*Kirkuk University Journal for Agricultural Sciences*
**ISSN:2958-6585**
https://kujas.uokirkuk.edu.iq

***RESEARCH ARTICLE***
https://doi.org. 10.58928/ku24.15305

# Effectiveness of *Dracaena sanderiana* in altering greywater properties for irrigation suitability assessment Kirkuk.

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**Received: 24/05/2024** **Revised: 28/06/2024** **Accepted: 05/07/2024** **Published: 01/09/2024**

## ABSTRACT

The present study aimed to evaluate the bioremediation effectiveness of Dracaena sanderiana in treating greywater (untreated and treated) at various dilutions (25%, 50%, 75%, and 100% undiluted) over incubation periods of 15 and 30 days. (electrical conductivity, total dissolved solids) , (pH, total alkalinity, potassium ions, sodium ions, calcium ions, magnesium ions, chloride ion, total nitrogen, total phosphorus) were assessed along with certain primary metabolites of Dracaena sanderiana plant to determine the irrigation water quality index (IWQI). The highest IWQI value of 67.91 was recorded for the 100% undiluted treated greywater after 30 days of incubation, while the remaining treatments exhibited values ranging from 8.30 to 37.45. The study highlights the potential of Dracaena as a sustainable and eco-friendly bioremediation agent for enhancing greywater quality for irrigation purposes. The study revealed an initial decline in carbohydrate content in plants irrigated with filtered greywater due to nutrient deficiency. However, over time, nutrient ion levels increased, stimulating carbohydrate formation. This was positively correlated with chlorophyll a and b levels in the filtered water. A significant increase in metabolism rates was also observed in both filtered and unfiltered greywater. The utilization of treated greywater for irrigation enhances plant growth and productivity by increasing leaf chlorophyll content, improving water quality, and boosting photosynthetic efficiency.

***Keywords*:** Kirkuk, irrigation Water, IWQI, Gray water, potassium.



## INTRODUCTION

The irrigation water quality index (IWQI) is a valuable tool for enhancing irrigation efficiency and conserving water resources. The suitability of irrigation water depends on its mineral salt content and other factors that can affect plant health and productivity [1]. It is crucial to implement sound irrigation management practices and enhance farmers' knowledge and skills to mitigate the risks associated with using unsuitable irrigation water and maintain agricultural productivity [2].
Greywater, defined as domestic wastewater excluding toilet discharge[3], offers a promising source of irrigation water [4]. The variation in cations and anions values in grey water makes it better suited for irrigation after biotreatment [1]. Plants such as reeds, which resemble Dracaena, have vital bioremediation capabilities [4]. Using *Dracaena sanderiana* establishes a promising bioremediation project.
*Dracaena* also known as Lucky Bamboo or Ribbon Plant, is a popular houseplant belonging to the Asparagaceae family. It is native to Cameroon in West Africa [5], A perennial evergreen ornamental plant, commonly grown in water or well-draining soil, characterized by its slender, cane-like stems and lanceolate leaves often adorned with shades of green and yellow. The tree features a single or multiple trunk reaching heights of up to 12 meters, bearing a dense canopy of thick foliage [6].
The aims of this study are to evaluate the Effectiveness of *Dracaena* Plant in Enhancing Greywater Quality for Irrigation Purposes.

## MATERIALS AND METHODS

The methodologies outlined in APHA (2017) [7] were employed to measure all physical and chemical properties of greywater for all treatments (25%, 50%, 75%, and 100% filtered and unfiltered) (Figure 1). Results were statistically analyzed using SPSS software version 26, employing one-way ANOVA and Duncan's multiple range test at a significance level of $p \leq 0.05$. Additionally, correlation coefficients were calculated to assess the relationships between the studied parameters.

