

Phytoremediation of Service Station Wastewater Using Water Hyacinth: A Sustainable Treatment Approach

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Abstract: Service station wastewater, typically rich in oil, grease, and detergents, poses a serious environmental threat when discharged untreated. This study explores a sustainable and low-cost phytoremediation approach using *Eichhornia crassipes* (water hyacinth) to treat wastewater from a vehicle washing station at SSM Polytechnic College, Tirur. A controlled laboratory experiment was conducted for 21 days using a 100 L tank containing wastewater collected from the service station. Key parameters—Biochemical Oxygen Demand (BOD), turbidity, pH, chloride, alkalinity, and oil and grease—were analyzed on Days 3, 14, and 21. Results revealed significant pollutant removal efficiencies: BOD (74%), turbidity (78%), oil and grease (65%), and chloride (58%), with pH stabilizing around 7.2. The findings demonstrate that water hyacinth provides an effective, eco-friendly solution for small-scale wastewater treatment, aligning with the goals of sustainable water management and SDG 6. The study highlights the potential for decentralized green wastewater treatment systems adaptable for institutional and semi-urban applications.

Keywords: Water hyacinth, Phytoremediation, Service station wastewater, Biochemical oxygen demand, Sustainable treatment, Green technology.

I. INTRODUCTION

Wastewater pollution is a major global concern, particularly from decentralized sources such as vehicle service stations. Runoff from these stations often contains high concentrations of oil, grease, and detergents that degrade soil and water quality if discharged untreated. Conventional wastewater treatment systems, though effective, require expensive infrastructure and energy inputs, making them impractical for small-scale operations.

Phytoremediation—the use of plants to remove, degrade, or stabilize pollutants—has emerged as a promising alternative for sustainable wastewater treatment. Among aquatic macrophytes, *Eichhornia crassipes* (water hyacinth) has shown exceptional pollutant removal capabilities due to its rapid growth, dense root system, and symbiotic relationship with pollutant-degrading microorganisms. Previous studies (Reddy & D'Angelo, 1997; Malik, 2007; Vymazal, 2011) have established its potential in reducing organic and inorganic contaminants, making it suitable for decentralized wastewater treatment.

This study investigates the use of water hyacinth to treat wastewater from the service station of SSM Polytechnic College, Tirur. The objective was to quantify its efficiency in removing contaminants and assess its potential as a low-cost and eco-friendly treatment system adaptable to similar institutional contexts.

II. MATERIAL AND METHODS

A. STUDY AREA

The wastewater was collected from the vehicle washing station of SSM Polytechnic College, Tirur, which lacks a treatment facility. The collected wastewater exhibited visible oil films and high turbidity, representative of service station effluent.

B. EXPERIMENTAL SETUP

A laboratory-scale phytoremediation system was designed using 100 L capacity glass aquariums, chosen for their inert and transparent characteristics. Three treatment tanks were used—two with water hyacinth and one as a control (without plants). Each tank was filled with 50 L of wastewater collected directly from the service station within one hour of generation to preserve sample integrity.

Healthy water hyacinth plants were selected from a nearby pond, washed with clean water to remove soil and debris, and acclimatized for 48 hours in laboratory conditions. The plants were introduced to cover about 70–80% of the tank surface, ensuring sufficient root exposure and aeration. The experimental units were placed in a semi-shaded area within the environmental engineering laboratory to allow 6–8 hours of indirect sunlight daily, facilitating photosynthesis while preventing excessive algal growth.

Each tank was monitored daily for physical changes such as odor, color, and plant health. No external aeration or mixing was provided; the treatment relied solely on natural plant and microbial interactions. To prevent mosquito breeding and external contamination, a mesh cover was used. Ambient temperature (27–30°C) was maintained throughout the experiment.



Fig. 1 Water Treatment Setup

C. TESTING AND ANALYSIS

Samples were analyzed on Days 3, 14, and 21 for the following parameters:



Fig. 2 Observation after 3 days



Fig. 3 Observation after 14 days



Fig. 4 Observation after 21 days



Fig. 5 Treated water after 21 days

- **BOD:** Winkler method (mg/L)
- **Turbidity:** Nephelometric method (NTU)
- **pH:** Digital pH meter
- **Chloride:** Argentometric titration (mg/L)
- **Alkalinity:** Acid titration method (mg/L as CaCO₃)
- **Oil & Grease:** Solvent extraction (mg/L)

Each test was performed in duplicate to ensure accuracy, and average values were recorded. Data were statistically analyzed to identify trends and evaluate treatment performance. Pollutant removal efficiency (E%) was calculated using: $E = \frac{C_i - C_f}{C_i} \times 100$ (where C_i = initial concentration and C_f = final concentration).

