

# Experimental Investigation on Treatment of Industrial Wastewater Using Water Hyacinth For Water Quality Improvement

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**Abstract-** Industrial wastewater generated from manufacturing and processing industries contains high concentrations of organic matter, dissolved solids, nutrients, oil and grease, and other pollutants that pose serious environmental and public health risks. This study experimentally investigates the effectiveness of water hyacinth (*Eichhornia crassipes*) as a low-cost and eco-friendly phytoremediation technique for improving the quality of industrial wastewater. Wastewater samples were collected from an industrial source and treated using a tank-based water hyacinth system over a period of six months. Key water quality parameters such as pH, total dissolved solids (TDS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), oil and grease, and nitrate concentration were analyzed at monthly intervals. The results indicated a gradual and significant improvement in water quality, with reductions of approximately 47.6% in TDS, 52.5% in BOD, 54.2% in COD, 48.3% in oil and grease, and 44.3% in nitrate concentration. The findings demonstrate that water hyacinth is an effective, economical, and sustainable treatment option for industrial wastewater, particularly suitable for decentralized treatment systems.

**Keywords:** Water Hyacinth, Industrial Wastewater, Phytoremediation, Water Quality Parameters, Eco-friendly Treatment

## I. INTRODUCTION

Rapid industrialization has resulted in the generation of large quantities of industrial wastewater containing organic matter, dissolved solids, nutrients, oil and grease, and other harmful pollutants. Discharge of untreated industrial effluents into natural water bodies leads to deterioration of water quality and poses risks to aquatic ecosystems and human health. In developing countries, limited treatment infrastructure and high operational costs restrict the use of advanced wastewater treatment technologies.

Phytoremediation is an emerging natural treatment method that uses plants to remove contaminants from water. Among aquatic plants, water hyacinth (*Eichhornia crassipes*) has gained attention due to its rapid growth rate, extensive root system, and high pollutant uptake capacity. Although it is considered an invasive species, its ability to remove organic matter, nutrients, and heavy metals makes it suitable for wastewater treatment applications.



Fig.1 Water Hyacinth

This study focuses on the experimental investigation of industrial wastewater treatment using water hyacinth under controlled tank conditions. The effectiveness of the treatment process was evaluated by monitoring changes in key water quality parameters over a six-month period.

## II. LITERATURE REVIEW

Several researchers have investigated the potential of water hyacinth (*Eichhornia crassipes*) for wastewater treatment through phytoremediation techniques. Due to its rapid growth rate, extensive root network, and high pollutant absorption capacity, water hyacinth has become one of the most widely studied aquatic plants for sustainable wastewater management.

Rezania et al. (2015) studied the efficiency of water hyacinth in treating domestic wastewater under continuous flow conditions. The researchers focused on the removal of organic pollutants and nutrient compounds from wastewater using aquatic plant-based treatment systems. Their study

reported significant reductions in Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and suspended solids due to microbial activity around the root zone of the plant. The authors concluded that water hyacinth-based systems are suitable for low-cost decentralized wastewater treatment applications, especially in developing countries.

In another study, Rezanian et al. analyzed the broader perspectives of phytoremediation using water hyacinth for the removal of heavy metals, organic matter, and inorganic pollutants from wastewater. The study highlighted that pollutant removal occurs through multiple mechanisms such as adsorption, nutrient uptake, microbial degradation, and sedimentation. The researchers also emphasized the environmental sustainability of phytoremediation systems due to their low operational cost and minimal energy requirements.

Mary Lissy and Madhu (2011) investigated the removal of heavy metals such as chromium and copper from wastewater using water hyacinth under laboratory conditions. The experiment demonstrated that water hyacinth effectively absorbed toxic metals through its fibrous root system. The study reported substantial reductions in heavy metal concentrations within a short treatment duration, proving the suitability of water hyacinth for industrial wastewater treatment containing metallic contaminants.