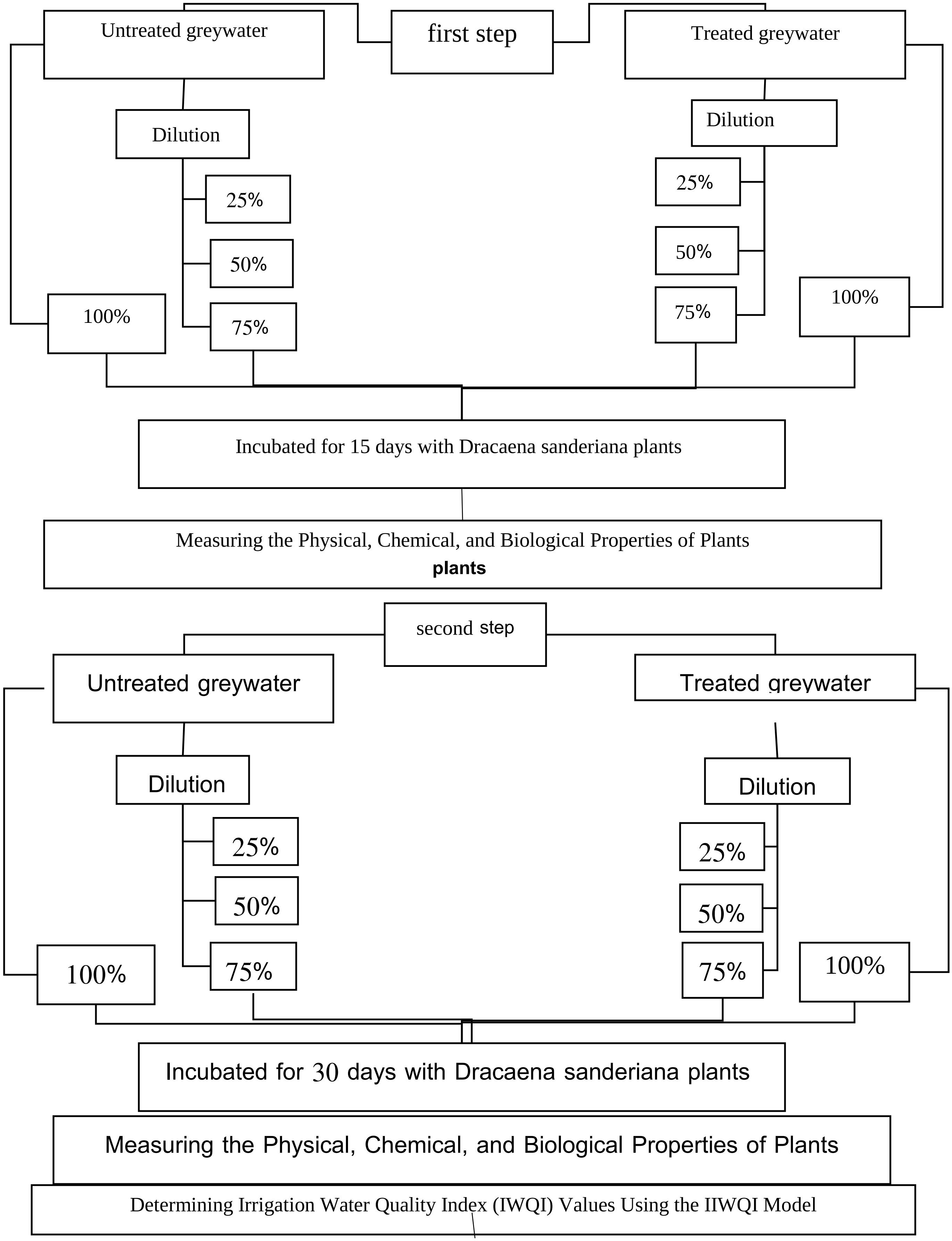
### Irrigation water quality index (IWQI)

Irrigation water quality index (IWQI) values were calculated for all treatments using the Islam and Mostafa (2022) equations.

1. Obtaining the rank of each study attribute within the contrasting classes.

$Qi= (2V_i/V_{max}) \times R_c \times\{[100-V_{min}]/(V_i+V_{max})\} \times r_i \times 100$

2. Computing the secondary attribute value for each attribute.


first step
Untreated greywater
Treated greywater
Dilution
25%
50%
75%
100%
Dilution
25%
50%
75%
100%
Incubated for 15 days with Dracaena sanderiana plants
Measuring the Physical, Chemical, and Biological Properties of Plants
plants
second step
Untreated greywater
Treated greywater
Dilution
25%
50%
75%
100%
Dilution
25%
50%
75%
100%
Incubated for 30 days with Dracaena sanderiana plants
Measuring the Physical, Chemical, and Biological Properties of Plants
Determining Irrigation Water Quality Index (IWQI) Values Using the IIWQI Model

## RESULTS AND DISCUSSION

Tables (1 and 2) revealed significant variations in the measured parameters, which notably influenced the characteristics of irrigation water. The highest total dissolved solids (TDS) values were recorded at 430 and 520 mg/L for untreated and treated greywater samples, respectively, in the 100% treatment after 15 and 30 days of incubation. TDS values increased in treated greywater with increasing treatment concentration, dilution, and mixing. The deterioration of greywater quality is attributed to the influx of human-induced pollutants, primarily food particles, detergent residues, and bacteria.[8].

