

An Approach to Improve the Water Quality on Industrial Effluent by Phytoremediation with Water Hyacinth (*Eichhornia Crassipes*)

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Abstract

INTRODUCTION: Industries and factories are the backbone of any nation to increase the economy through its productivity and develop the county globally. But the wastages and sewages produced by each industry are creating pollution and make cleanliness environment on the society.

OBJECTIVES: The recycling process and decontamination process of that industrial effluent is a challenging task for all the industries in and around the world. Ancient techniques are followed in industrial effluent cleaning processes but the output of those is not sufficient in terms of recycling..

METHODS: Phytoremediation is the new technique used to control industrial effluent with the help of water hyacinth available in the water places. This paper discussed all possible solutions of industrial effluent removal along with water quality improvement techniques. Decontamination of the industrial effluent using water hyacinth is mainly dealt in leaves, stems, and root parts. There are only water hyacinth is used to remove industrial effluent, no other products like powder, liquid plants, and other chemicals are used.

RESULTS: Total duration of 21 days has to be considered for the growth of water hyacinth used in water places to monitor the recycling of industrial effluent at different parts. A water quality test has been conducted to identify the level of contaminants in the Industrial effluent. Furthermore, BOD (Biological oxygen demand), COD (Chemical oxygen demand), TDS (Total dissolved solids), TSS (Total suspended solids), Turbidity, and chloride levels are taken as a parameter from the industrial effluents.

CONCLUSION: Every 24hours, for continuous 3-5days the color of effluent has been notified to predict the changes. Turbidity and other impurities are noted by the effects of the water hyacinth used as results.

Keywords: Water hyacinth, Industrial effluent, Decontamination, Turbidity, Impurity.

Received on 04 July 2021, accepted on 26 September 2021, published on 12 October 2021

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doi: 10.4108/eai.12-10-2021.171251

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1. Introduction

Water hyacinth scientifically called *Eichhornia crassipes* is generally grown in South America's subtropical and it's native too. Generally, the growth of the water hyacinth is a minimum of 40cm and a maximum of 1m in the water-filled areas [1-3]. The industrial effluent particles are connected with the water places such as lakes, ponds, rivers, and pits. To control the effluent addition in water is the most complicated task in the polluted environment due to its scattered nature and spread in nearby places too. Various techniques are used to handle these effluents such as chemicals added to these particles, removed manually; machines used, and so on, which have not given complete solutions for industrial effluent handling [4-6]. Later, the Phytoremediation method has introduced to handle the problems in industrial effluent. It looks with purple and black color feathery has a root and pink, lavender color six petals are visible at their growth of 8 to 15 days [7-9]. Water hyacinth plants are produced 1000 seeds per year due to their growing nature. The sustainability of the water hyacinth is more than 28 years once it starts growing. It grows 2 and 5 meters generally in a day in South Asia side countries [10-13]. Normally, water hyacinths are vigorous and the size is growing double. As per the records of the Centre for Agriculture and Bioscience International website the global spread of water hyacinth all over the world is shown in the following figure 1.



Figure 1. Global spread of water hyacinth on 2021

In one hectare of land, water hyacinth development is very high and produced with 70,000m³/ha of biogas which contains 70%CH₄ and 30% as biomass products [14], [15]. Also, it observes organic compounds used in industries as heavy metals. The average of 65-85% nitrogen and 79% of potassium is removed using water hyacinth in the water. Nitrogen gas has detached from the industrial effluent using water hyacinth roots and also founds Eutropicated wetland on a natural surface [16-20].

The growing rate of water hyacinth is optimum level while the process of nutrition subtraction, purification on wastewater. Impurities and floating particles of the water can be absorbed by the roots of the water hyacinth. The soil, water, and air's normal contaminants are rendered by degradation of hyper accumulators using the bioaccumulation process of the plants naturally [21]. The phytoremediation concept is mainly used to concentrate on the purification of poisonous metals and organic pollutants. For environmental cleanup, and feasibility training of the plants have taken. Chemically and physically general treatments of the processes are clotting along with adsorption [22], [23]. The following figure 2 shows the water hyacinth grown in industrial waste water surfaces.