This experimental design enabled both quantitative and qualitative assessment of phytoremediation performance and provided a model for small-scale wastewater treatment applications.

III. RESULT AND DISCUSSION

A. WATER QUALITY IMPROVEMENT

The 21-day experiment demonstrated a substantial improvement in wastewater quality. Table 1 presents the comparative results for key parameters.

TABLE I TEST RESULTS

Parameter	Initial	Day 3	Day 14	Day 21	% Reduction
BOD (mg/L)	260	220	186	150	74%
Turbidity (NTU)	70	66	43	21	78%
Chloride (mg/L)	158	128	66	66	58%
Alkalinity (mg/L)	67	35	7	3	95%
Oil & Grease (mg/L)	15	12	8	5	65%
pH	6.8	6.9	7.1	7.2	—

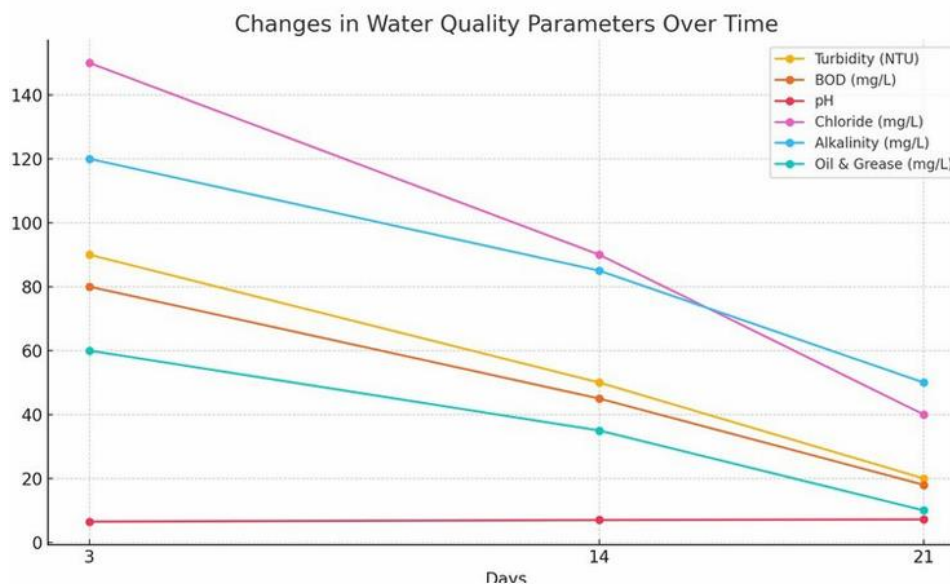


Fig. 3 Graphical Representation of water quality parameters over time

Biochemical Oxygen Demand (BOD) decreased significantly over time, indicating effective degradation of organic pollutants by microbial communities associated with hyacinth roots. The **turbidity** drop corresponded with visible water clarity improvements, confirming particulate trapping by the plant root network.

Chloride and alkalinity reductions reflect ionic absorption and neutralization effects, highlighting the plant’s buffering capacity. **Oil and grease** showed a 65% reduction, illustrating the root zone’s affinity for hydrocarbons and the role of microbial degradation. The **pH** remained near-neutral, supporting balanced biogeochemical activity.

B. COMPARISON WITH LITERATURE

Similar studies have reported 70–85% BOD removal and 60–80% turbidity reduction using *Eichhornia crassipes* (Kumar & Anitha, 2015; Singh & Moshood, 2013). The results from this case study align closely with these benchmarks, validating the effectiveness of water hyacinth for service station wastewater.

C. SUSTAINABILITY AND APPLICABILITY

The system operated without electricity or chemical additives, proving suitable for rural and semi-urban areas. The harvested biomass can be reused as compost or biofuel, promoting circular economy principles. The method aligns with SDG 6 (Clean Water and Sanitation) and SDG 13 (Climate Action) by providing a low-carbon water treatment alternative.

IV. CONCLUSION

Water hyacinth proved to be an efficient, low-cost, and sustainable solution for treating service station wastewater. The 21-day experimental results showed substantial reductions in key contaminants, demonstrating the plant’s strong phytoremediation potential. The system’s simplicity and scalability make it suitable for decentralized wastewater management in institutional and community contexts.

Future studies can integrate hybrid systems combining water hyacinth with other macrophytes or biofilters to improve treatment efficiency and mitigate the plant’s invasive nature. The approach holds promise as a green technology for sustainable water management in developing regions.

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