Study of Water Hyacinth's Efficiency on Textile Effluent Treatment: An Eco-friendly Approach

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Abstract:
In untreated natural areas, such as underground streams, rivers, ponds, and lakes that are utilized as sources of drinking water, dye effluents from a variety of businesses, including those in the textile, leather, paper, food industry, and agriculture, are dumped, which causes pollution. The high pollutant load in textile dye effluent enhances the change in physicochemical parameters. Water hyacinths and other aquatic macrophytes take up toxins and store them in their biomass. They have a high tolerance for contaminants are able to absorb a lot. This study compares the effectiveness of using water hyacinth to detoxify dye effluents. The physicochemical parameters pH, TS, DO, COD, and dye concentration were initially determined for water. In general, DO was absent from every sample of collected wastewater. Reduction in COD in the effluents suggested that there was an increase in DO following treatment. According to the findings, water hyacinth is especially effective in cutting down on pollution in textile effluents.

Keywords: Water Hyacinth, textile effluent, biological treatment methods, effluent treatment
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Introduction:

The primary cause of environmental contamination in our nation over the past many decades has been the textile sector. The primary cause of processing water contamination is chemicals and auxiliary products used in textile production. The majority of textile effluents (water) are discharged directly or via municipal sewers into surface waters like rivers, lakes, or canals. In these effluent Heavy metals contains high amount of organochlorine compounds, alkalis, sulphides, oils, acids etc. Only a small part of these substances naturally disintegrate; the remainder have detrimental impacts on the environment and the general public's health.

Presence of heavy metals in untreated waste water, interfere the activity of enzymes and the generation of red blood cells, which may have adverse consequences on individuals. Even minor changes in pH can also affect the solubility of chemical forms in wastewater, exacerbating the nutritional problems.

Fish cannot breathe due to fine suspended particles clogging their respiratory system. These dyestuff companies release a range of pollutants through various methods [1]. Since dyes have a wide range of structural characteristics, treating them with just one procedure becomes challenging. Dye levels as low as 1ppm can still be easily identified *due to their visibility. The toxicity of dyes to plants and animals has a long history [2]. Due to their non-biodegradable qualities, textile effluents color exacerbates the environmental problem [3]. The presence of even a very little amount of a coloring material renders anything unattractive owing to its look because color is a visible pollution. Industries that generate and use dyes produce high COD and BOD (chemical and biological oxygen needs) values, suspended particles, and brightly colored effluents. Due to the presence of color in wastewaters it provides resistance to their biodegradation, upsetting aquatic life, as these dyes are frequently resistant to heat, light, and oxidative agents. [4,5]. There have recently been numerous initiatives to find less expensive alternatives to conventional wastewater treatment methods. The importance of recent advances in novel treatment methods using commonly available, affordable biological and agricultural components is growing. The aquatic plant water hyacinth (Eichhornia crassipes) has enormous potential for removing a wide range of contaminants from water [6].*

Eichornia crassipes has been extensively investigated as an aquatic plant that can be utilized to treat municipal, agricultural, and industrial waste streams and enhance effluent quality. It is also a crucial component of a single, contemporary, integrated system [7]. In this study, the ability of the plant material is evaluated by evaluating the effluent's BOD, COD, and DO, pH, temperature, and TDS, TSS, and heavy metals levels. Additionally, the outcomes were contrasted with the identical effluent parameters that underwent biological treatment. This study compares the efficacy of biologically and water hyacinth-treated wastewater and covers the majority of effluent characteristics, which makes it particularly significant.

Figure1.1: Water hyacinth's roots and its environment (inset)

II. Experimental Methods:

2.1 Plant Material

Fresh water hyacinth were first procured from Jaipur's Sanganer textile area, and they were cleaned with tap water before being kept in water for a day. For experiment, samples were collected from three different Zones (i.e. Sitapura industrial area, Sanganer textile area and Bagru textile area) in suitable glass jar for measurement of various parameters and into a suitable plastic jar for heavy metal measurement to prevent various contamination.

Sample preparation: The raw effluent's various characteristics were measured, and then 4 liters of the effluent each in a glass jar and a plastic jar were filled. Making sure that each jar's effluent carefully contained the roots of two plants. The jars were put in a space that was open and shielded from the sun and rain. The treated effluent's parameters, with the exception of heavy metals, were checked every 24 hours. The common parameters of effluents were measured after the intake wastewater had processed and passed through the full setup of the ETP for around 72 hours. The parameters were measured three times, and the means were taken into consideration.

Evaluation procedure: Standard techniques and tools were used to measure the parameters. A BOD incubator was used to measure BOD, COD was measured by the standardized process, a standard method was used to measure the DO, a standard thermometer was used to measure temperature, a digital pH meter was used to measure pH, TDS and TSS were determined by the gravimetric analysis. The heavy metals were tested by AAS method.

