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Efficiency of bio-purification using some organic wastes in reclaiming some chemical properties of water general drain

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Abstract
Water suffers from severe pollution, especially in the southern regions of Iraq, and high salt concentrations, which negatively affected plant growth and consequently deteriorated agricultural production. As a way to sustain the environment and reduce these salt levels, and then purify the water with materials or filters. that do not affect the environment and are low-cost, and reuse this water for irrigation. A laboratory experiment was conducted to study the efficiency of some aquatic plants and agricultural waste. In reducing the electrical conductivity values and some chemical properties of water passing through filters, which are papyrus, *Ceratophyllum*, and rice husk ash. Mixing filters with the following combinations: (papyrus + rice husk ash) and (papyrus + *Ceratophyllum*) (rice husk ash + champagne) and (papyrus + rice husk ash + champagne) {and in an equal volume ratio (1:1) for each of the drain water (200 ml). As for the filter, (200 cm^3) was used in the case of a single filter alone, and (100 cm^3) for each filter in the case of a combination of two filters, and (75 cm^3) for each filter in the case of a combination of three filters, so the ratio here is (225 cm^3 filter: 225 ml water). The water for the experiment was collected from the site of the general drain in Dhi Qar. This water was passed through the filters used in the experiment, and the filtered water was collected directly from the filter in plastic containers. Then the reduction efficiency was calculated**.** Reducing efficiency for both positive and negative ions and electrical conductivity. The results showed a difference in the reduction efficiency of electrical conductivity and the studied ions for the filters, but it can be noted that the papyrus filter is superior in its efficiency to all filters. The filters took the following order in terms of reduction efficiency: (Papyrus) > (Rice husk ash) > (Papyrus + Rice husk ash + *Ceratophyllum*)**.** The highest efficiency in reducing cations and inions from the general drain water was according to the following order:
Cl > Na > Ca > Mg > HCO_3 > SO 4

Keywords: Drain, aquatic plants, purification

Introduction
Water is one of the most critical factors for sustainable development, making the rational use of available water resources essential, particularly in arid and semi-arid regions, including Iraq, which suffers from severe water scarcity and limited availability. Consequently, the importance of treating and reusing alternative water sources, such as saline water, wastewater, and industrial effluents, has grown significantly. Most countries have adopted integrated planning and management strategies to efficiently treat and reuse these waters for irrigation and other purposes (Maryam, 2022) [15]. In recent years, Iraq has faced a significant water shortage, particularly in freshwater resources derived from surface and groundwater, which are the primary sources of water in the country, especially in southern Iraq. However, these resources contain high concentrations of salts. When combined with the high soil salinity in the southern and central regions due to harsh climatic conditions that increase evaporation and transpiration rates, and the lack of an efficient drainage system and proper management, the problem is exacerbated. This negatively impacts the growth and productivity of cultivated crops. To mitigate the effects of soil and water salinity, there is a need to explore affordable, easily applicable, and locally available technologies. Water quality is a key determinant of agricultural productivity in terms of both quantity and quality. Moreover, the use of poor-quality water not only harms plant productivity but also affects soil properties, leading to salinization and toxicity issues in crops.