The highest electrical conductivity (EC) value was observed in the untreated greywater sample (100% treatment) at 770 µS/cm after 15 and 30 days of incubation, and the highest EC value in treated greywater was 1047 µS/cm (100% treatment) after 30 days of incubation. The highest pH was recorded at 7.9 in the untreated greywater (100% treatment) after 30 days of incubation and in the treated greywater before incubation. Total alkalinity exhibited peak values of 180 mg/L in untreated water before incubation and 248 mg/L in treated greywater after 30 days, both in the 100% treatment.

Potassium (K+) concentrations reached their highest levels at 5.960 mg/L and 16.55 mg/L in untreated and treated greywater, respectively, in the 100% treatment after 15 days of incubation. Sodium (Na+) levels peaked at 116.480 mg/L before incubation and 107.520 mg/L in untreated and treated greywater after 15 days, respectively, with variations in incubation duration. Calcium (Ca2+) concentrations were highest at 54.108 mg/L and 61.124 mg/L in untreated and treated greywater, respectively, in the 100% treatment with varying incubation periods. Magnesium (Mg2+) levels reached their maxima at 52.896 mg/L in both untreated and treated greywater, recorded in the 75% treatment before and after 30 days of incubation, respectively. Chloride (Cl-) concentrations peaked at 22.720 mg/L and 29.820 mg/L in untreated and treated greywater, respectively, in the 100% treatment after 15 and 30 days of incubation. Sulfate (SO42-) concentrations reached their highest levels at 51.860 mg/L and 79.613 mg/L in untreated and treated greywater, respectively, in the 100% treatment after 30 and 15 days of incubation.

Regarding nutrients, total nitrogen (TN) reached its maximum at 3.56 mg/L in the 75% treatment before incubation for treated greywater and 0.8 mg/L in the 25% and 50% treatments after 15 days of incubation. Total phosphorus (TP) peaked at 2.513 mg/L and 0.481 mg/L in the 75% treatment for untreated and treated greywater, respectively, before incubation in the 25% treatment.

Table 1: characteristics of Untreated Greywater

| Factors | 25% | | | 50% | | | 75% | | | 100% | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 15 | 30 | 0 | 15 | 30 | 0 | 15 | 30 | 0 | 15 | 30 |
| TDS ppm | 110 | 180 | 128 | 180 | 260 | 179.2 | 300 | 230 | 198.4 | 410 | 430 | 268.8 |
| EC µs/cm | 193 | 297 | 377 | 320 | 453 | 591 | 514 | 400 | 586 | 707 | 770 | 770 |
| pH | 7.1 | 7 | 7.2 | 7.2 | 7.4 | 7.6 | 7.3 | 7.3 | 7.3 | 7.6 | 7.6 | 7.9 |
| TALK ppm | 48 | 68 | 90 | 80 | 104 | 119 | 120 | 88 | 157 | 180 | 142 | 146 |
| K+ ppm | 1.324 | 1.324 | 1.324 | 1.986 | 2.649 | 2.649 | 2.650 | 1.324 | 2.649 | 5.298 | 5.960 | 3.973 |
| ppm | 17.920 | 26.880 | 17.920 | 26.880 | 40.320 | 17.920 | 35.840 | 40.320 | 22.400 | 116.480 | 71.68 | 40.320 |
| $Na^+$ | | | | | | | | | | | | |
| ppm | 10.020 | 18.036 | 26.052 | 22.044 | 26.052 | 46.092 | 34.068 | 28.056 | 46.092 | 54.108 | 40.080 | 50.100 |
| $Ca^+$ | | | | | | | | | | | | |
| ppm | 19.456 | 26.752 | 36.480 | 29.184 | 38.912 | 48.640 | 48.64 | 31.616 | 52.896 | 36.48 | 37.696 | 40.736 |
| $Mg^+$ | | | | | | | | | | | | |
| $Cl^-$ ppm | 9.940 | 7.100 | 9.940 | 12.780 | 11.360 | 12.780 | 15.620 | 2.840 | 7.100 | 18.460 | 22.720 | 19.880 |
| $So^4$ ppm | 4.335 | 7.506 | 28.071 | 8.141 | 13.639 | 34.414 | 15.859 | 10.995 | 44.564 | 22.097 | 21.423 | 51.860 |
| TN% | 1 | 2 | 0.4 | 1.25 | 2 | 0.2 | 3.56 | 2 | 0.2 | 4 | 2.5 | 0.2 |
| Tp ppm | 0.103 | 0.533 | 0.481 | 0.129 | 0.152 | 0.270 | 2.513 | 0.522 | 0.507 | 0.202 | 0.522 | 0.207 |