Figure2.1: Water under treatment with plant material

Biological Oxygen Demand (BOD): It is the amount of soluble oxygen that an effluent sample consumed after five days at 200^0 C. (BOD Incubator helped with the use of Winkler's technique.

Chemical Oxygen Demand (COD): One litter effluent sample was used to conduct a COD test using the Dichromate Reflux Method to determine the quantity of oxygen present.

Dissolved Oxygen (DO): The Winkler's Method was used to determine how much dissolved oxygen is present in a lake, river, or stream to support marine life.

Total Suspended Solids: A conventional filter is used to filter a sample of waste water; the TSS is calculated using the mass of the residue. The usage of a digital TSS meter

Total Dissolved Solids: It is the amount of all inorganic and organic components which is present in liquid form in waste water either in molecular, ionized or in colloidal form. It was determined using a standard filtration method.

Heavy Metals: The heavy metal content of waste water was examined using an atomic absorption spectrophotometer (AAS).

pH: A digital pH meter was used to measure the pH readings.

Results and Discussions:

There have been attempts to provide an explanation of the potential process at work in the Water Hyacinth-based treatment systems [8, 9, 10, 11]. Metal, hydrocarbon, pesticide, and chlorinated solvent-contaminated hazardous waste sites are said to be easily and economically cleaned up using the newly developed process known as phytoremediation, which is garnering more and more attention. Inorganic pollutants like nitrate, ammonium, soluble phosphorus, and heavy metals can be effectively eliminated by water hyacinth through uptake and accumulation [12, 13, 14]. Heavy metals are cationic in nature, whereas water hyacinth is anionic. As a result, Water Hyacinth can quickly absorb heavy metals [15,16,17]. The Water Hyacinth's stem (rhizome) and roots absorb a significant amount of water. Taking into account all of these, the implementation of an economical and environmentally beneficial wastewater treatment process, can be provided by Water Hyacinth. The main goal of this study is to compare the efficacy of biological treatment to that of water hyacinth in treating effluent.

The efficiency of the experiment's findings is attributable to the fact that the macrophytes underground root zone (rhizosphere) is teeming with bacteria and other microorganisms, and that reductions take place when water travels through the complex rhizosphere of the floating macrophytes [8]. These tests show that the amount of TSS, BOD, COD, N, and P may be significantly decreased so this water can be easily used for other purposes. The Water Hyacinth may remove so many heavy metals because of its large adventitious root system, which collects these harmful compounds from wastewaters and absorbs them.

3.1 Biochemical Oxygen Demand (BOD)

Below are standard values, biological and Water Hyacinth treatment effluent BOD levels, and raw effluent BOD values.

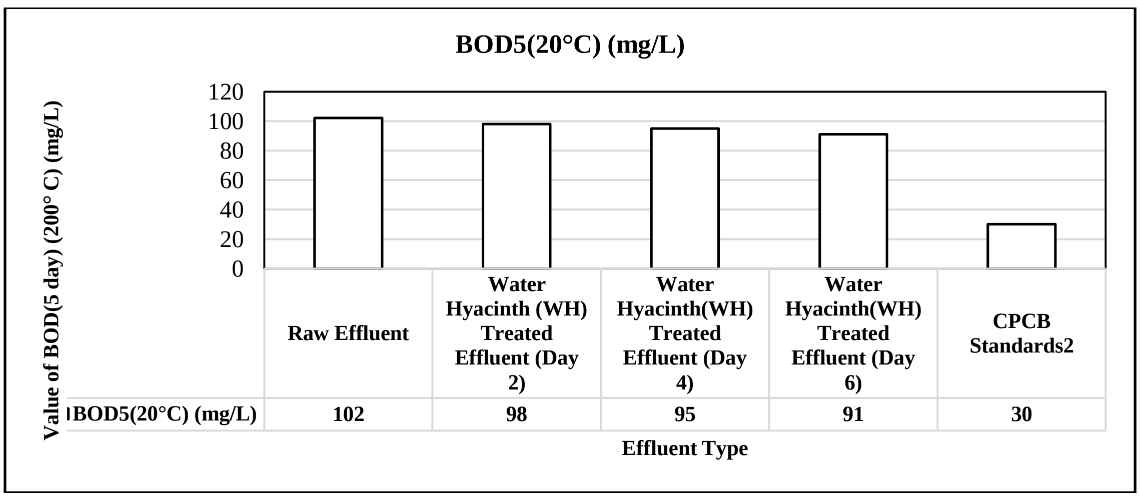

Figure 3.1: BOD levels of the treated effluent by water hyacinth were equivalent to the standard values of the effluent and were
Within acceptable ranges on all treatment days, according to the study.

An increase in DO causes the wastewater to become more aerobic, which encourages aerobic bacterial activity to lower BOD [10]. The dissolved oxygen concentration of waste water may rise as a result of the decrease in BOD. By losing pieces of their roots, hyacinths would release soluble organic chemicals into the water, along with other organic material. As a result, the water would likely require a somewhat high amount of BOD [17,18].