Although water treatment technologies such as reverse osmosis, ion exchange, and membrane filtration are effective in reducing toxic and metallic ions from contaminated water, they remain economically costly. As a result, local researchers, such as Al-Amiri (2006) [2], Al-Khafaji (2012) [5], Radi (2014) [17], Al-Hakim (2016) [3], and Al-Helfi (2020) [4], have turned to more cost-effective and locally available options, such as agricultural plant residues, for treating saline and contaminated water and reusing it for crop irrigation. The use of plant residues, including rice husks, is a promising technique due to their desirable properties, such as high surface area and adsorption capacity for various ions. Additionally, leaving these residues unused in the environment can contribute to environmental pollution. Therefore, it is hoped that these residues can provide a suitable solution to mitigate the adverse effects of salinity on plants, potentially increasing productivity and improving crop quality when applied scientifically. Furthermore, the use of organic waste from aquatic plants as a technique for treating saline water as an alternative to freshwater for irrigation can reduce pollution, as these methods are environmentally friendly and cost-effective. Examples include papyrus, which belongs to the Cyperaceous family and is a marsh plant similar to reeds, commonly found in shallow waters, and water hyacinth, which grows on the water surface and has a high tolerance for pollutants. Due to the diversity and widespread presence of aquatic plants in water bodies, as well as their ability to adapt to changing environmental conditions, various plant families have been extensively used in biotechnology. These plants are ideal agents for purifying soil and water from pollutants due to their genetic, biochemical, and physiological properties, as they accumulate and store pollutants in non-toxic forms within vacuoles (FAO, 1999) [10]. Therefore, this study aims to achieve the following objectives: Utilizing organic waste and dried aquatic plants as a technique to treat saline water as an alternative to freshwater for irrigation, reducing pollution in an environmentally friendly and cost-effective manner with minimal environmental impact and Promoting the rational use of freshwater and river water for irrigation by utilizing saline water, such as seawater and drainage water, as well as contaminated water, such as sewage water.

Materials and Methods

Water Sampling

Water samples for the experiment were collected from the Main Outfall Drain (MOD) with an electrical conductivity (EC) of 15 dS/m. Some chemical and physical properties of the water samples were measured before and after filtration according to the methods described in APHA (2017) [7], as follows:

- pH was measured directly using a pH meter (AMTAST-3).
- Electrical Conductivity (EC) was measured directly using an EC meter (AMTAST-3) at 25 °C.
- Calcium ions (Ca^{2+}) were determined by titration with 0.01 N Na_2-EDTA solution using Murexide as an indicator.
- Magnesium ions (Mg^{2+}) were calculated using the following equation:
- Mg^{2+} (mg/L) = (Total Hardness - Calcium Hardness) × 0.224.
- Sodium (Na^{+}) and Potassium (K^{+}) ions were measured using a Flame Photometer (JENWAY PFP7).
- Chloride ions (Cl^{-}) were determined by titration with 0.05 N $AgNO_3$ solution using Potassium Chromate ($K_2Cr_2O_7$) as an indicator.
- Bicarbonate ions (HCO_3^{-}) were measured by titration with 0.01 N H_2SO_4 solution using Methyl Orange as an indicator.
- Sulfate ions (SO_4^{2-}) were determined using the Turbidimetric Method with a Spectrophotometer (UVD 3200) at a wavelength of 420 nm.

Filters Used in the Study

1. ***Cyperus papyrus* Filter:** Samples of *Cyperus papyrus* were collected and stored in plastic containers until transported to the laboratory. Impurities and dust were removed, and the samples were washed with tap water followed by distilled water. They were then air-dried and oven-dried at 70°C. After drying, the samples were ground and stored in plastic containers to prevent contamination until laboratory experiments were conducted.
2. **Rice Husk Ash (RHA) Filter:** Raw Rice Husk (RR) samples of the Amber variety (*Oryza sativa* L.) were collected from agricultural fields in the Al-Shamiya district of Al-Qadisiyah Governorate. Impurities and soil were removed, and the samples were washed with distilled water. The samples were air-dried and then burned in a Muffle Furnace at 1000°C for 3 hours to obtain Rice Husk Ash (RHA).
3. ***Ceratophyllum demersum* Filter:** Samples of *Ceratophyllum demersum* were collected from the marshes of Al-Jubayesh. Impurities and dust were removed, and the samples were washed with tap water followed by distilled water. They were air-dried and then oven-dried at 70 °C. After drying, the samples were ground and stored in plastic containers until laboratory experiments were conducted.
4. **Mixed Filters**
   The following combinations were prepared in a 1:1 ratio

