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Ecological and chemical study of *Eichhornia Crassipes* plant growing in water of Shatt Al-Ksar in Thi Qar - southern Iraq

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Abstract

The results of this study highlight the important ecological role of water hyacinth in aquatic environments, in particular in improving water quality through the absorption of trace elements and organic pollutants. The study samples were collected from Shatt al-ksar during the autumn of 2023,The results of the three sample stations showed noticeable differences in the main physical and chemical parameters , including dissolved oxygen (DO), salinity, electrical conductivity (EC), and total petroleum hydrocarbons (TPH). These variations were closely associated with the density of water hyacinth coverage at each site. Station 1, characterized by dense plant cover, exhibited the lowest DO levels alongside the highest concentrations of trace elements and TPH outcome attributed to increased oxygen consumption from plant biomass decomposition and limited gas exchange due to dense growth. In contrast, Station 2, with moderate vegetation, showed intermediate values. Station 3, which lacked vegetation almost entirely, recorded the highest DO and the lowest levels of EC and TPH, reflecting better water clarity and quality in the absence of plant cover. Furthermore, analysis of pollutant accumulation in different plant parts revealed that the roots and vesicles retained the highest levels of trace elements (Ni, Cr, Cu, Zn, and Pb) and TPH. These results reinforce the effectiveness of water hyacinth in pollutant uptake and stabilization, particularly in areas subject to contamination, underscoring its potential role in phytoremediation applications. As for the chemical composition of the plant, analyses showed a high content of organic matter (with an average exceeding 60% of the dry weight) and varying proportions of fibers, proteins, and ash. This reflects the plant's suitability for use in industrial and agricultural applications. This is consistent with the results of other studies that showed a relative compatibility in the ratios of ash, protein, and humidity. The novelty of this study lies in comparing aquatic sites with different levels of water hyacinth growth, examining vegetation density, water properties, trace element concentrations, and TPH. It analyzes the accumulation of heavy metals and TPH in the different parts of the plant and presents a dual perspective on the role of the water hyacinth as both a pollutant and a sustainable environmental solution.

Keywords: Aquatic Environment, Shatt al-Ksar, Eichhornia crassipes,Trace elements,TPH

I. INTRODUCTION

Water hyacinth (*Eichhornia crassipes*) is an invasive aquatic plant related with a variety of environmental and economic impacts on freshwater ecosystems [1]. The spread of invasive species is difficult to manage and not easy to reverse, this threatens not only biodiversity of aquatic ecosystems but also economic development and human wellbeing [2].It is a free-floating aquatic plant that grows in ponds or slow moving water channels .It is native to the Amazon Basin in Brazil and other nearby South American countries [3]. And Holm, et al., [4] Explained that, *E. crassipes,* It is consideredas the most troublesome aquatic plant and from the worst aquatic plant in the world [5]. Water hyacinth, due to its rapid propagation and morphological characteristics, is well-suited for

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successful colonization of various habitats in a short time[6]. And it is, a plant that reproduces sexually and asexually, rapidly grows and spreads due to its vegetative reproduction, causing significant infestations in new areas [7] .