Figure 2. Water Hyacinth

Different types of industrial removal were working in ancient methods like manual, the machine makes and chemical used in the water surfaces. But the results of the entire method cannot be succeeded because of the high rate of water hyacinth growth in the water surfaces [24]. Later only, the phytoremediation method was introduced to improve the quality of the wastewater. The following figures show the different methods of industrial effluent removal methods [25].



Figure 3. Water hyacinth managed methods

2. Literature Survey

Zarkami et al [1] proposed a method of Modelling Occurrence of Invasive Water hyacinth in wetlands. This will help to purify the wet land in vast area using the modelling occurrences at different places. Mukarugwiro et al [2] proposed the system of mapping spatio-temporal variations in water hyacinth coverage on Rwandan water bodies using multispectral imageries to purify the industrial effluents. This multispectral imageries helps to identify the changes periodically happened in water hyacinths.

Al-lami et al [3] proposed vegetation indices for monitoring the spread of Nile Rose plant in the Tigris River within Waste province, Iraq using water hyacinths on the surface of water. Once they removed all wastages vegetable cultivations are experimented with the purified water. Madikizela [4] proposed methods for Removal of organic pollutants in water using water hyacinth (*Eichhorniacrassipes*) using organic matters mixed with the water or industrial effluents.

Chun et al [5] discussed the potential of water hyacinth in the phytoremediation of industrial wastewater with their parameters. It has given the details of water hyacinth particles and their extraction capabilities on waste water surface. Phytoremediation method is familiar to remove impurities on industrial effluent. Ajithram et al [6] describe detailed review about Water hyacinth natural composite extraction methods and properties using phytoremediation methods. This will be helpful to most of the industries developed near water surface areas and doing their recycling process also successfully.

Sundarakumar et al [7] proposed a method for Improving the Performance of Industrial Effluent Treatment by Phytoremediation method using Water Hyacinth and Data Management in Big Data. All are ethanol mixed with powders on the water hyacinth particles to improve the extraction capability of them on industrial effluent. Suthar et al [8] discussed Enhanced biogas production in dilute acid-thermal pretreatment and cattle dung biochar mediated biomethanation of water hyacinth. It also produces the bio gas for recycling processes and chemical based water wastage removal techniques.

Carreño-Sayago [9] discussed the development of microspheres using water hyacinth for treatment of contaminated water with Cr (VI) particles as a chemical based removal technique. Adewoye et al [10] proposed Phytoremediation of heavy metals from a point source in as drainage systems using Water Hyacinth particles. This system improves the quality of the water in waste surfaces and drained the heavy metals from the effluents on drainage areas.

Parameswari et al [11] and Narayanan et al [12] proposed a recycling method of industrial effluents to a bio mass amalgamation and extracted the heavy metals from them using biochar and *Aspergillus* principles. The production of bio gas levels are varied depends on the toxic heavy metals presents in the effluents.

Islam et al, Singh et al, and Abbas et al [13-15] proposed methods for raw material for the production of bio-compost and handmade paper along with Kinetics and prediction modeling of heavy metal phytoremediation from glass industry. Also it uses to remove the heavy metals from the waste water from effluents using water hyacinths. All are discussed about the process of recycling with the existing water hyacinths growth and how to re-produce bio gas, bio mass products with the help of water hyacinths.

Ilo et al, Auchterlonie et al, and Wei et al [16-18] discussed with Methodological Approaches to Optimizing Anaerobic Digestion of Water Hyacinth for Energy Efficiency and a review on phytoremediation of contaminants in air, water and soil using water hyacinths. They also discussed the A case study from Hartbeespoort Dam, South Africa. Using chemical mixer to the water surfaces on the vast area and added the minerals for the growth of water hyacinths.