- *Cyperus papyrus* + Rice Husk Ash (RHA)
- *Cyperus papyrus* + *Ceratophyllum demersum*
- Rice Husk Ash (RHA) + *Ceratophyllum demersum*
- *Cyperus papyrus* + Rice Husk Ash (RHA) + *Ceratophyllum demersum*

Experimental Setup: Plastic tubes with a diameter of 7.5 cm and a height of 20 cm were used. The tubes had a conical end connected to a valve to control the flow rate of the filtered water. Glass wool was placed at the valve opening to prevent filter material from escaping. The tubes were mounted on a wooden stand to stabilize them, following the method described by Liu *et al*. (2000) [14] for filter preparation. Each filter contained 50 g of material, while mixed filters contained 25 g of each material (1:1 ratio).
After stabilizing the water sample in the filter, the valve was opened to collect the treated water, which was immediately stored in airtight plastic containers. The samples were refrigerated at 4 °C until further analysis.

Reduction Efficiency Calculation: The percentage reduction efficiency of element concentrations was calculated using the following formula:

Reduction Efficiency (%) = [(Concentration before filtration - Concentration after filtration) / (Concentration before filtration)] × 100.

Results and Discussion

Efficiency of Filters in Reducing Chemical Properties of Main Outfall Drain Water Used in the Study.

1. Electrical Conductivity (EC): The results shown in Figure (1) demonstrate the role of the filters used in the study—*Cyperus papyrus*, rice husk ash (RHA), *Ceratophyllum demersum*, and mixed filters (*Cyperus papyrus* + RHA, *Cyperus papyrus* + *Ceratophyllum demersum*, RHA + *Ceratophyllum demersum*, and *Cyperus papyrus* + RHA + *Ceratophyllum demersum*)—in reducing the electrical conductivity of highly saline water (Main Outfall Drain water). The *Cyperus papyrus* filter outperformed the others, achieving the highest reduction efficiency of 87.04%. This was followed by the mixed filter (*Cyperus papyrus* + *Ceratophyllum demersum*) with a reduction efficiency of 69.60%, and the mixed filter (*Cyperus papyrus* + RHA) with a reduction efficiency of 67.33%. The other filters showed varying efficiencies, ranging from 53.90% to 58.85% for the mixed filters (*Cyperus papyrus* + RHA + *Ceratophyllum demersum*) and RHA, respectively. The lowest reduction efficiency was recorded for the *Ceratophyllum demersum* filter at 41.28%. These results indicate that the *Cyperus papyrus* filter was highly effective in reducing salinity, both individually and when combined with other materials. The ranking of filters based on efficiency is as follows:

Cyperus papyrus > *Cyperus papyrus* + *Ceratophyllum demersum* > *Cyperus papyrus* + RHA > *Cyperus papyrus* + RHA + *Ceratophyllum demersum* > RHA > RHA + *Ceratophyllum demersum* > *Ceratophyllum demersum*.

This aligns with the findings of El-Baz *et al*. (2020) [9], who explained the adsorption mechanism between the filter material (adsorbent) and water (adsorbate), where functional groups on the surface of the adsorbent attract ions from the water.

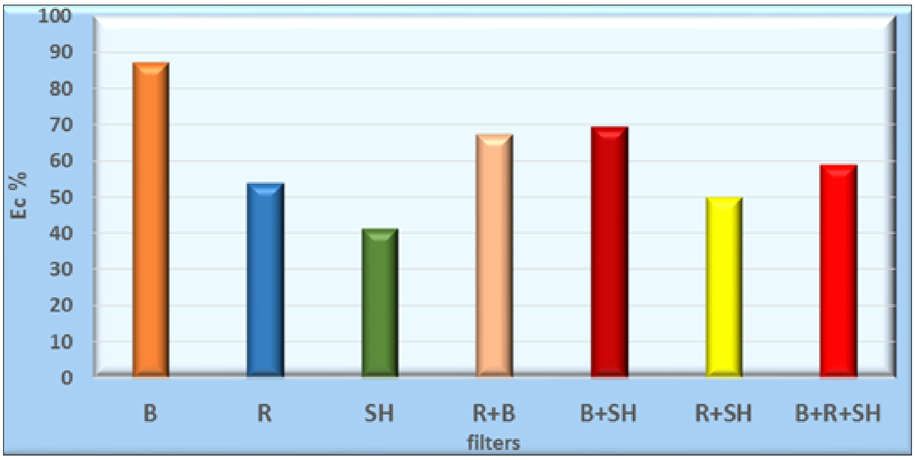

Fig 1: Percentage reduction in electrical conductivity of Main Outfall Drain water passed through the filters.