Valipour et al. (2015) developed a modified wetland treatment system using water hyacinth and a bio-hedge support matrix. Their experimental setup operated under controlled hydraulic retention time conditions, achieving approximately 80–86% removal efficiency for BOD and COD parameters. The study concluded that shallow wetland systems integrated with water hyacinth significantly improve wastewater treatment efficiency and reduce organic pollution levels.

Ajayi and Ogunbayo (2012) focused on achieving environmental sustainability through phytoremediation-based wastewater treatment systems. Their research highlighted the ability of water hyacinth to remove nutrients, organic pollutants, and suspended solids while maintaining low operational and maintenance costs. The study emphasized that phytoremediation techniques are particularly beneficial in rural and semi-urban regions where conventional treatment systems are economically difficult to implement.

Magar et al. (2017) investigated wastewater treatment using water hyacinth under Indian environmental conditions. Their findings demonstrated that the plant effectively reduces pollutant concentrations and improves water quality over time.

The study further suggested that harvested biomass can be utilized for biogas production, making the treatment process environmentally and economically sustainable.

Kaur (2022) reported that water hyacinth treatment systems provide a simple and eco-friendly solution for reducing organic pollutants and nutrient concentration in wastewater. The study highlighted that the plant's dense root structure supports microbial growth, which contributes significantly to pollutant degradation and nutrient uptake.

From the reviewed literature, it is evident that water hyacinth possesses excellent phytoremediation potential for industrial and domestic wastewater treatment. However, performance varies depending on wastewater characteristics, retention time, climatic conditions, and system design. The present study aims to experimentally investigate the treatment efficiency of water hyacinth for industrial wastewater collected from SunStar Pvt. Ltd., Shirpur, under local environmental conditions.

### III. MATERIALS AND METHODOLOGY

The present experimental investigation was conducted to evaluate the efficiency of water hyacinth (*Eichhornia crassipes*) in improving the quality of industrial wastewater through phytoremediation. The methodology included collection of wastewater samples, preparation of a tank-based treatment system, periodic sampling, and laboratory analysis of important water quality parameters.

#### Experimental Setup

A laboratory-scale tank setup was adopted for the treatment process due to its simplicity, low operational cost, and suitability for controlled experimental observations. The treatment unit consisted of a plastic tank containing industrial wastewater collected from SunStar Pvt. Ltd., Shirpur, a corn-processing industry. Water hyacinth plants were introduced into the tank to cover approximately 50–60% of the water surface area.

The setup was operated under static conditions without external aeration or chemical additives in order to simulate a natural phytoremediation system. Environmental conditions such as sunlight exposure and temperature were maintained under normal atmospheric conditions throughout the study period. The experimental arrangement was designed to allow direct interaction between the wastewater and the root system of the water hyacinth plants, which plays an important role in pollutant absorption and microbial activity.

Healthy and mature water hyacinth plants were collected from a local pond and acclimatized in clean water before introducing them into the treatment tank. Only floating plants with well-developed root systems were selected to ensure efficient pollutant uptake during the experiment. The plants were regularly observed for growth condition and survival throughout the treatment duration.

### Wastewater Source and Sample Collection

Industrial wastewater used in this study was collected from SunStar Pvt. Ltd., Shirpur. The collected wastewater contained dissolved solids, organic pollutants, oil and grease, and nutrient compounds typically present in industrial effluents. Before treatment, the wastewater was visually inspected and stored in clean containers for experimental use.



Fig.2 Sample Collection

Sampling was carried out monthly from July 2025 to December 2025. Water samples were collected carefully from the treatment tank at selected intervals to evaluate the gradual improvement in water quality parameters over time. Each sample was preserved and analyzed in accordance with standard laboratory procedures.

### Parameters Analyzed

The effectiveness of the phytoremediation process was evaluated by analyzing important physical and chemical parameters of wastewater. The selected parameters included pH, Total Dissolved Solids (TDS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Oil and Grease, and Nitrate concentration. These parameters were chosen because they indicate the pollution level and overall quality of wastewater.

