shatt al-Arab water, the chloride content decreased to 1.18% in clayey-loamy soil and 0.99% in sandy-loam soil.

The interaction between filter type, soil, and water source was also significant. The highest chloride content (1.46%) was found in clayey-loamy soil irrigated with Shatt al-Basra water filtered through water lentil, while sandy-loam soil irrigated with the same filtered water recorded 0.80%. The lowest chloride concentration was observed in sandy-loam soil irrigated with water treated through Azolla, at 0.71%. This suggests that Azolla is effective in reducing chloride concentration in contaminated water, consistent with GEMS (1997), which indicated the ability of aquatic plants to remove chloride from water, and Prusty and Satapathy (2020), who noted Azolla's effectiveness in removing various contaminants from soil and water.

III. Summary

The study demonstrated that clayey-loamy soil irrigated with water filtered through Azolla showed superior results in all studied traits (dry matter weight, nitrogen, phosphorus, potassium) and lower concentrations of sodium and chloride in the plants compared to sandy-loam soil. The effectiveness of the filters in removing contaminants from the water, combined with soil type, significantly influenced nutrient content and overall plant health.

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 13, Issue 2 (2024) PP 706-720
https://jam.utq.edu.iq/index.php/main https://doi.org/10.54174/utjagr.v13i1.323

Table (2) Dry matter of wheat plants irrigated with treated water passing through different filters in two different soil textures (g per pot)

Water Type	Soil Type	Filter Type	Soil Type * Water Type Interaction	Azolla	Shumpland	Water Lentil
Shatt Al-Basra	Clayey Loam	6.57	5.61	5.37	5.85	
	Sandy Loam	4.46	4.47	4.4	4.44	
Shatt Al-Arab	Clayey Loam	9.60	8.43	7.87	8.63	
	Sandy Loam	6.8	5.6	4.4	5.33	
	Effect of Water Type	Soil Type * Filter Type Interaction	Shatt Al-Basra	5.51	5.04	4.88
			Shatt Al-Arab	8.2	7.01	6.13
	Effect of Soil Type	Soil Type * Filter Type Interaction	Clayey Loam	8.08	7.02	6.62
			Sandy Loam	5.63	5.03	4.4
	Average Filter Type			6.85	6.02	5.51
	Least Significant Difference at 0.01 Level **	Filter Type * Water Type	Soil Type * Filter Type	Water Type * Soil Type	Filter Type * Water Type * Soil Type	
			0.28**	**	**	0.40**

Table (3) Percentage of Nitrogen Content in Wheat Irrigated with Treated Water Passing Through Different Filters in Two Different Soil Textures

Water Type	Soil Type	Filter Type	Soil Type * Water Type Interaction	Azolla	Shumpland	Water Lentil
Shatt Al-Basra	Clayey Loam	1.28	1.02	1.05	1.11	
	Sandy Loam	1.04	0.71	0.93	0.89	
Shatt Al-Arab	Clayey Loam	2.35	1.63	1.09	1.69	
	Sandy Loam	1.28	1.04	0.94	1.08	
	Effect of Water Type	Soil Type * Filter Type Interaction	Shatt Al-Basra	1.16	0.86	0.99
			Shatt Al-Arab	1.81	1.33	1.01

University of Thi-Qar Journal of agricultural research
Thi-Qar Journal of agricultural research
ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 13, Issue 2 (2024) PP 706-720
https://jam.utq.edu.iq/index.php/main https://doi.org/10.54174/utjagr.v13i1.323

Water Type	Soil Type	Filter Type	Soil Type * Water Type Interaction	Azolla	Shumpland	Water Lentil
	Effect of Soil Type	Soil Type * Filter Type Interaction	Clayey Loam	1.81	1.32	1.07
			Sandy Loam	1.16	0.87	0.93
	Average Filter Type			1.48	1.10	1.00
	Least Significant Difference at 0.01 Level **	Filter Type * Water Type	Soil Type * Filter Type	Water Type * Soil Type	Filter Type * Water Type * Soil Type	
			0.16**	**	**	0.24**

Drinking Water (Comparison)
Clayey Loam Soil: 0.97
Sandy Loam Soil: 0.66

Table (4) Percentage of Phosphorus Content in Wheat Irrigated with Treated Water Passing Through Different Filters in Two Soil Types