2. Cations

- **Sodium (Na^{+}):** The results in Figure (2) show that most filters were effective in reducing sodium ions from the Main Outfall Drain water. The *Cyperus papyrus* and RHA filters achieved the highest reduction efficiencies of 94.60% and 94.67%, respectively. The mixed filters (*Cyperus papyrus* + RHA + *Ceratophyllum demersum*) and (*Cyperus papyrus* + RHA) also showed high reduction efficiencies of 94.58% and 94.37%, respectively. The mixed filter (*Cyperus papyrus* + *Ceratophyllum demersum*) achieved a reduction efficiency of 93.32%, while the *Ceratophyllum demersum* filter and the mixed filter (RHA + *Ceratophyllum demersum*) both recorded a reduction efficiency of 87.61%. These findings are consistent with those of Al-Masri *et al*. (2008) [6], who highlighted the effectiveness of biomass in removing metal ions from aqueous solutions, particularly through adsorption mechanisms involving diffusion and osmosis.

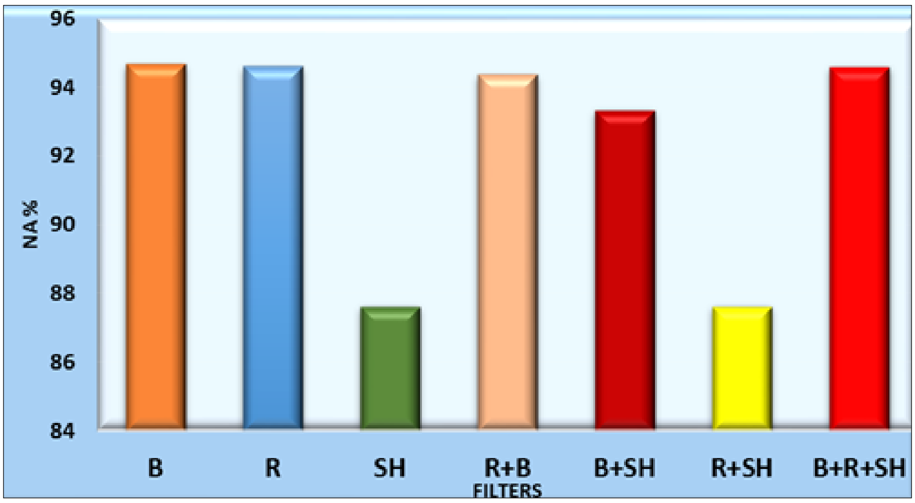

Fig 2: Percentage reduction in sodium ions from Main Outfall Drain water passed through the filters.

- **Calcium (Ca^{2+}):** Figure (3) shows that the mixed filter (*Cyperus papyrus* + *Ceratophyllum demersum*), the *Cyperus papyrus* filter, and the mixed filter (*Cyperus papyrus* + RHA + *Ceratophyllum demersum*) achieved the highest reduction efficiencies for calcium ions, with values of 85.66%, 85.84%, and 85.90%, respectively. The mixed filter (RHA + *Ceratophyllum demersum*) recorded a reduction efficiency of 84.35%, while the RHA filter and the mixed filter (*Cyperus papyrus* + RHA) achieved reduction efficiencies of 83.50% and 83.95%, respectively. The *Ceratophyllum demersum* filter had the lowest reduction efficiency at 79.36%. These results are encouraging for the use of these filters in removing calcium from contaminated water, particularly drainage and industrial wastewater.