Chemical Oxygen Demand (COD):

The following chart displays the COD values of untreated wastewater, treated effluent by biological and Water Hyacinth processes, and standard values:

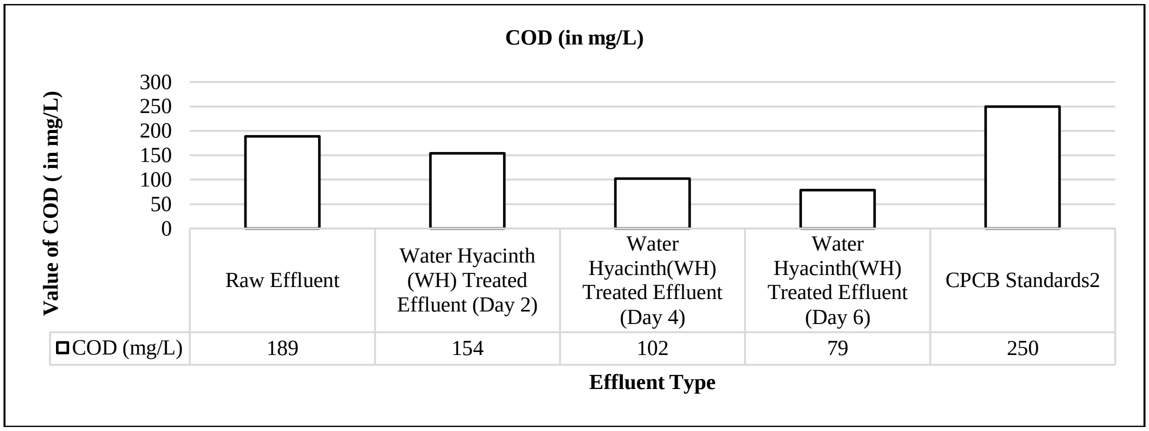

Figure 3.2: COD levels of the treated effluent by water hyacinth were equivalent to the standard values of the effluent and were
Within acceptable ranges on all treatment days.

3.3 Dissolved Oxygen (DO): The following chart displays the DO levels of untreated effluent, wastewater that has been treated biologically and/or with Water Hyacinth, and standard values:

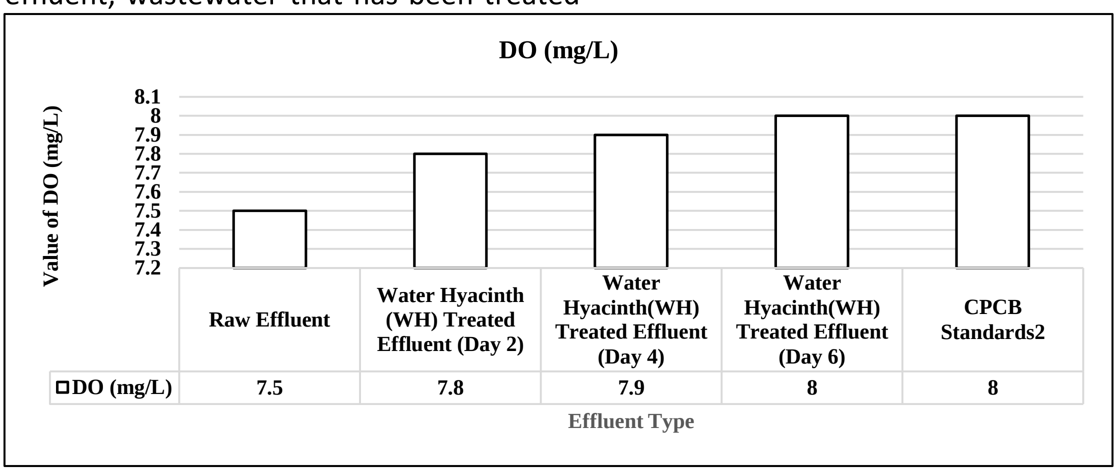

Figure 3.3: demonstrates how the DO values of the wastewater treated with water hyacinth were equivalent to those of the
Effluent treated with biological means and within the range on all of the treatment days.

Increased DO in wastewater generates aerobic conditions that encourage aerobic bacterial activity to lower the COD [19, 20]. A rise in dissolved oxygen concentration in wastewater can follow a decrease in COD.

At the peak of their photosynthetic activity, plants can reduce the amount of dissolved CO_2 in wastewater. The amount of dissolved oxygen in the water rises as a result of water hyacinth thick mats preventing oxygen from reaching the water's surface or reducing the production of oxygen by other microorganisms and plant materials [21, 22]. The biomass that is rotting at the water's surface when a plant falls to the bottom reduces the amount of oxygen. As a result, the amounts of dissolved oxygen might get dangerously low. According to this study, low dissolved oxygen (DO) could be a result of phosphorus-induced algal development. Another nutrient that can aid in the growth of algae is nitrogen [23]. The breakdown and eventual death of the algae consumes all of the dissolved oxygen. Fish and other aquatic species could not have enough access to dissolved oxygen as a result. The death and decay of submerged plant materials lowers down the dissolved oxygen level into waste water [24]. Carbonaceous Biochemical Oxygen Demand is a term used to describe the process of decomposition.