Sharma et al and Mustafa et al [19],[20] proposed the Role of microbial community and metal-binding proteins in phytoremediation of heavy metals from industrial wastewater and explains the Recent studies on applications of aquatic weed plants in phytoremediation of wastewater. Narayanan et al and Yan, et al [21], [22] proposed the methods of Phytoremediation competence of short-term crops on magnesite mine tailing. Chemosphere and Phytoremediation of radionuclides in soil, sediments and water techniques elaborately.

Liu et al, Tripathi et al and Hejna et al [23-25] proposed a method of disposal and utilization of phytoremediation plants containing heavy metals and Distillery wastewater detoxification and management through phytoremediation. Also it described Heavy-metal phytoremediation from livestock wastewater and exploitation of exhausted biomass techniques clearly with water hyacinth particles.

3. Experimental Setup

3.1. Structure of the Plant

Mettur Dam, Salem, Tamilnadu is the place where we have collected the raw materials with the latitude 11.786253, and the longitude is 77.800781. Their particles such as leaves, roots, and stem are detached in the plant is described in figure 4. It was kept in a separate room with a certain temperature level continuously for 7 to 9 days and some tiny particles were packed down with a kitchen mixer and acquired fine particles. It was kept in a bottle with an air lock for successive experimentation.



Figure 4. Eichhornia crassipes particles

3.2. Extraction Components from the Plants

The cold separation technique is used for the extraction of water hyacinth plants. Herbal extraction method which is famous for extraction technique like no hotness was used in water. A powdered material has been taken for cleaning the base of the bottle and 1:15 ratio extraction is followed with ethanol solvent. Ethanol quantity is 100ml and 10gm powder is used for cleaning. 500ml conical flasks (set of three) were taken and these samples were kept on that for the experiment. They are mixed with proper proportions and then shaken by a rotary unit with 200 rpm. Every day this experiment has taken with the regular interval as cycles. A filter paper is used for clarification then store in separate Falcon tubes.

3.3. Water Sampling

Different places of industrial effluents have taken like from Salem and Namakkal districts of tamilnadu. It contains impurities and several heavy toxic component metals at a different color. The following figure 5 denotes the color and hue of the industrial effluents taken from the different places.



Figure 5. Industrial effluent taken at different places

3.4. Analysis of Chemical Ingredients

Industrial effluents have a lot of impurities, heavy toxic metals; TSS, BOD, COD, TDS, and other organic matters are available in each sample. Removing all the particles and materials is mandatory for the purification of water and recycling. Finally, water test has been taken to identify the quality of the water at VV Laboratories, Salem.

3.5. Analysis of Gas Chromatography and Mass Spectrum

GCMS analysis has been taken to find the compounds available in the parts of the water hyacinth in the industrial effluent such as their leaf, tem and roots. This analysis was done at Dens Laboratory and research Centre, Bangalore.

3.6. Analysis Using Spectrophotometer

The parts of the plant such as leaf, stem and root are extracted the mixed effluent particles at 2:2 ratio level using the spectrophotometer by UV method. The range is 700 nm and the absorbance level has decreased and increased based on the impurities removed from the water contaminants periodically. This test has been taken to identify the quality of the water at VV Laboratories, Salem.

4. Experimental Results with Discussion

This article will explain the techniques to purify the industrial effluents using the Phytoremediation method with the help of water hyacinths. GCMS test has been taken for identifying the presence of the compound in the industrial effluents such as toxic materials, heavy metals present, and some organic impurities. The UV

Spectrophotometer is used to remove the micronutrients in the water wastages with absorbance techniques have shown in the tables. Water quality tests will help to find the impurity particles present in the wastewater that are also represented in the table. The percentage of the purification from the industrial effluent by water hyacinth root, leaf, and stem of water hyacinth has to be described in the tables.

4.1. Methods of Extraction

Different particles of water hyacinths are mixed with powders to improve the working efficiency of the particles. It is also worked for liquid extraction from the water hyacinth for the purification purposes. The following figure 6 describes the powder mixed water hyacinth parts.