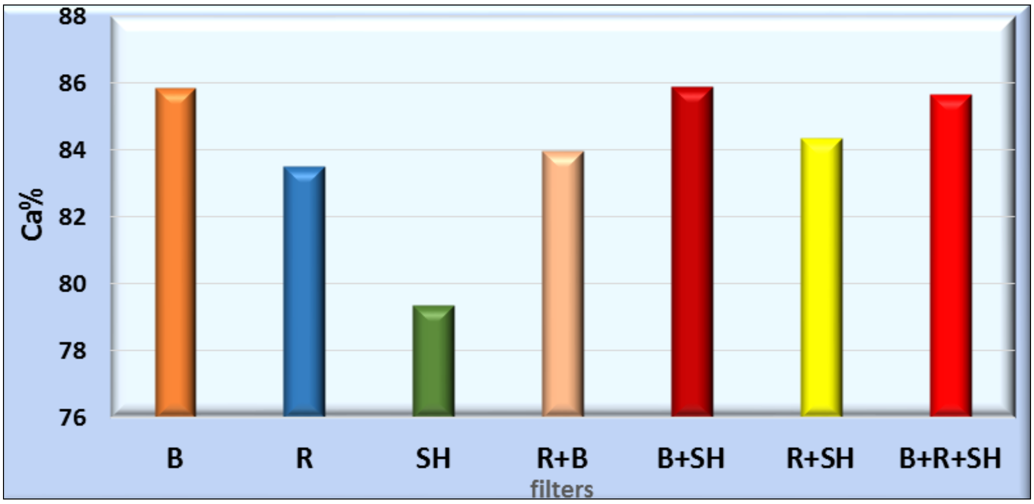

Fig 3: Percentage reduction in calcium ions from Main Outfall Drain water passed through the filters.

- **Magnesium (Mg^{2+}):** The results in Figure (4) indicate that the *Cyperus papyrus* filter was the most efficient in reducing magnesium ions, with a reduction efficiency of 85.41%. The mixed filters (*Cyperus papyrus* + RHA + *Ceratophyllum demersum*), (*Cyperus papyrus* + RHA), and (*Cyperus papyrus* + *Ceratophyllum demersum*) achieved reduction efficiencies of 81.00%, 81.52%, and 81.62%, respectively. The RHA filter and the mixed filter (RHA + *Ceratophyllum demersum*) recorded reduction efficiencies of 80.09% and 80.85%, respectively. The *Ceratophyllum demersum* filter had the lowest reduction efficiency at 74.25%. These results are consistent with the findings of Salamen and Harahsen (2011) [18], who confirmed the effectiveness of organic waste in removing ions such as calcium and magnesium from water, making it a cost-effective method for reducing water hardness and pollution.

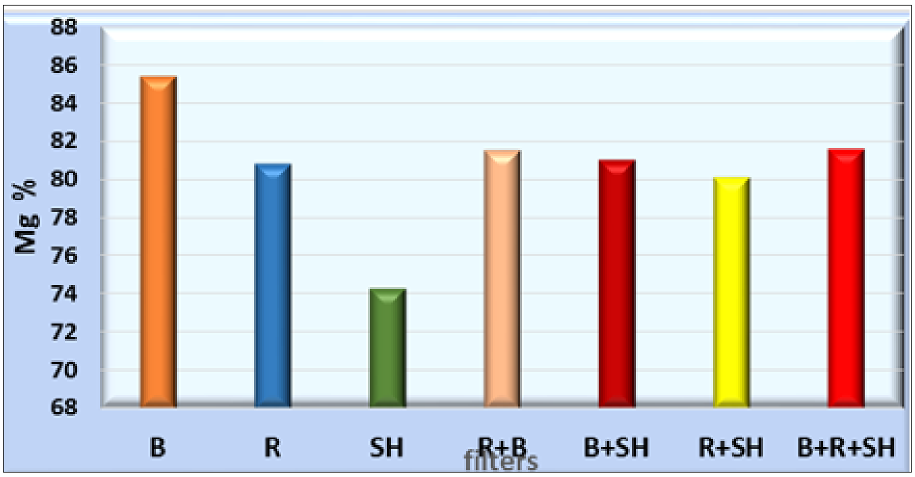

Fig 4: Percentage reduction in magnesium ions from Main Outfall Drain water passed through the filters