2: characteristics of treated Greywater

| Factors | 25% | | | 50% | | | 75% | | | 100% | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 15 | 30 | 0 | 15 | 30 | 0 | 15 | 30 | 0 | 15 | 30 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TDS ppm | 128 | 200 | 190 | 179.2 | 310 | 370 | 198.4 | 410 | 510 | 268.8 | 470 | 520 |
| EC μs/cm | 377 | 426 | 391 | 521 | 670 | 738 | 586 | 880 | 1023 | 770 | 982 | 1047 |
| pH | 7.2 | 7.1 | 6.4 | 7.6 | 7.1 | 6.5 | 7.3 | 7.3 | 6.8 | 7.9 | 7.0 | 6.6 |
| TALK ppm | 88 | 74 | 80 | 144 | 118 | 132 | 188 | 180 | 222 | 216 | 230 | 248 |
| K+ ppm | 1.324 | 0.662 | 1.324 | 2.649 | 10.595 | 1.324 | 2.649 | 14.569 | 3.311 | 3.973 | 16.556 | 15.893 |
| ppm | 17.920 | 22.400 | 53.760 | 17.920 | 44.800 | 89.600 | 22.400 | 53.760 | 107.520 | 40.320 | 62.720 | 89.560 |
| $Na^+$ ppm | 26.052 | 24.048 | 22.044 | 46.092 | 42.084 | 38.076 | 46.092 | 54.108 | 58.116 | 50.100 | 61.124 | 52.104 |
| $Ca^+$ ppm | 36.480 | 14.592 | 10.944 | 48.640 | 20.672 | 25.536 | 52.896 | 30.4 | 48.032 | 40.736 | 34,948 | 6.800 |
| $Mg^+$ | | | | | | | | | | | | |
| $Cl^-$ ppm | 9.940 | 8.520 | Intangible values | 12.780 | 14.200 | Intangible values | 7.100 | 22.720 | 19.880 | 19.880 | 25.560 | 29.820 |
| $So^4$ ppm | 28.071 | 33.939 | 32.670 | 34.414 | 53.604 | 54.397 | 44.564 | 66.926 | 55.666 | 51.860 | 79.613 | 63.437 |
| TN% | 0.4 | 0.8 | Intangible values | 0.2 | 0.8 | 0.2 | 0.2 | 0.4 | 0.4 | 0.2 | 0.1 | 0.2 |
| Tp ppm | 0.481 | 0.052 | 0.052 | 0.270 | 0.078 | 0.089 | 0.507 | 0.111 | 0.229 | 0.207 | 0.126 | 0.081 |

No significant differences ($P \leq 0.05$) were observed in protein, carbohydrate, and chlorophyll concentrations in Moses' staff plants used for greywater treatment in either untreated or treated greywater (Table 3). Total chlorophyll concentrations ranged from 26.120 ppm in the 50% untreated greywater treatment to 32.844 ppm in the 100% treated greywater treatment. In comparison, chlorophyll a concentration ranged from 18.75 ppm in the 50% untreated greywater treatment to 21.78 ppm in the 75% untreated greywater treatment. Chlorophyll b concentrations ranged from 7.364 ppm in the 50% untreated greywater treatment to 11.522 ppm in the 100% treated greywater treatment. Carbohydrate concentrations ranged from 14.901 ppm in treated greywater to 21.56 ppm in the 25% untreated greywater treatment. In comparison, protein concentrations ranged from 1.878 ppm in the 25% untreated greywater treatment to 2.472 ppm in the 100% treated greywater treatment.