Total Suspended Solids: The following chart displays the TSS values for raw wastewater and treated effluent together by water hyacinth with standard values

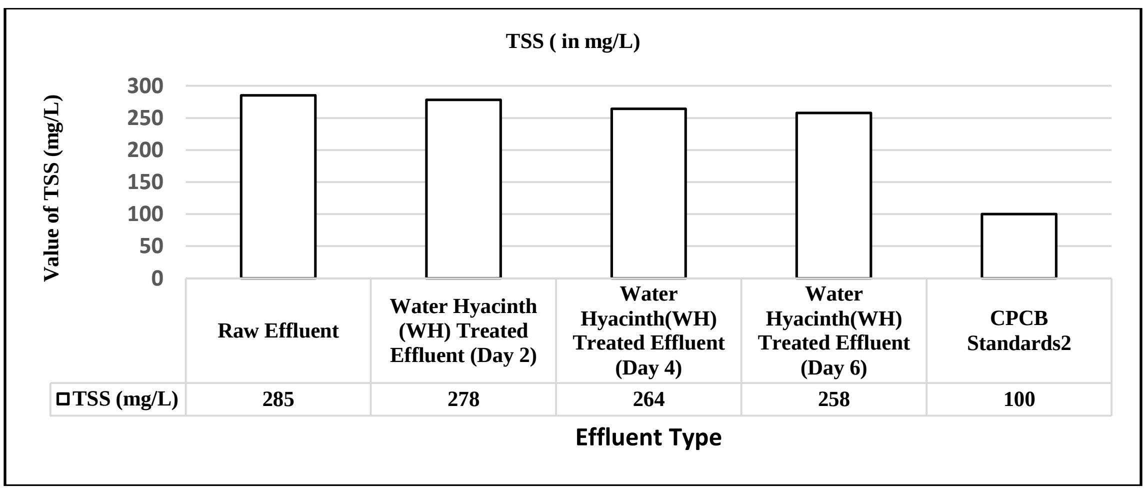

Figure 3.4: demonstrates, the TSS values of the effluent treated with water hyacinth were not always below the Acceptable range,

They were nevertheless quite near to those of the biologically treated effluent.

The TSS value of effluents is typically very difficult to lower even with numerous chemical treatments [25]. Our treatment with the water hyacinth resulted in somewhat effective results because the suspended particles are caught in the feathery and fibrous roots of the plant [12]. TSS also traps bacteria in the rhizosphere of the macrophytes. Bacteria and fungi can grow by attaching to the fibrous, feathery roots.

Total Dissolved Solids:

The following graph compares the TDS values of raw effluent, treated effluent using biological processes and Water Hyacinth, and standard values:

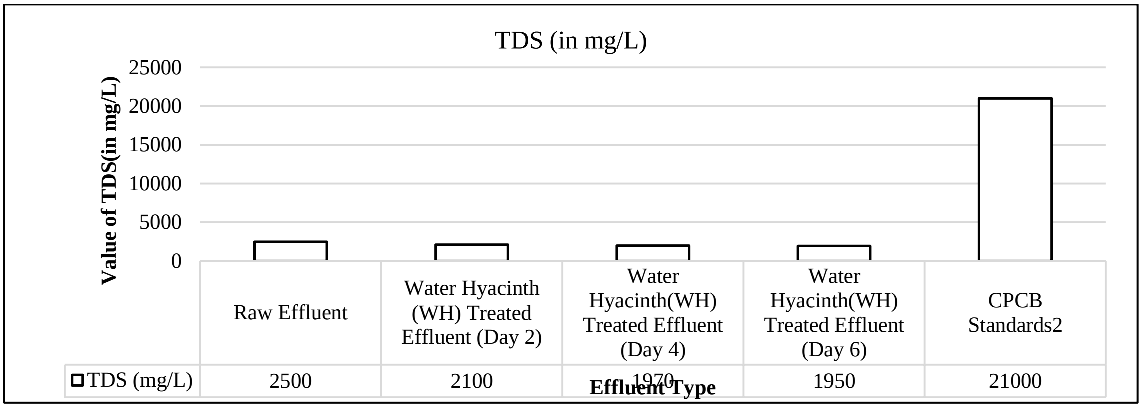

Figure 3.5: showing the TDS value of the wastewater that had been treated with water hyacinth reduced on the first

Day and was near to the value of the effluent that had been treated biologically.