- **Potassium (K^{+}):** The behavior of the filters in reducing potassium ions, as shown in Figure (5), differed from that of other cations. The *Cyperus papyrus* filter achieved the highest reduction efficiency of 71.22%, followed by the mixed filter (*Cyperus papyrus* + RHA + *Ceratophyllum demersum*) at 64.01%. The RHA filter recorded a reduction efficiency of 63.01%, while the mixed filter (RHA + *Ceratophyllum demersum*) achieved 61.11%. The *Ceratophyllum demersum* filter had a reduction efficiency of 59.45%, and the mixed filters (*Cyperus papyrus* + *Ceratophyllum demersum*) and (*Cyperus papyrus* + RHA) recorded the lowest reduction efficiencies of 44.69% and 49.75%, respectively. This result is significant for agricultural applications, as potassium is an essential nutrient for plants, and its presence in irrigation water can benefit crop growth.

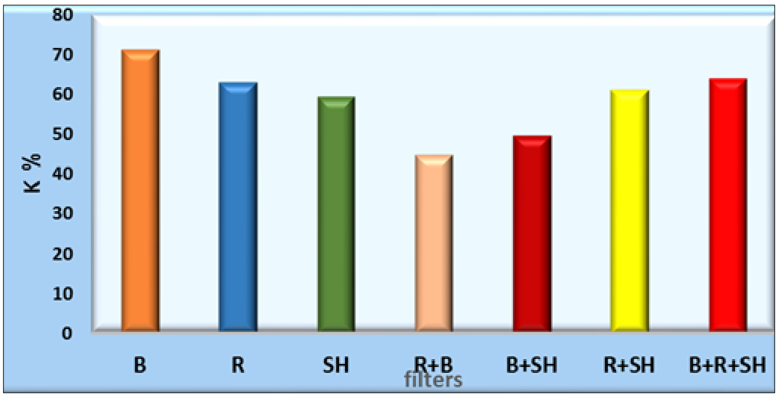

Fig 5: Percentage reduction in potassium ions from Main Outfall Drain water passed through the filters

3. Anions

- **Chloride (Cl^-):** Figure (6) shows that all filters were effective in removing chloride ions from highly saline water (Main Outfall Drain water). The *Cyperus papyrus* filter achieved the highest reduction efficiency of 95.28%, followed by the mixed filters (*Cyperus papyrus* + RHA) and (*Cyperus papyrus* + *Ceratophyllum demersum*) with reduction efficiencies of 94.08% and 94.12%, respectively. The mixed filter (*Cyperus papyrus* + RHA + *Ceratophyllum demersum*) and the RHA filter achieved reduction efficiencies of 93.76% and 93.31%, respectively. The mixed filter (RHA + *Ceratophyllum demersum*) recorded a reduction efficiency of 90.92%, while the *Ceratophyllum demersum* filter had the lowest reduction efficiency at 88.84%. These results are encouraging for the treatment of highly saline water, particularly in reducing chloride concentrations.