#### pH Test

The pH test was conducted to determine the acidic or alkaline nature of the wastewater. A digital pH meter with glass electrode arrangement was used for measurement. The instrument was calibrated using standard buffer solutions before testing. The electrode was immersed in the wastewater sample, and the stabilized reading was recorded. The pH value

is an important parameter because it influences biological and chemical treatment processes.

#### Total Dissolved Solids (TDS)

The TDS test was performed to determine the concentration of dissolved inorganic and organic substances present in wastewater. The sample was filtered to remove suspended impurities, and a measured volume was evaporated in a pre-weighed dish at controlled temperature conditions. The remaining residue was weighed to calculate the TDS concentration in mg/L. Reduction in TDS indicates the removal of dissolved pollutants from wastewater.

#### Biochemical Oxygen Demand (BOD)

The BOD test was conducted to determine the amount of oxygen required by microorganisms for decomposition of biodegradable organic matter present in wastewater. Diluted wastewater samples were incubated in BOD bottles at 20°C for five days. Initial and final dissolved oxygen levels were measured, and BOD values were calculated accordingly. Reduction in BOD indicates effective removal of biodegradable pollutants.

#### Chemical Oxygen Demand (COD)

The COD test was performed to evaluate the total quantity of oxygen required for chemical oxidation of organic and inorganic substances present in wastewater. Potassium dichromate and sulfuric acid were used as oxidizing reagents during the digestion process. After refluxing, the remaining dichromate was titrated to determine COD concentration. COD analysis helps in assessing the overall pollution strength of wastewater.

#### Oil and Grease Test

The oil and grease content of wastewater was determined using the solvent extraction method. The wastewater sample was acidified and mixed with an organic solvent to separate oily substances. After evaporation of the solvent, the remaining residue was weighed to calculate oil and grease concentration. Reduction in oil and grease indicates the capability of water hyacinth roots to adsorb and trap oily pollutants.

#### Nitrate Test

The nitrate concentration in wastewater was analyzed using the colorimetric method. Filtered wastewater samples were treated with nitrate reagents, and the developed color

intensity was measured using standard comparison procedures. Reduction in nitrate concentration indicates nutrient uptake by water hyacinth and helps in controlling eutrophication problems in receiving water bodies.

**Data Analysis**

The experimental results obtained during monthly monitoring were analyzed and compared to evaluate the efficiency of the treatment process. Percentage reduction for each parameter was calculated by comparing initial and final readings. The observed changes in pollutant concentration were further compared with standard wastewater quality guidelines to assess the effectiveness of water hyacinth in improving industrial wastewater quality.

**IV. RESULTS AND DISCUSSION**

The monthly monitoring of industrial wastewater treated using water hyacinth demonstrated a continuous improvement in water quality from July 2025 to December 2025. Significant reductions were observed in major pollution indicators such as TDS, BOD, COD, Oil and Grease, and Nitrate concentration.

Month	pH	TDS (mg/L)	BOD (mg/L)	Oil & Grease (mg/L)	COD (mg/L)	Nitrate (mg/L)
July 2025	6.7	850	80	6.0	240	7.0
Aug 2025	6.8	820	72	5.8	210	6.8
Sept 2025	6.8	730	68	5.0	190	6.2
Oct 2025	7.0	650	56	4.3	155	5.8
Nov 2025	7.1	585	50	4.0	140	4.2
Dec 2025	7.3	445	38	3.1	110	3.9

Table 1: Monthly Variation of Wastewater Quality Parameters During Treatment

**pH Analysis**

The pH of industrial wastewater increased gradually from 6.7 in July 2025 to 7.3 in December 2025, indicating a shift from slightly acidic conditions toward a near-neutral range. Neutral pH conditions are desirable because they improve the stability of biological treatment processes and reduce harmful effects on aquatic ecosystems. Water hyacinth

roots support microbial growth and biological activity, which contribute to balancing the chemical composition of wastewater. The observed pH values after treatment were found to be closer to acceptable discharge standards, indicating improved water quality.