Water hyacinth, a plant that moves easily with water currents, winds, or accidental means, invades rivers, canals, ponds, lakes, dams, and other freshwater bodies . It colonizes slow-moving waters, resulting in thick, extensive mats that degrade aquatic ecosystems and limit their utilization [8],[9]. The dense, impenetrable mats restrict water access, affecting fisheries, commercial activities, irrigation canals, navigation, hydroelectric programs, and tourism [10]. The plant features light blue flowers on spikes and green, roundish leaves with an inflated bladder-like petiole ,The plant can withstand various environmental conditions like temperature, humidity, lighting, pH, salinity, wind, current, and drought [11]. This plant has caused significant harm to the aquatic environment since its first introduction to Iraq in the mid-1980s, when it reached the waters of the Tigris and Euphrates rivers, becoming a major problem threatening the aquatic environment in a short period [12]. Studies on water hyacinth plants, local and global studies, including those conducted in Iraq, have revealed significant environmental and economic impacts. These include blockage of irrigation channels, high evaporation rates leading to water loss, decreased biodiversity, and challenges in navigation and fishing activities. Control methods include manual removal, mechanical harvesting, and chemical applications. Integrated management, which combines physical, chemical, and biological control, along with awareness campaigns to prevent reintroduction, is also being explored.
These studies highlight the need for effective management strategies to mitigate these effects [13,14,15,16,17,18] .
The novelty and aims of this study lie in conducting a comprehensive comparison between different aquatic sites with varying growth rates of the water hyacinth, linking vegetation density to changes in the physical and chemical properties of the water, the concentration of trace elements, and the total hydrocarbon compounds. This study also focuses on analyzing the accumulation of trace elements and petroleum compounds in the different parts of the plant. To provide a perspective on the role of the water hyacinth, both as a pollutant in the absence of management and as an active agent in sustainable environmental solutions when used through well-studied scientific methods. and demonstrate the environmental effects and chemical composition of water hyacinth on the aquatic ecosystem in the water of the study area while challenging the ecological stability of freshwater ecosystems.

II. MATERIAL AND METHOD

Study area

Shatt al-Ksar is a water stream in southern Iraq, feeding numerous agricultural villages. It is a tributary stream that originates from the Shatra River, which in turn branches from the Al-Gharraf River, a branch of the Tigris River, located in the Thi Qar governorate north of Nasiriyah. This study included three stations (Figure 1). Station 1, dense water hyacinth plant: 31°10'20.6"N 46°16'56.7"E; Station 2, partial coverage of the water hyacinth plant: 31°10'26.8"N 46°17'20.7"E; and Station 3, no hyacinth, is a reference station far from the water hyacinth plant: 31°10'29.3"N 46°17'40.9"E. As shown in (Figures 2), The density of water hyacinth plant growth at the study station is indicated, and (Figure 3) illustrates the external appearance of the *Eichhornia crassipes*

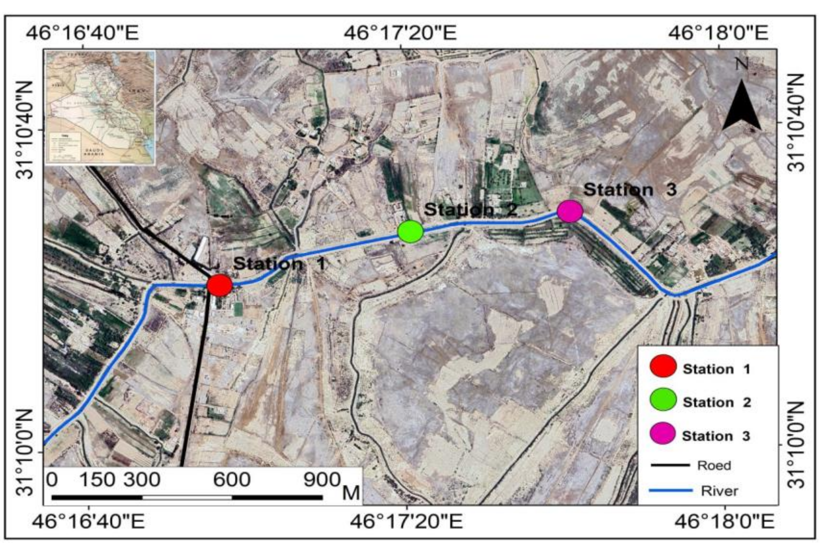

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Figure 1: shows the stations in the study area.
Figure 2 : shows the growth density of the water hyacinth plant at the study station.

Figure 3: shows the *Eichhornia crassipes* [19].

Collection of sample

Samples of the *Eichhornia crassipes* plant were collected from Shatt al-Ksar in the autumn of 2023 ; its roots and leaves were cut off and packed in airtight polyethylene bags for chemical analysis.

Water samples were collected from three stations: Station 1, a dense water hyacinth plant, and Station 2, partial coverage of the water hyacinth plant. And Station 3, No Hyacinth, is a reference station far from the water hyacinth plant .