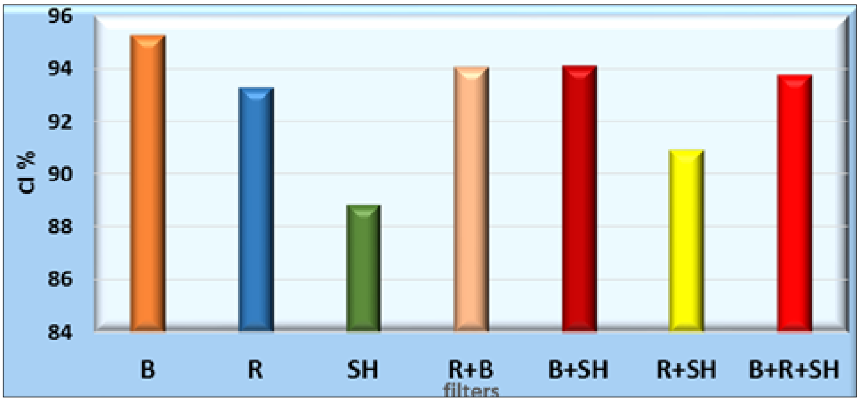

Fig 6: Percentage reduction in chloride ions from Main Outfall Drain water passed through the filters

- **Sulfate (SO_4^{2-}):** The results in Figure (7) show that the *Cyperus papyrus* filter achieved the highest reduction efficiency for sulfate ions at 64.21%, followed by the mixed filter (*Cyperus papyrus* + RHA) at 58.31%. The mixed filter (*Cyperus papyrus* + RHA + *Ceratophyllum demersum*) achieved a reduction efficiency of 58.19%, while the RHA filter recorded 56.73%. The mixed filter (*Cyperus papyrus* + *Ceratophyllum demersum*) achieved 54.65%, and the mixed filter (RHA + *Ceratophyllum demersum*) recorded 52.29%. The *Ceratophyllum demersum* filter had the lowest reduction efficiency at 47.51%. These results suggest that the filters were less effective in reducing sulfate ions, which is beneficial for agricultural use, as sulfate is an essential nutrient for plants and plays a role in reclaiming sodic soils.

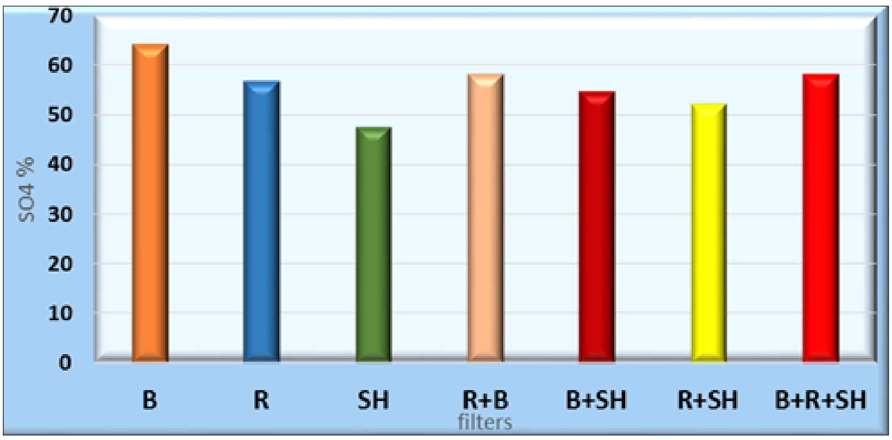

Fig 7: Percentage reduction in sulfate ions from Main Outfall Drain water passed through the filters.

- **Nitrate (NO_3^-):** Figure (8) shows that the filters were less effective in removing nitrate ions from the Main Outfall Drain water, with reduction efficiencies ranging from 10% to 30%. The *Cyperus papyrus* filter achieved the highest reduction efficiency of 30%, while the RHA filter, the mixed filter (RHA + *Ceratophyllum demersum*), and the mixed filter (*Cyperus papyrus* + RHA + *Ceratophyllum demersum*) all recorded a reduction efficiency of 20%. The other filters achieved the lowest reduction efficiency of 10%. This result is positive for agricultural applications, as nitrate is an essential nutrient for plant growth, and its presence in irrigation water can benefit crop productivity.