Table 3: Dry weight values of Dracaena sanderiana for treated and untreated greywater

| Greywater | treatment | 25% | 50% | 75% | 100% |
|---|---|---|---|---|---|
| untreated greywater | Proteins | 1.878 a | 2.145 b | 1.939 a | 1.917 a |
| | Carbohydrates | 21.565 a | 15.756 a | 20.209 a | 21.006 a |
| | Chlorophyll a | 20.673 a | 18.756 a | 21.787 a | 18.949 a |
| | Chlorophyll b | 9.108 a | 7.364 a | 10.434 a | 7.751 a |
| | Total chlorophyll | 29.781 a | 26.120 a | 32.221 a | 26.700 a |
| treated greywater | Proteins | 2.366 a | 2.561 a | 2.469 a | 2.472 b |
| | Carbohydrates | 15.621 a | 16.078 a | 14.901 b | 17.190 b |
| | Chlorophyll a | 20.474 a | 19.906 a | 21.283 a | 21.322 a |
| | Chlorophyll b | 10.106 a | 9.753 a | 11.376 a | 11.522 a |
| | Total chlorophyll | 30.58 a | 29.659 a | 32.659 a | 32.844 a |

The irrigation water quality index (IWQI) results revealed a significant influence of incubation duration on the index value due to alterations in greywater characteristics. As shown in Table 4, treating greywater at 25%, 50%, 75%, and 100% dilutions, filtering it, and incubating it with Moses' staff plant resulted in varying IWQI values. The highest value was recorded for the 100% treatment after 30 days of incubation, reaching 67.91 out of 100 for filtered greywater, followed by comparable values in other treatments. This high IWQI value indicates an enhancement in greywater quality parameters, making it suitable for the irrigation of certain plants and agricultural lands.

Table 4: Irrigation Water Quality Index (IWQI) Values

| Sl.no | Greywater | Treatment | Incubation period | Indicator value |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| 1 | treated | 100% | After 30 days | 67.91 |
| 2 | treated | 100% | Before the start of the experiment | 67.54 |
| 3 | Untreated | 50% | Before the start of the experiment | 67.39 |
| 4 | treated | 75% | Before the start of the experiment | 67.05 |
| 5 | treated | 50% | After 15 days | 66.10 |
| 6 | treated | 50% | Before the start of the experiment | 65.96 |
| 7 | Untreated | 75% | Before the start of the experiment | 65.40 |
| 8 | Untreated | 50% | After 15 days | 65.35 |
| 9 | Untreated | 75% | After 30 days | 63.53 |
| 10 | Untreated | 25% | Before the start of the experiment | 63.44 |
| 11 | Untreated | 75% | After 15 days | 63.29 |
| 12 | treated | 25% | Before the start of the experiment | 62.73 |
| 13 | Untreated | 25% | After 30 days | 62.43 |
| 14 | Untreated | 25% | After 15 days | 62.15 |