Figure 6. Water Hyacinth parts mixed with powder

The cold separation technique is used for the extraction of water hyacinth plants. Herbal extraction method which is famous for extraction technique like no hotness was used in water. A powdered material has been taken for cleaning the base of the bottle and 1:15 ratio extraction is followed with ethanol solvent. Ethanol quantity is 100ml and 10gm powder is used for cleaning. 500ml conical flasks (set of three) were taken and these samples were kept on that for the experiment. They are mixed with proper propositions and then shaken by a rotary unit with 200 rpm. In each cycle of water hyacinth Root, Stem and Leaves are 9ml, 9ml, and 12 ml respectively. Ethanol is a solvent used to extract the water hyacinth particles and will be used for further experimental study. The following figure 7 describes the ethanol used for extraction.

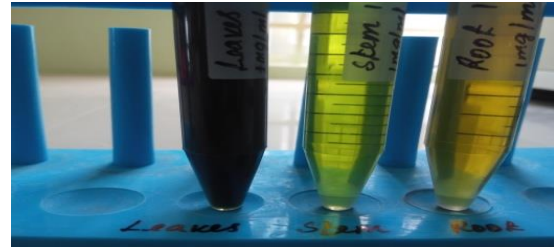


Figure 7. Water hyacinth parts with ethanol for extraction

4.2 GCMS Analysis

Water Quality test has conducted before the purification process on water hyacinths and the level of purification depends on the impurities available in the industrial effluent. GCMS analysis has been taken to find the compounds available in the parts of the water hyacinth in the industrial effluent such as their leaf, stem, and roots. This analysis was done at Dens Laboratory and Research Centre, Bangalore. The parameters taken for the test are listed in table 1 used to compounds extracted from the water hyacinth particles such as root, leaf, and stem.

Table 1. Parameters taken for purification

Parameters Taken	Values in mg/lit
Total Dissolved Solids (TDS)	17582
Solids in numbers	348
Residual Free Chlorine	1785
Total Suspended Solids	40.8
Oil and Grease	1.37
Sulphide	1.9
Chloride	3497
Phosphorus	175
Nitrates	134
Nitrites	9.7
Nitrogen	14.8
Phenolic Compounds	0.49
Sodium	2.1
Potassium	1.7
Demand Biochemical Oxygen	12
Demand Chemical Oxygen	84
Dissolved Oxygen levels	1.92
Arsenic	1.4
Cadmium	7.89
Copper	24.7
Pb	10.5
Mercury	0.7
Zinc	10.8
Chromium	17.4
Iron	6.8
Nickel	3.8
Selenium	2.8
Manganese	3.4
Fluorides	3.6

4.3. Process of Purification

The solvent Ethanol is used to extract the particles of water hyacinth which are mixed in industrial effluents. It's been kept in separate flask and the level of impurities of that will be varied based on the absorbance level (700nm). The following table 2, table 3 and table 4 have shown the extraction levels of water hyacinth's leaf, stem and roots.

Table 2. Leaf extracts absorbance

Day	waste water volume (ml)	Leaf extract volume level (ml)	Absorbance levels
First	100	10	0.654
Second	100	10	0.643
Third	100	10	0.615
Fourth	100	10	0.534
Fifth	100	10	0.465
Sixth	100	10	0.253
Seventh	100	10	0.275
Eighth	100	10	0.163
Ninth	100	10	0.123

Table 3. Stem extracts absorbance

Day	waste water volume (ml)	Leaf extract volume level (ml)	Absorbance levels
First	100	10	0.949
Second	100	10	0.935
Third	100	10	0.942
Fourth	100	10	0.851
Fifth	100	10	0.754
Sixth	100	10	0.572
Seventh	100	10	0.543
Eighth	100	10	0.475

Table 4. Root extracts absorbance

Day	waste water volume (ml)	Leaf extract volume level (ml)	Absorbance levels
First	100	10	1.451
Second	100	10	1.434
Third	100	10	1.425
Fourth	100	10	1.386
Fifth	100	10	1.248

Sixth	100	10	1.089
Seventh	100	10	1.034
Eighth	100	10	0.943

From the above results, detailed study has been processed with the levels of absorbance and impurity levels presence after the experiments. They have collected the results and it shown only leaf of the water hyacinth is purified the industrial effluent more than other parts.