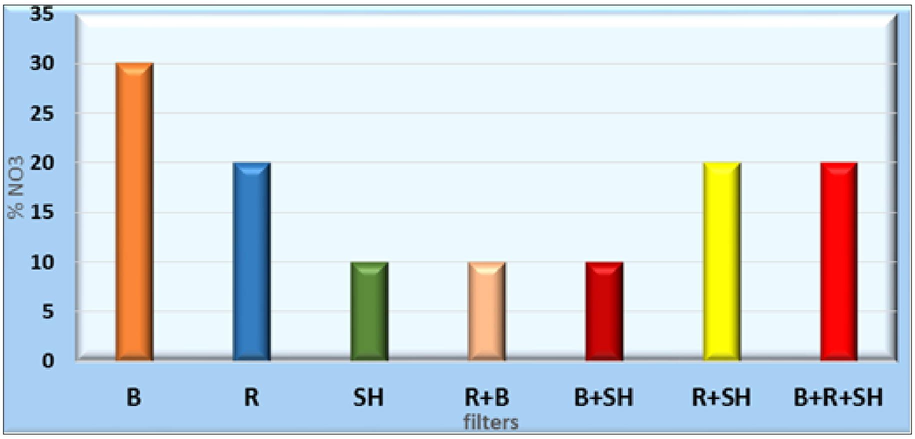

Fig 8: Percentage reduction in nitrate ions from Main Outfall Drain water passed through the filters.

- **Bicarbonate (HCO_3^-):** The results in Figure (9) show that the *Cyperus papyrus* filter achieved the highest reduction efficiency for bicarbonate ions at 81.30%, followed by the RHA filter at 74.34%. The mixed filter (*Cyperus papyrus* + RHA + *Ceratophyllum demersum*) achieved a reduction efficiency of 73.01%, while the mixed filter (*Cyperus papyrus* + RHA) recorded 67.69%. The *Ceratophyllum demersum* filter achieved 66.96%, and the mixed filters (*Cyperus papyrus* + *Ceratophyllum demersum*) and (RHA + *Ceratophyllum demersum*) recorded the lowest reduction efficiencies of 64.42% and 64.67%, respectively. These findings are consistent with the work of Cordero *et al*. (2004) [8], who explained the adsorption mechanisms of aquatic plants and algae in removing pollutants from water.

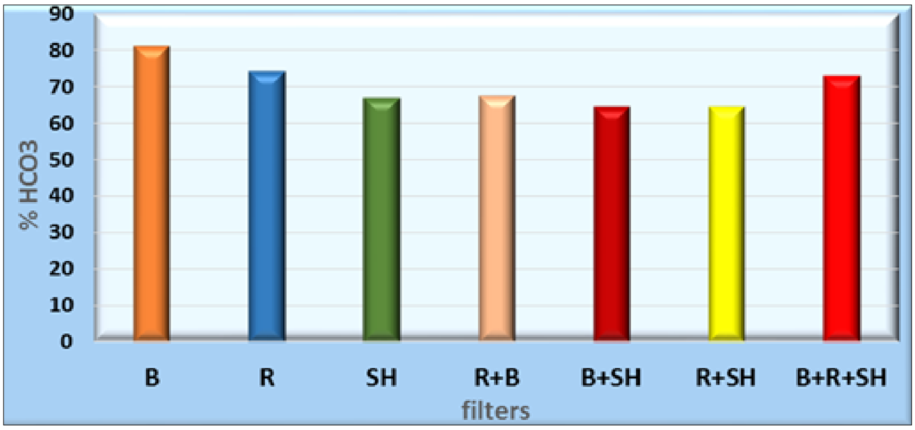

Fig 9: Percentage reduction in bicarbonate ions from Main Outfall Drain water passed through the filters.

Conclusion

We conclude from this study that some dried plants and organic wastes are capable of reducing the salinity of irrigation water to acceptable levels, enabling plants irrigated with this water to grow well without adverse effects on the plant itself or the environment, and at a low economic cost. This method can be used in areas suffering from freshwater scarcity due to high pollution and high temperatures, particularly in the southern regions of Iraq.

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