It was likewise within standard range. On successive treatment days, the values rose. It is highly challenging to minimize the TDS value of wastewater in a practical setting. In that regard, the outcomes of our use of water hyacinth as a treatment method were mediocre at best. When the plants were added to the jar, the TDS levels rose. This increase is brought on by clay or other tiny particles that are present in plant roots [26].

pH Variation:

Below are the PH values for standard values, biologically and Water Hyacinth-treated effluent, and raw effluent:

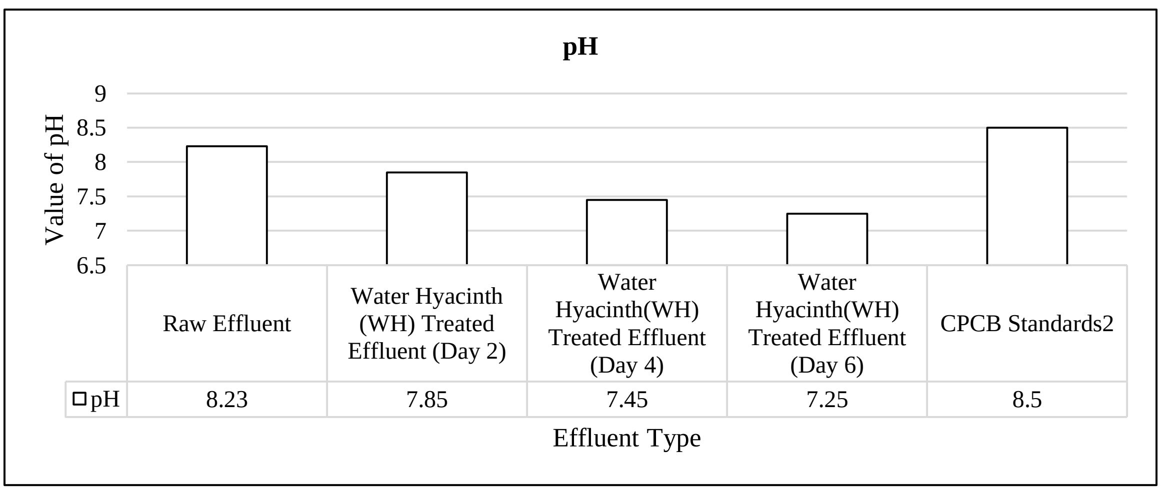

Figure 3.6: demonstrates that the PH levels of the wastewater treated with water hyacinth were within normal limits on all treatment

Days and were comparable to the levels of the effluent treated biologically.

The wastewater's pH was significantly reduced as evidenced by the results of the natural Water Hyacinth treatment. In every day of the research, the pH was brought down to almost neutral. The pH decreases as a result of nutritional absorption or when metal ions are consumed while [H+] ions are simultaneously released [27]. As the PH dropped, bacteria were better able to break down COD and BOD in the wastewater.

Heavy Metals- The amount of heavy metals as well as standard values, are indicated in the charts below for raw effluent and water hyacinth-treated effluent.

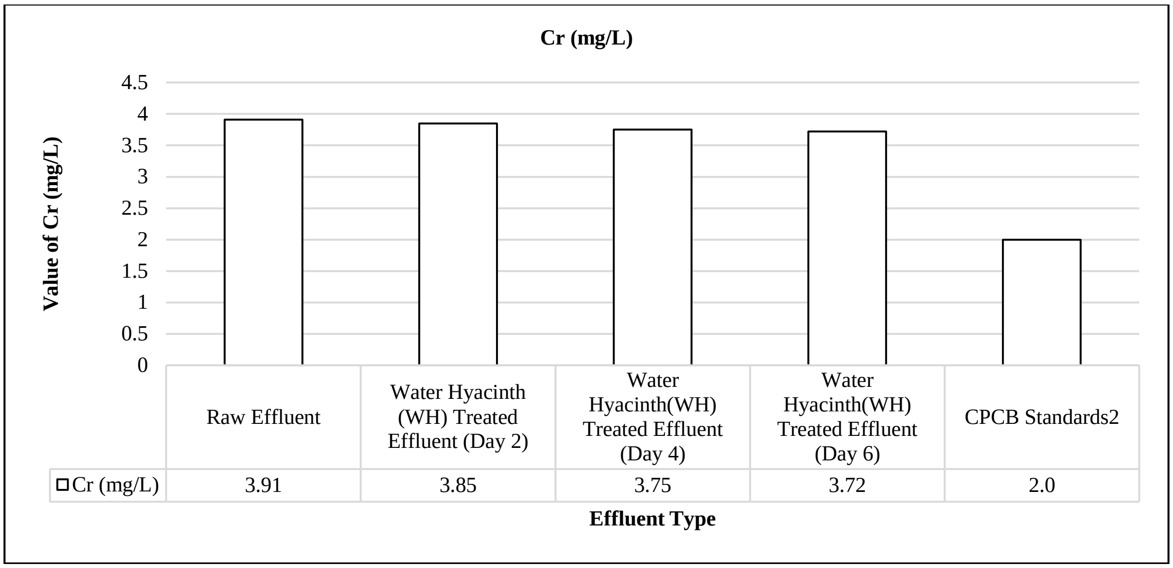

Figure3.7.1: Chart showing results of Heavy Metal-Cr.