Using clean 5-liter polyethylene bottles, with three repeaters per station, and at a depth of about 20 cm below the water surface. Clean 1-liter bottles were used to measure trace elements.

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Digestion and Estimation of Trace Elements and TPH

The water samples were digested following the procedures described in the references [20] and [21]. It involved evaporation of the solution at 70C0 , followed by the addition of 0.5 N hydrochloric acid (HCL) to facilitate dissolution . Then the resulting mixture was diluted to a final volume of 25 ml using deionized distilled water. The trace elements present in the samples were measured using a flame atomic absorption spectrophotometer, with reported concentrations in (µg/L). As for the determination of total petroleum hydrocarbons (TPH) in both water and *Eichhornia crassipes* tissues, depending on the method described by [18] .

Environmental factors, water chemistry, and the composition of water hyacinth

In this study, the physical and chemical properties of water, as well as the chemical composition of the water hyacinth plant, were evaluated following the procedures described in the references [21], [22], and [23]. The environmental parameters evaluated included pH, turbidity, salinity, electrical conductivity (EC), total dissolved solids (TDS), and dissolved oxygen (DO). With regard to the chemical composition of the plant, the analysis focused on determining the humidity content, crude protein, lipids (fats), fiber, ash content, and total extractable components.

III. RESULTS AND DISCUSSION

The study measured environmental factors in three study stations' waters to assess their impact and correlation with the presence of the water hyacinth plant (Table 1).

Table 1 . Environmental factors in the water in the study stations.

Parameters / Stations	Temp.	pH	EC.	TDS	Salinity	Turbidity	DO
	C^o	-	µs /cm	mg/L	PPT	NTU	mg/L
Sta1 (Dense Hyacinth)	31	6.3	1375	890	1.41	39	2.3
Sta2 (Partial Coverage)	30.2	7.7	1050	610	1.22	21	4.7
Sta3 (No Hyacinth)	30	8.1	900	530	0.92	14	6.3

The study recorded varying temperature values, with station 1 being slightly higher compared to the second and third stations. The reason could be the timing of the sample collection, which gives gradually varying values [24], The increase in temperature may be linked to the hydrocarbon reduction process, which releases heat by phytoremediators during water purification. Or it could be due to heat retention under the dense plant cover and the inability of the water body to exchange gases with the external environment. As for the pH value, higher values were recorded at stations 3 due to the materials resulting from the washing of agricultural soil near the station and the arrival of calcareous materials and plant fertilizers, which reduce acidity [25]. The lowest value was found at Station 1, which might be linked to the absorption of CO_2 during photosynthesis in the daytime or the breakdown of organic materials from the large amount of plant life, causing a drop in pH values. This is consistent with [26]. And it did not agree with Study [18].

As for salinity, total dissolved solids, and electrical conductivity, the values were higher in Sta1, indicating the release of soluble organic materials, compounds, and ions from the decomposing plant mass. Additionally, washing the nearby agricultural soil may lead to the arrival of salts, fertilizer residues, and nutrients into the water body, where they become trapped in the dense plant biomass [24], [25]. Thus, it increases the values of these ions compared to the other study stations.

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As for the turbidity values, they were higher in stations 1 due to the accumulation of decomposed materials and the movement of roots and plants caused by water currents that disturb the sediments. Its values were partially reduced in stations 2 compared to Sta3, where turbidity was at a minimum, indicating that the water was clearer [26].

The study recorded low DO values in stations 1, which may be due to the dense coverage of the water hyacinth *Eichhornia crassipes* [27]. The plants form a canopy that blocks sunlight, which negatively affects the photosynthesis process of aquatic algae and oxygen production. In addition, the large amounts of decomposed organic matter resulting from the plant biomass or its respiration lead to a reduction in (DO) levels This is consistent with [27],[28]. And it did not agree with Study [18].

In this study, we measured the levels of certain trace elements and TPH in the water at the study locations (Table 2), as well as in different parts of the water hyacinth plant based on how dense they were growing (Table 3).