4.4. Study on Water Hyacinth Purification Results

From the water quality test and purification test conducted with various samples taken from different places, we have to study the results deeply and compared with the previous methods it has given more improvements. The development level of purifying the industrial effluent by the water hyacinth is varied depends on the ethanol mixed in their particles such as root, stem, and leaf. Finally from the study has taken, Leaf has given 67.34% and Stem has got the purification result of 37.54%. But the root of the water hyacinth has given 12.36% efficiency of purification only from the experiments. Later the conclusion of results has identified from the values and decision has taken that only leaves of the water hyacinth will purify the wastewater effectively compared with other parts like stem and root. The formula which is used to identify the percentage of efficiency of the plant extraction from their particles is followed as ($\%T = \text{antilog} [2 - \text{Absorbance (OD)}]$). With these formulas, the percentage of efficiency has calculated for leaf, stem and root in the following tables 5, 6, and 7.

Table 5. Leaf extract

Day	Formula used	Percentage
First	antilog (2-0.643)	20.35
Second	antilog (2-0.686)	21.41
Third	antilog (2-0.635)	20.52
Fourth	antilog (2-0.543)	27.54
Fifth	antilog (2-0.356)	35.84
Sixth	antilog (2-0.234)	54.37
Seventh	antilog (2-0.268)	61.24
Eighth	antilog (2-0.135)	62.87
Ninth	antilog (2-0.123)	63.54

Table 6. Stem extract

Day	Formula used	Percentage
First	antilog (2-0.964)	11.35
Second	antilog (2-0.942)	12.41
Third	antilog (2-0.913)	12.52
Fourth	antilog (2-0.893)	13.54
Fifth	antilog (2-0.864)	15.84
Sixth	antilog (2-0.843)	16.37
Seventh	antilog (2-0.634)	18.24
Eighth	antilog (2-0.549)	22.87
Ninth	antilog (2-0.423)	32.54

Table 7. Root extract

Day	Formula used	Percentage
First	antilog (2-1.934)	3.4
Second	antilog (2-1.931)	4.5
Third	antilog (2-1.907)	4.8
Fourth	antilog (2-1.893)	5.1
Fifth	antilog (2-1.843)	5.6
Sixth	antilog (2-1.813)	5.7
Seventh	antilog (2-1.631)	5.8
Eighth	antilog (2-1.613)	7.9
Ninth	antilog (2-1.531)	11.5

5. Conclusion and Future Work

Water hyacinth is used for the removal of industrial effluent by phytoremediation methods in the wastewater surfaces around the industries and other areas. The overall effect of the purification method is to be identified with various techniques used in this article and their results are compared with the previous methods for analysis. GCMS analysis is used to find the compounds of the water hyacinth. The study will explain all compounds levels have taken for experiments and their results shown improvements in phytoremediation. Leaf, stem, and root of the water hyacinth extract the ability to purify the industrial effluent is 67.34%, 37.54%, and 12.36% respectively. No other problems like water

discharge and environmental issues were raised during the whole experiment. At the end of the experiments, the overall results indicate only the leaf of the water hyacinth controlled the industrial effluent toxic compounds while compared with the other parts like stem and root.

Industrial effluents are the major problem raised all over the world and so many techniques are suggested to remove them. But the huge amount of industrial effluents were occupied the water surface it is quite difficult to remove in an easy manner. Industries have taken several steps to purify the water and recycling it from the industrial effluent. In the future, the levels of compounds and toxic materials present in the industrial effluent can be identified using sensors present in the water surfaces by the IoT framework. Every second the generated data can be processed by the sensors and send to the centralized server place for analysis. Those could be handled by big data analytics for further more processes. This process could help all the industry people to make their environment clean and good.

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