**Total Dissolved Solids (TDS) Analysis**

The Total Dissolved Solids concentration showed a continuous reduction from 850 mg/L in July to 445 mg/L in December, corresponding to an overall reduction of approximately 47.6%. TDS represents the concentration of dissolved salts, minerals, and inorganic compounds present in wastewater. High TDS levels negatively affect water quality and may interfere with industrial reuse or environmental discharge. In addition, sedimentation and filtration effects around the dense root network contributed to lowering dissolved solid concentration. The gradual decline in TDS confirms the capability of phytoremediation systems to improve wastewater quality under natural treatment conditions.

**Biochemical Oxygen Demand (BOD) Analysis**

Biochemical Oxygen Demand values reduced significantly from 80 mg/L in July to 38 mg/L in December, achieving a reduction efficiency of approximately 52.5%. BOD indicates the amount of oxygen required by microorganisms to decompose biodegradable organic matter present in wastewater. Higher BOD values signify severe organic pollution and oxygen depletion in natural water bodies. The substantial reduction in BOD observed during the treatment process indicates effective degradation of biodegradable organic compounds. Water hyacinth creates a favorable environment for microbial activity around its root zone, promoting decomposition of organic matter. The reduction in BOD reflects improved wastewater quality and lower environmental impact after treatment.

**Chemical Oxygen Demand (COD) Analysis**

Chemical Oxygen Demand values decreased from 240 mg/L to 110 mg/L during the experimental period, representing a total reduction of approximately 54.2%. COD is an important parameter used to determine the total quantity of oxygen required for chemical oxidation of organic and inorganic pollutants present in wastewater. The reduction in COD indicates the removal of both biodegradable and non-biodegradable contaminants from industrial wastewater. The dense root system of water hyacinth promotes adsorption and microbial degradation of pollutants, thereby reducing the oxygen demand of wastewater. The consistent decline in COD

values confirms the efficiency of water hyacinth in improving the overall chemical quality of industrial effluent.

**Oil and Grease Analysis**

Oil and grease concentration decreased gradually from 6.0 mg/L in July to 3.1 mg/L in December, achieving approximately 48.3% reduction. Oil and grease present in industrial wastewater form a surface film that restricts oxygen transfer and negatively affects aquatic organisms. During treatment, the fibrous root structure of water hyacinth helped in trapping and adsorbing oily substances from wastewater. Some oily pollutants were also removed through natural sedimentation and microbial degradation processes. The reduction in oil and grease concentration demonstrates the suitability of water hyacinth for treatment of industrial wastewater containing petroleum-based contaminants and fatty substances.

**Nitrate Analysis**

Nitrate concentration reduced from 7.0 mg/L in July to 3.9 mg/L in December, resulting in an overall reduction efficiency of approximately 44.3%. Excess nitrate concentration in wastewater contributes to nutrient pollution and eutrophication in natural water bodies. Water hyacinth absorbs nitrate and other nutrient compounds during its growth process, thereby reducing nutrient concentration in wastewater. The reduction observed during the experiment indicates efficient nutrient uptake by the plant roots. Lower nitrate concentration after treatment suggests that the phytoremediation system can effectively control nutrient pollution and improve the environmental quality of treated wastewater.

**Overall Treatment Performance**

The experimental investigation demonstrated that water hyacinth treatment produced continuous improvement in wastewater quality throughout the six-month study period. The graph showing monthly variation of wastewater parameters clearly indicates a decreasing trend in pollutant concentration from July to December 2025. Maximum reduction was observed during the later stages of treatment, suggesting that longer retention periods improve phytoremediation efficiency. The combined effects of nutrient uptake, adsorption, microbial degradation, and sedimentation contributed to the overall reduction in pollution levels.