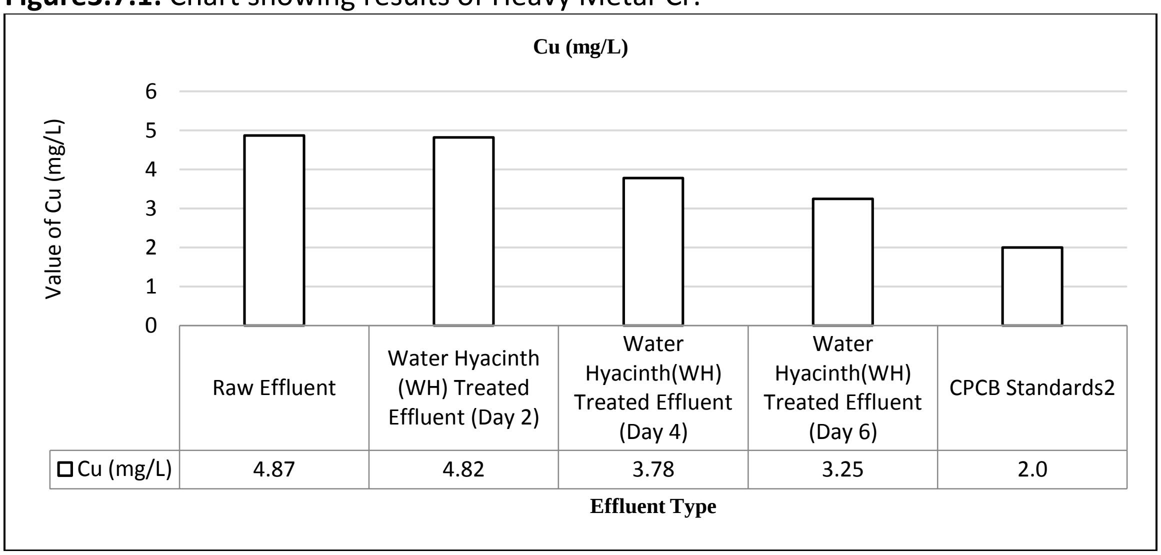

Figure3.7.2: Chart showing results of Heavy Metal-Cr.

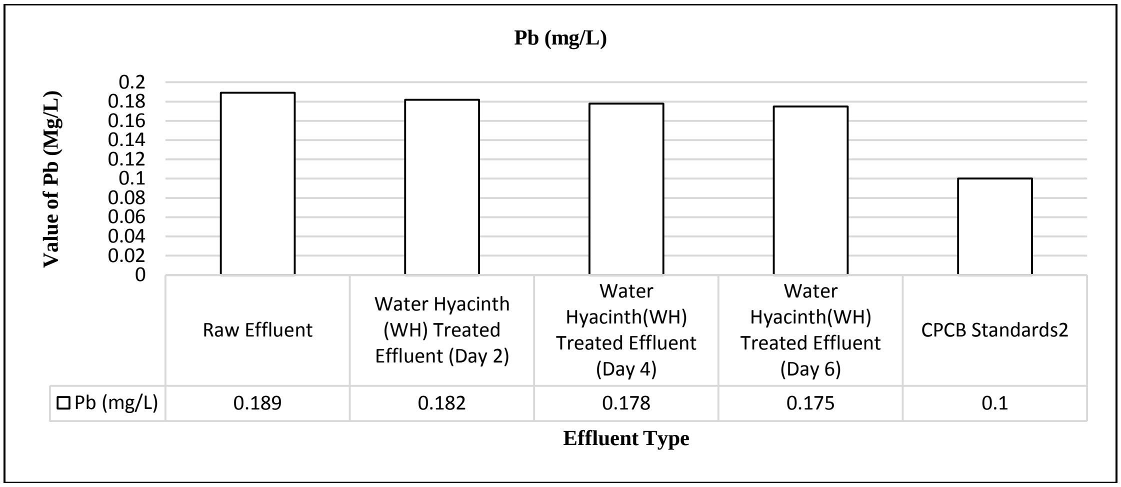

Figure3.7.3: Chart showing results of Heavy Metal-Pb.