The findings of the present study align with those of [9], who reported the release of ions into the aqueous medium upon root decomposition of Moses' staff plant. Consistent with the observations of [10] and [11], who noted an increase in total dissolved solids (TDS) in treated greywater following plant-based treatment, the current study found a direct correlation between TDS concentration and treatment duration, dilution ratio, and mixing ratio. Consequently, plant-based greywater treatment resulted in an elevated TDS concentration. The increase in electrical conductivity is likely attributed to the influx of positive and negative ions leached from the plant roots, especially with extended incubation periods. The decline in pH values of treated greywater indicates lower concentrations of bicarbonate, carbonate, and hydroxide ions, aligning with the findings of [12]. The elevated total alkalinity values in greywater could stem from increased alkalinity-inducing ions resulting from organic matter decomposition and the release of carbon dioxide. This gas reacts with water to form carbonic acid, which dissociates into bicarbonate and carbonate ions, contributing to the observed rise in total alkalinity, which generally increased across treatments with extended incubation [13]. In some instances, potassium concentration increases due to its release from plant roots as an adaptive mechanism to compensate for the deficiency of other nutrients [14]. The roots of Dracaena sanderiana may interact with bacteria present in greywater, and these interactions could lead to the release of potassium from organic matter in the greywater [15], The elevated sodium levels observed in filtered greywater could be attributed to the presence of organic matter within the filtration media. These organic compounds can form stable complexes with sodium ions, potentially leading to their retention during the filtration process. The decomposition of these organic materials, particularly in unfiltered greywater, could subsequently release the associated sodium ions, contributing to the overall sodium content in both filtered and unfiltered greywater [16]. In agreement with the findings of [13], the present study observed that filtration using Dracaena sanderiana plant led to an increase in magnesium levels by up to 40%. In contrast, total nitrogen levels decreased in the filtered greywater. This reduction in nitrogen is attributed to the plant's ability to absorb nitrogen from greywater containing a diverse range of ions. Additionally, the decomposition of organic matter into inorganic forms of nitrogen ions, such as ammonia and nitrate, facilitates their uptake by plant roots for growth processes [17]. The impact of incubation was evident in the decreased carbohydrate content of filtered greywater plants. This is attributed to the stress imposed by the surrounding environmental conditions on the plant, negatively affecting carbohydrate formation. Microorganisms, such as bacteria, play a crucial role in releasing ions and altering the chemical properties of the water. Over time and with extended incubation periods, nutrient ion levels increase, stimulating carbohydrate formation [4]. The positive correlation between chlorophyll a and b content in treated greywater and the concentrations of potassium, nitrogen, and phosphorus further supports the effectiveness of Dracaena sanderiana in bioremediation. A significant increase in metabolite levels was observed in both treated and untreated greywater at 50%, 75%, and 100% dilutions, respectively. This increase can be attributed to the presence of high concentrations of ions such as potassium, nitrogen, and phosphorus in these waters. These ions play a crucial role in activating the photosynthesis process. Nitrogen is essential for chlorophyll production, the pigment that enables plants to absorb sunlight. It also plays a vital role in building proteins and amino acids, and in forming chloroplasts, the organelles where photosynthesis takes place. Consequently, the presence of these ions in greywater leads to an increase in leaf chlorophyll content, enhancing photosynthesis and boosting plant growth efficiency [18], Filtration processes can enhance greywater quality by removing organic matter and suspended solids, leading to an increased availability of essential plant nutrients. This, in turn, promotes chlorophyll production, the green pigment that plays a pivotal role in photosynthesis, a process that relies on the availability of nutrients [19]. Enhanced photosynthesis efficiency leads to increased energy production in plants. Consequently, utilizing treated greywater for irrigation purposes promotes plant growth and productivity[20]

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# تأثير نبات دراسينيا في تغير خصائص المياه الرمادية لتحديد صلاحيتها الري

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الخلاصة
هدفت الدراسة الحالية الى تقييم فعالية نبات دراسينيا في المعالجة الحيوية للمياه الرمادية (غير المرشحة والمرشحة) في سلسلة من المعاملات 25%، 50%،75% وغير مخففة 100% بعد حضنها لمدة 15 يوم و30 يوم. وقيست مجموعة من الخصائص الفيزيائية (قابلية التوصيل الكهربائية والمواد الذائبة الكلية) والكيميائية (الاس الهيدروجيني، القاعدية الكلية، ايون البوتاسيوم، ايون الصوديوم، ايون الكالسيوم، ايون المغنسيوم، ايون الكلوريد، النتروجين الكلي، الفسفور الكلية) وبعض مركبات الايض الاولي لنبات الدراسينيا لتحديد مؤشر جودة مياه الري والتي سجلت أفضل قيمه لها 67.91 في المعاملة 100% بعد 30 يوم حضن للمياه الرمادية المرشحة فيما تدرجت قيم بقية المعاملات وسجلت ادناه 8.30 في المياه الرمادية غير المعاملة وغير المحضونة. أظهرت الدراسة انخفاض محتوى الكربوهيدرات في نباتات المياه الرمادية المرشحة في البداية، وذلك بسبب نقص العناصر الغذائية. ولكن مع مرور الوقت، زادت مستويات الأيونات المغذية، مما حفز تكوين الكربوهيدرات. وارتبط ذلك بشكل إيجابي بمستويات الكلوروفيل $a$ و $b$ في المياه المرشح، كما لوحظت زيادة ملحوظة في قيم الأيض في كل من المياه الرمادية المرشحة والمياه الرمادية غير المرشحة. أنّ استخدام المياه الرمادية المعالجة لريّ النباتات يُعزز نموها وإنتاجيتها من خلال زيادة محتوى الأوراق من الكلوروفيل وتحسين نوعية المياه وزيادة كفاءة التمثيل الضوئي.

الكلمات المفتاحية: كركوك، مياه الري، مؤشر جودة مياه الري، المياه الرمادية، البوتاسيوم.