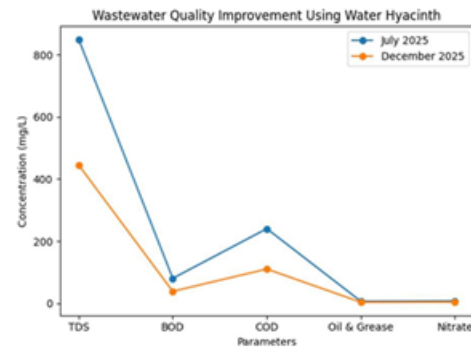


Fig.2 Variation in Wastewater Quality Parameters from July to December

**V. CPCB PERMISSIBLE STANDARDS**

The Central Pollution Control Board (CPCB) has established permissible discharge standards for treated industrial wastewater to minimize environmental pollution and protect public health. These standards define acceptable concentration limits for important water quality parameters before discharge into natural water bodies.

Parameter	CPCB Permissible Limit
pH	5.5 – 9.0
TDS	2100 mg/L
BOD	30 mg/L
COD	250 mg/L
Oil&Grease	10 mg/L
Nitrate	10 mg/L

Table 2: CPCB Permissible Limits for Wastewater Discharge

The CPCB standards are used as reference values to evaluate the effectiveness of wastewater treatment systems and environmental safety of treated effluents.

**5.1 Comparison of Treated Water with CPCB Standards**

The treated wastewater obtained after phytoremediation using water hyacinth showed significant improvement when compared with CPCB permissible standards. The pH value improved from 6.7 to 7.3, indicating stabilization of wastewater chemistry and suitability for discharge.

The TDS concentration reduced from 850 mg/L to 445 mg/L, which remained well within the CPCB permissible limit. Similarly, COD values decreased from 240 mg/L to 110 mg/L, indicating effective removal of chemical pollutants and improved treatment efficiency. Oil and grease concentration reduced to 3.1 mg/L, which is considerably below the

permissible limit specified by CPCB. Nitrate concentration also reduced significantly due to nutrient uptake by water hyacinth roots.

Although substantial improvement was achieved in most parameters, the final BOD value of 38 mg/L remained slightly above the CPCB permissible limit of 30 mg/L. This indicates that additional post-treatment processes such as aeration, filtration, or biological polishing may further improve water quality before final discharge or reuse.

Overall, the comparison confirms that water hyacinth-based phytoremediation is an effective and eco-friendly method for improving industrial wastewater quality and reducing environmental pollution.

## VI. CONCLUSION

The present experimental investigation evaluated the effectiveness of water hyacinth (*Eichhornia crassipes*) for the treatment of industrial wastewater using a phytoremediation approach. The study showed noticeable improvement in wastewater quality during the six-month treatment period from July 2025 to December 2025. Significant reductions were observed in major pollution parameters including Total Dissolved Solids (TDS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Oil and Grease, and Nitrate concentration. The pH of the wastewater also shifted toward a neutral range, indicating stabilization of water quality after treatment.

The reduction in pollutant concentration confirms that water hyacinth possesses good pollutant absorption and nutrient uptake capability. The fibrous root system of the plant supported microbial activity and contributed to removal of organic and inorganic contaminants from wastewater. The treatment process operated under natural conditions without the requirement of complex machinery or chemical additives, demonstrating the environmental and economic benefits of phytoremediation systems. Comparison of treated wastewater characteristics with CPCB permissible standards indicated substantial improvement in overall water quality. The treatment system was found to be economical, eco-friendly, and suitable for decentralized wastewater treatment applications. However, longer retention periods and proper biomass management are important for achieving improved treatment efficiency and sustainable operation. In certain cases, additional polishing treatment may be necessary to meet potable water quality standards.

Overall, the study confirms that water hyacinth-based phytoremediation can serve as an effective and sustainable

alternative for industrial wastewater treatment and environmental pollution control.

## VII. FUTURE SCOPE

Future research may focus on large-scale implementation of water hyacinth-based wastewater treatment systems under different environmental conditions. Further studies can be conducted to improve treatment efficiency by optimizing retention time and plant density. Integration of phytoremediation with filtration or aeration systems may help achieve higher water quality standards. Utilization of harvested water hyacinth biomass for biogas or compost production can also enhance the sustainability of the treatment process.

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