Table 2. The values of trace elements and TPH in the study station water

Parameters / Stations	Cd	Pb	Zn	Cu	Cr	CO	Ni	TPH
	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Sta1 (Dense Hyacinth)	0.0041	1.95	19.4	0.7	0.9	0.01	3.1	23.8
Sta2 (Partial Coverage)	0.0068	2.38	20.1	1.3	1.4	0.03	3.5	31.4
Sta3 (No Hyacinth)	0.0077	2.85	28.25	2.3	1.9	0.08	3.6	36.7

The study recorded low TPH levels at stations 3 (without plants), while the highest levels were at stations 1 (dense water hyacinth). Therefore, the water hyacinth demonstrates a high capacity to absorb and degrade total hydrocarbon compounds through root absorption and the associated microbial activity. The study shows the ability of this plant for phytoremediation of organic pollutants. And this is consistent with Study [18],which clarified that hyacinth has been extensively researched as a phytoremediator, effectively reducing 99.5% of hexavalent chromium in industrial wastewater, TDS, BOD, and COD content. It also effectively remediates heavy metals like Hg and MeHg attached to plant leaves [29].

As for the absorption of trace elements (Cr, Cu, Zn, Pb, Cd), most of them show a decreasing gradient from station 3 to station 1. This indicates the active bioaccumulation of the bulrush plant, especially at stations with dense vegetation cover. Which may be due to the nature of the plant's fibrous roots that retain and store minerals, thereby reducing their values in the aquatic body.

This is consistent with what was indicated in studies [18] and [30] as they pointed to the possibility of using the water hyacinth as a bioindicator for heavy metals in aquatic ecosystems due to its ability to reduce hydrocarbon and heavy metal pollutants in saline waters. Additionally,[31] and [32] indicated that the water hyacinth can be used as cost-effective, environmentally friendly, and well-documented phytoremediation treatments. The nickel (Ni) element has relatively stable concentrations across the stations. This indicates either a limited absorption capacity of nickel by the water hyacinth. As for cobalt (Co), it shows an increasing concentration from Sta1 to Sta3. This indicates a potential retention by water hyacinth, although the efficiency seems moderate. Absorption may be affected by competing ions and environmental variables such as pH This is consistent with [33],[34].

In general, it is observed that the dense presence of the aquatic bulrush plant contributes to the reduction of oil pollutants and trace element concentrations.

Table 3. Concentrations of Trace elements and TPH in parts of the water hyacinth plant

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Parameters / Stations	Cd	Pb	Zn	Cu	Cr	CO	Ni	TPH
	μg/gm dry weight							mg/kg
Root	0.0093	2.3	23.7	1.75	1.71	0.03	5.2	42.4
Stem	0.011	2.1	20.4	1.42	1.62	0.02	3.1	48.1
Leaves	0.01	2.25	18.1	1.47	1.51	0.017	2.5	40.3
Vesicles	0.015	2.75	31.7	2.35	2.91	0.035	6.9	78.1
Flower	0.0017	1.02	10.72	0.93	0.54	0.009	2.1	Nill

The study showed that the concentrations of TPH were highest in the vesicles (78.1 mg/kg), followed by the stem (48.1 mg/kg), roots (42.4 mg/kg), and leaves (40.3 mg/kg). This suggests that the vesicles serve as reservoirs for organic pollutants by accumulating hydrocarbons, thereby mitigating their toxicity in essential plant tissues. Notably, total petroleum hydrocarbons (TPH) were not detected in the flowers, implying that the plant limits pollutant accumulation in its reproductive organs, possibly as a protective mechanism for its reproductive functions. Regarding trace elements such as (Ni), (Co), (Cr), (Cu), (Zn), (Pb), and (Cd), their distribution varies across different plant parts, The Roots show higher concentrations . This emphasizes the primary role of roots in the absorption and accumulation of these elements from the aquatic environment . It is observed that the movement of minerals to the stems and leaves is organized to reduce toxicity [35], As the vesicles show high concentrations, which may be due to their role in storage in this plant. While the flowers contain the lowest concentrations of metals, reflecting the protective mechanisms of the water hyacinth to safeguard its reproductive parts. Through the above, these results demonstrate the plant's ability to function as a biofilter in aquatic environments by Distribution patterns indicate advanced strategies in detoxification while minimizing damage to vital tissues. This is consistent with what several studies have found that the rate of heavy metal removal from the roots was much higher compared to other parts of the plant (leaves, stems, and flowers) [36],[37],[38], [39],[40]and [41].