	Phosphorus Content in Plant %	
Water Type	Soil Type	Filter Type
-------------	-----------------------	-------------------
		Azolla
Shatt al-Basra	Clayey Silty	0.09
	Sandy Loam	0.09
Shatt al-Arab	Clayey Silty	0.18
	Sandy Loam	0.09
Effect of Water Type	Interaction Between Water Type * Filter Type	
Shatt al-Basra		0.09
Shatt al-Arab		0.13
Effect of Soil Type	Interaction Between Soil Type * Filter Type	
Clayey Silty		0.13
Sandy Loam		0.09
Average Filter Type		0.112

Least Significant Difference at 0.01 Level

Filter Type	Water Type	Soil Type	Filter Type * Water Type	Filter Type * Soil Type	Water Type * Soil Type	Filter Type * Water Type * Soil Type
ns	-	-	ns	ns	ns	ns

Water Type	Soil Type	Filter Type	Potassium Content in Plant %	Two-Way Interaction (Soil Type * Water Type)

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 13, Issue 2 (2024) PP 706-720
https://jam.utq.edu.iq/index.php/main https://doi.org/10.54174/utjagr.v13i1.323

Filter Type	Water Type	Soil Type	Filter Type * Water Type	Filter Type * Soil Type	Water Type * Soil Type	Filter Type * Water Type * Soil Type
Shatt al-Basra	Clayey-Silty	Azolla	1.45		1.36	
		Shamblan	1.35			
		Water Lentil	1.30			
	Sandy Loamy	Azolla	0.92		0.83	
		Shamblan	0.84			
		Water Lentil	0.75			
Shatt al-Arab	Clayey-Silty	Azolla	1.65		1.41	
		Shamblan	1.53			
		Water Lentil	1.06			
	Sandy Loamy	Azolla	1.24		1.11	
		Shamblan	1.08			
		Water Lentil	1.02			

Effect of Water Type

Filter Type	Shatt al-Basra	Shatt al-Arab
Azolla	1.18	1.44
Shamblan	1.09	1.30
Water Lentil	1.02	1.04
Average	1.09	1.26

**Effect

Effect of Soil Type

Filter Type	Clayey-Silty	Sandy Loamy
Azolla	1.55	1.08
Shamblan	1.44	0.96
Water Lentil	1.18	0.88
Average	1.39	0.97

Average by Filter Type

Filter Type	Average
Azolla	1.32
Shamblan	1.20
Water Lentil	1.04

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 13, Issue 2 (2024) PP 706-720
https://jam.utq.edu.iq/index.php/main https://doi.org/10.54174/utjagr.v13i1.323

Least Significant Difference at 0.01 Level

Filter Type	Water Type	Soil Type	Filter Type * Water Type	Filter Type * Soil Type	Water Type * Soil Type	Filter Type * Water Type * Soil Type
0.16	-	-	ns	ns	0.07	ns

Irrigation Water (Comparison)

Clayey-Silty Soil	Sandy Loamy Soil
0.23	0.12

Table (6): Percentage of Sodium Content in Wheat Irrigated with Treated Water Passing Through Different Filters in Two Different Soil Textures

	Sodium Content in Plants %	Filter Type	Interaction (Soil Type * Water Type)		Azolla Shumplan	Lentil Water
Water Type	Soil Type	Filter Type	Shatt Al-Basra	Shatt Al-Arab		
Shatt Al-Basra	Clayey-Silty	Azolla	1.62	1.02		
		Shumplan	1.61	1.07		
		Lentil Water	1.64	1.12		
		Average	1.62	1.07		
	Sandy-Loamy	Azolla	0.67	0.087		
		Shumplan	0.74	0.085		
		Lentil Water	0.79	0.073		
		Average	0.73	0.081		
Interaction Effects	Filter Type	Shatt Al-Basra	1.14	0.55		
		Shatt Al-Arab	1.17	0.57		
		Average	1.17	0.57		
Soil Type	Filter Type	Clayey-Silty	1.32	0.37		
		Sandy-Loamy	1.34	0.41		
		Average	1.34	0.40		

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 13, Issue 2 (2024) PP 706-720
https://jam.utq.edu.iq/index.php/main *https://doi.org/10.54174/utjagr.v13i1.323*

	Sodium Content in Plants %	Filter Type	Interaction (Soil Type * Water Type)		Azolla Shumplan	Lentil Water
Average Filter Type		0.84	0.87	0.90		

Least Significant Difference (LSD) at 0.01 Level:

Interaction Type	LSD Value
Water Type	0.03**
Soil Type	-
Filter Type * Water Type	0.04**
Filter Type * Soil Type	0.04**
Water Type * Soil Type	0.03**
Filter Type * Water Type * Soil Type	0.06**

Table (7): Percentage of Chloride Content in Wheat Irrigated with Treated Water Passing Through Different Filters in Two Different Soil Textures

	Chloride Content in Plants %	Filter Type	Interaction (Soil Type * Water Type)		Azolla Shumplan	Lentil Water
Water Type	Soil Type	Filter Type	Shatt Al-Basra	Shatt Al-Arab		
Shatt Al-Basra	Clayey-Silty	Azolla	1.32	1.01		
		Shumplan	1.31	1.09		
		Lentil Water	1.46	1.44		
		Average	1.36	1.18		
	Sandy-Loamy	Azolla	0.71	0.91		
		Shumplan	0.76	0.95		
		Lentil Water	0.80	1.13		
		Average	0.75	0.99		
Interaction Effects	Filter Type	Shatt Al-Basra	1.01	0.96		
		Shatt Al-Arab	1.03	1.02		

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 13, Issue 2 (2024) PP 706-720
https://jam.utq.edu.iq/index.php/main *https://doi.org/10.54174/utjagr.v13i1.323*

	Chloride Content in Plants %	**Filter Type**	**Interaction (Soil Type * Water Type)**		**Azolla Shumplan**	**Lentil Water**
		Lentil Water	1.13	1.28		
		Average	1.05	1.08		
Soil Type	Filter Type	Clayey-Silty	1.16	0.81		
		Sandy-Loamy	1.20	0.85		
		Average	1.27	0.87		
Average Filter Type		0.98	1.02	1.20		

Least Significant Difference (LSD) at 0.01 Level:

Interaction Type	**LSD Value**
Water Type	0.06**
Soil Type	-
Filter Type * Water Type	0.09**
Filter Type * Soil Type	0.08**
Water Type * Soil Type	0.07**
Filter Type * Water Type * Soil Type	0.13**

I. References:

1. **Al-Rawi, Khashash Mahmoud & Abdel-Aziz Mohamed Khalafallah** (1980). Design and Analysis of Agricultural Experiments. Dar Al-Kutub Publishing and Printing House, University of Mosul, Iraq.

2. **Al-Zubaidi, Ahmed Haider** (1992). Land Reclamation: Theoretical and Applied Foundations. Dar Al-Hekma Printing House, Baghdad.

3. **Al-Atab, Salah Mahdi Sultan** (2008). Variation in Soil Texture Properties and Classification for Some Areas of Basra Governorate. Ph.D. Dissertation, College of Agriculture, University of Basra.

4. **Al-Essa, Najla Mansour** (2012). Effect of Alternate Irrigation with Different Water Sources on the Availability and Absorption of Some Micronutrients and Heavy Metals in Barley Plants. M.Sc. Thesis, College of Agriculture, University of Basra.

5. **Junaydi, Hussein, George Dib, & Dima Aqda** (2016). Tertiary Treatment of Wastewater Using Azolla Plants at the Jandairiya Station Model. Tishreen University Journal for Research and Scientific Studies – Biological Sciences Series, Vol. 38, No. 3.

6. **Salman, Naras Farid** (2017). The Role of Some Plant Residues in Reducing Water Pollution and Altering Some Soil Properties and Growth of Wheat (Triticum aestivum L.) Irrigated with Polluted Water. M.Sc. Thesis, College of Agriculture, University of Basra.

7. **Maktouf, Afrah Abdul, Bassim Youssef Al-Khafaji, Rasha Saleh Naheer, & Majda Sabah Al-Anzi** (2018). Assessment of the Efficiency of Shumplan Plant in Treating Wastewater in Dhi Qar Governorate, Southern Iraq. Journal of Engineering and Technology, 36 (3): 236–247.