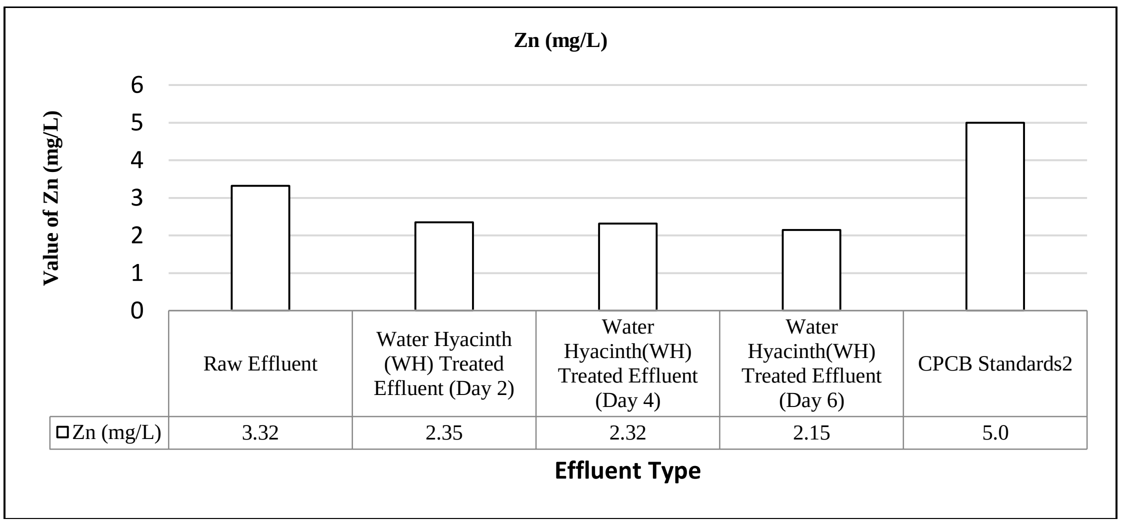

Figure3.7.4: Chart showing the level of Heavy Metal - Zn.

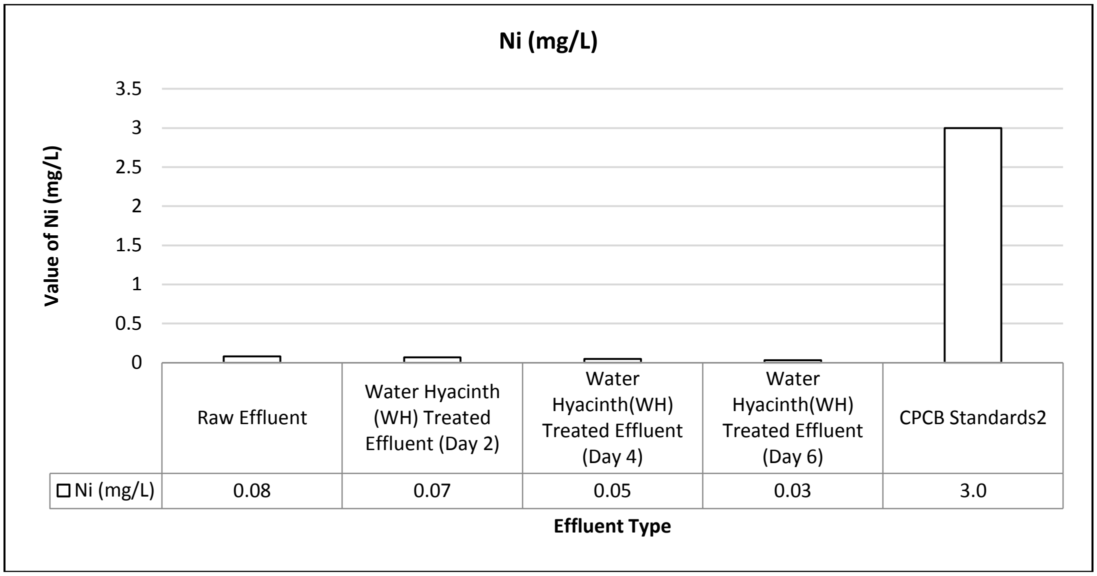

Figure3.7.5: Chart showing results of Heavy Metal-Ni.