Table 4 . Chemical composition of Water Hyacinth with other studies

Parameters / References	chemical composition of the water hyacinth plant					
	Humidity (%)	Crude protein (%)	Fats (%)	Fibers (%)	Ash (%)	Extract
This study	9.41	11.2	2.3	7.9	5.44	60.48
[11]	8.9	11.8	1.9	9.8	5.8	61.20
[42]	6.1	12.6	1.5	10.4	7.2	63.10
[43]	8.3	10.1	2.0	12.0	6.9	58.70
[44]	7.7	13.4	2.7	15.5	8.35	59.55

The chemical composition of the water hyacinth (*Eichhornia crassipes*) as identified in this study was compared with the results of previous studies [11],[42]and[44] to assess the degree of consistency and differences resulting from environmental conditions. The extraction yield in this study was 60.48%, which is consistent with the results of study [43] (58.70%) and study [44] (59.55%). This indicates a relative stability in the content of soluble organic materials. While [42] showed a higher percentage of 63.10%, which may be attributed to differences in drying methods, the age of the plant at harvest, or environmental conditions that could lead to increased production of biodegradable compounds, which are beneficial for bioremediation and composting applications.

The ash content, which reflects the total mineral content, was also the lowest in this study at 5.44% compared to 7.2–8.35%. This may indicate a decrease in water salinity or mineral content in the aquatic environment of the study

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sites, or it could be due to differences in processing after sample collection, such as washing or ash analysis burning temperature. As for crude fiber, a percentage of 7.9% was recorded, which is the lowest among all comparative studies, especially study [44], which showed 15.5%. The observed differences in plant composition can be attributed to the age or part of the plant sampled, as smaller or densely leafy specimens usually have a lower fiber content compared to stem-rich specimens . In addition, environmental factors such as water availability and nutrient levels influence the structural development of the plant . This study recorded a fat content of 2.3% which is slightly higher than the values indicated by [42] and [25] ranging from 1.5% to 2.0%, respectively, but slightly lower than those recorded by [44] 2.7%. Although lipid levels are generally low in aquatic plants, these differences may result from differences in the maturity stage of the plant or environmental conditions that affect lipid synthesis.

Regarding crude protein, the study recorded a concentration of 11.2%, which is comparable to the results of [11] and [43] which ranged from 11.8% to 10.1%, respectively, but slightly lower than the values reported by [42] and [44], which were 12.6% and 13.4%, respectively . In general that the protein content in water hyacinth is influenced by the availability of nitrogen in the surrounding water, as well as seasonal environmental factors and the stage of plant growth, this explains the moderate levels of protein content observed in this study.

A relatively high humidity of 9.41% was also recorded, compared with the 6.1% indicated by [42], however this value remains within the normal range. This reflects the plant's remarkable ability to absorb water and react to water pollutants.

As previous studies on the chemical composition of water hyacinth show , such differences in nutritional and chemical parameters may arise from differences in the biological and chemical characteristics of the aquatic environments from which the plants were collected

IV. CONCLUSIONS

Eichhornia crassipes (water hyacinth) is an invasive aquatic plant known for its ability to form dense mats on the surface of water bodies, which leads to a decrease in biodiversity and impaired photosynthetic activity in submerged plants due to limited light penetration. Despite its environmental problems, water hyacinth has shown great potential in phytoremediation, effectively removing pollutants of trace elements and hydrocarbons from polluted aquatic systems among its various parts, as the roots showed high efficiency in the removal and accumulation of trace elements while the vesicles recorded high efficiency in the accumulation of hydrocarbons, highlighting its importance in environmental monitoring and public health risk assessment.

The study also showed the possibility that the chemical composition of the water hyacinth plant varies depending on the biological and chemical characteristics of the aquatic environment in which it grows, which explains the observed differences in the content of nutrients and pollutants during different sampling sites.

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