8. **Black, C. A. (1965).** Methods of soil analysis. Part 1. Physical Properties American Society of Agronomy, Inc. Pub., Madison, Wisconsin, U.S.A. PP: 770
9. **Brouwer P, van der Werf A, Schluepmann H, Reichart G-J, Nierop KG (2015)** Lipid yield and composition of Azolla filiculoides and the implications for biodiesel production. Bioenergy Res 1–9. doi:10. 1007/s12155-015
10.
11. **Barker, V.A. and Pilbeam, J.D. (2007)** Handbook of Plant Nutrition. CRC Press, Taylor and Francis Group, Boca Raton, FL.
12.
13. **Cresser, M.S. and J.W. Parsons (1979)** . Sulphuric perchloric and digestion of plant material for the determination of nitrogen ,phosphorus, potassium, calcium and magnesium .Anal .Chem .Acta .109:431-436.
14.
15. **Doty, S. L. (2008).** Enhancing phytoremediation through the use of transgenics and endophytes. New
16. Phytologist, 179: 318 – 333.
17.
18. **GEMS**. Global Environmental Monitoring System, "Water operational guide, 3rd ed. National water research center for inland water". Burlington, Ontario, 274pp, 1997
19. **Ingole, N.W. and A.G.Bhole 2003**.Removal of heavy metal from aqueous solution by water hyacinth(*Eichornia Crassepes*) water s ply.Res.Technol. AQUA,52(2)119-128
20. **Jackson, M. L.(1958).** Soil Chemical Analysis Prentic Hall. Inc. Englewood Cliffs, N. J. USA. P: 558
21. **Karimi, G.; Ghorbanli, M.; Heidari, H.; Khavarinejad, R. A. and Assareh, M. H. (2005).** The effects of NaCl on growth, water relations, osmolytes and ion content in Kochia prostrate. Biol. Plant., 49: 301- 304.
22. **Kalra, Y.P. (1998).** Hand book of methods for plant analysis. Soil and plant analysis council, inc. extractable chloride, nitrate, orthophosphate, potassium, ad sulfate I, plant tissue: 2% acetic acid extraction. Robert O. Miller: Copyright 1998 by Taylor and Francis Group, LLC. P 115-118.
23. **Munns, R. and Tester, M. (2008).**Mechanisms of salinity tolerance. Ann. Rev. Plant Bio., 59: 651-681.
24. **Papanicolaou, E. P. (1976).** Determination of cation exchange capacity of calcareous soils and their percent base saturation. Soil Sci., 121: 65 – 71.
25. **Page, A. L; Miller , R. H. and Kenny, D. R. (1982).** Methods of soil analysis. Part (2). 2nd ed. Agronomy 9 – Wisconsin, Madison. Amer . Soc. Agron . Inc. publisher.
26.
27. **Prusty**,P.K; Satapathy,K.B.2020. Phytoremedation of wastewater by using Azolla Anabaena consortium and its aquatic assocates:Arever. Plant Archives Volume 20 No. 1, 2020 pp. 1933-1943 e-ISSN:2581-6063 (online), ISSN:0972-5210.
28.
29. **Parashuramulu SH , Partha S.S , Devanaboyina N. (2013)** . Protein fractionation and in vitro digestibility of Azolla in ruminants
30.
31. **Phocaides , A. (2001) .** Handbook on pressurized irrigation techniques FAO photosynthetic capacity and water relations as selection criteria . **Photosynthetica . 41:273 – 280 .**
32.
33. **Raja W, Rathaur P, John SA, Ramteke PW (2012)** Azolla: an aquatic
34. pteridophyte with great potential. Int J Res Biol Sci 2:68–72
35.
36. **Sutcliffe, J. (1979).** Plants and Water Baltimore: University Park Press, Institute of Biology's studies in biology. 2nd ed. 122.
37. **Subedi P, Shrestha J (2015)** Azarian Journal of Agriculture Sujatha T, Udhayakumari D,

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 13, Issue 2 (2024) PP 706-720

https://jam.utq.edu.iq/index.php/main *https://doi.org/10.54174/utjagr.v13i1.323*

Kundu A, Jeyakumar S, Sundar J, Kundu MS (2013) Utilization of raw Azolla as a natural feed additive for sustainable production in Nicobari Fowl. Anim Sci 7

38. **Torries, B. C. 1972.** The effect of nitrate and sodium chloride on germination of mexiam wheat. Ph. D. thesis. Univ. of California.
39. **Yerlikaya, B. A., Ömezli, S., & Aydoan, N. (2020).** Climate Change Forecasting and Modeling for the Year of 2050. In Environment, Climate, Plant and Vegetation Growth (pp. 109–122). https://doi.org/10.1007/978-3-030-49732-3_
40. **Xiaoyun Fu.and Xingyuan He2015.** Nitrogen and phosphorus removal from contaminated water by five aquatic plants. International Conference on Mechatronics, Electronic, Industrial and Control Engineering (MEIC 2015).. The authors - Published by Atlantis Press.