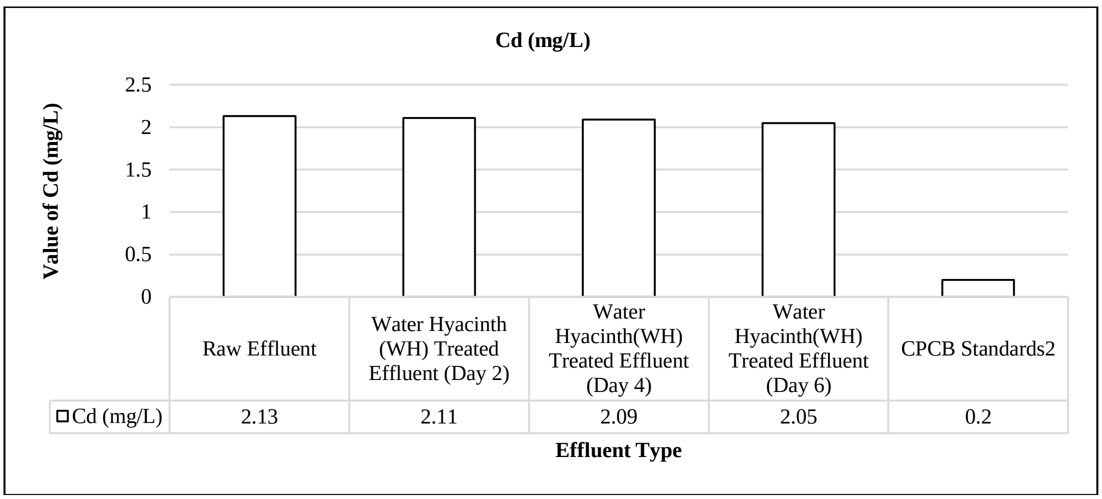

Figure3.7.6: Chart showing the level of Heavy Metal-Cd.

Figures show that by water hyacinth heavy metal decreased as compared to wastewater left untreated. The outcomes were rather close to the effluent value after biological treatment. Heavy metals can be eliminated from contaminated water sources using one of three methods (phytoextraction):

Root absorption- Both the water's impurities and water are absorbed by the roots. The presence of carboxyl groups, which results in a significant cation exchange through cell membrane. Aquatic plants like water hyacinths and other plants provide an environment where aerobic bacteria can flourish [28].

Foliar absorption- Plants could obtain minor levels of some pollutants through foliar absorption in addition to root absorption. Through cuticle fissures and stoma cells, they are passively absorbed [29, 30].

Adsorption- When bacteria and suspended solids (SS) are readily captured by the feathery, fibrous roots, they can act as attachment sites for the growth of fungal and bacterial growth. The bacteria that live there adsorb the pollutants to the root surface [29]. The root of the immersed water hyacinth's cell membrane's ionic equilibrium is also to blame.

3.10 The experimental results are compared to various other benchmarks.

Table1: Study findings and comparisons with benchmarks

	Sample Effluent	Water Hyacinth Treated Effluent (Day-2)	Water Hyacinth Treated Effluent (Day-4)	Water Hyacinth Treated Effluent (Day-6)	CPCB Standards[2]
pH	8.23	7.85	7.45	7.25	6.5-8.5
Temperature (°C)	45	43	32	31.5	40
DO (mg/L)	7.5	7.8	7.9	8	4.5-8
TDS (mg/L)	2500	2100	1970	1950	21000
TSS (mg/L)	285	278	264	258	100
COD (mg/L)	189	154	102	79	250
BOD5(20°C) (mg/L)	102	98	95	91	30
Cr (mg/L)	3.91	3.85	3.75	3.72	2.0
Cu (mg/L)	4.87	4.82	3.78	3.25	2.0
Pb (mg/L)	0.189	0.182	0.178	0.175	0.1
Zn (mg/L)	3.32	2.35	2.32	2.15	5.0
Ni (mg/L)	0.08	0.07	0.05	0.03	3.0
Cd (mg/L)	2.13	2.11	2.09	2.05	0.2

The efficiency of Water Hyacinth's treatment of dye-house effluent is summarized in Table 1, which demonstrates that PH drops by roughly 7% during the biological process. The effectiveness of water hyacinth is demonstrated by a striking 10% reduction on the first day following treatment. Biological therapy reduced temperature by 20%, whereas Water Hyacinth treatment reduced it by 27%. On the first day of treatment, DO climbed 93% with water hyacinth treatment compared to 90% with biological treatment. In comparison, biological therapy increased hardness by 67%, while the amazing effectiveness result was between 80 and 90%. On the second and third days of treatment, Water Hyacinth caused a hardness rise. Although the effectiveness of TDS observation by Water Hyacinth treatment is relatively low. Compared to biological treatment, the TSS effectiveness of water hyacinth treatment dropped by 17% instead of 7%. Even though COD was reduced by 79% by biological treatment, water hyacinth treatment led to reductions of 49% on the first day and 91% on the second. Most substantially, treatment with water hyacinth reduced BOD by 99% as opposed to 31% just with biological methods.

In the case of heavy metals in effluent water biological treatment has generally resulted in a decrease of (91-95) %, whereas treatment based on water hyacinth has resulted in a decrease of (93-98) %.

Conclusion: The study shown that Water Hyacinth may successfully treat effluent while substantially reducing numerous hazardous parameters. According to the experiment's findings, the effluent treatment using water hyacinth is more cost-effective than biological treatment (expensive chemicals and processes may be eliminated), and it is also more environmentally friendly (As in this treatment method, plant material is used which is completely biodegradable so that it can be used for the production of biogas). A model for "Water Hyacinth based effluent treatment plant" is now being created in order to usher in a new era for wastewater treatment on a global scale. In the purification of dye-house effluents water hyacinth plays an important role, and research is ongoing to identify the best circumstances and comprehend how this happens.

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