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# Constructed Wetlands –Lake Water Treatment Using Aquatic Plants

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**ABSTRACT-** Constructed wetlands are engineered and managed wetland systems that are increasingly receiving worldwide attention for wastewater treatment and reclamation. Compared to conventional treatment plants, constructed wetlands are cost-effective and easily operated and maintained, and they have a strong potential for application in a small community. Constructed wetlands for wastewater treatment have substantially developed in the last decades. As an eco-friendly treatment process, constructed wetlands may enable the effective, economical, and ecological treatment of agricultural, industrial, and municipal wastewater. Due to water scarcity challenges around the world, it is essential to think about non-conventional water resources to address the increased demand in clean freshwater. Environmental and public health problems may result from insufficient provision of sanitation and wastewater disposal facilities. Because of this, wastewater treatment and recycling methods will be vital to provide sufficient freshwater in the coming decades, since water resources are limited and more than 70% of water are consumed for irrigation purposes. Therefore, the application of treated wastewater for agricultural irrigation has much potential, especially when incorporating the reuse of nutrients like nitrogen and phosphorous, which are essential for plant production. Among the current treatment technologies applied in urban wastewater reuse for irrigation, wetlands were concluded to be the one of the most suitable ones in terms of pollutant removal and have advantages due to both low maintenance costs and required energy. Wetland behavior and efficiency concerning wastewater treatment is mainly linked to macrophyte composition, substrate, hydrology, surface loading rate, influent feeding mode, microorganism availability, and temperature. Constructed wetlands are very effective in removing organics and suspended solids, whereas the removal of nitrogen is relatively low, but could be improved by using a combination of various types of constructed wetlands meeting the irrigation reuse standards. The removal of phosphorus is usually low, unless special media with high sorption capacity are used. Pathogen removal from wetland effluent to meet irrigation reuse standards is a challenge unless supplementary lagoons or hybrid wetland systems are used. In this paper Futala Lake, Nagpur lake water treatment using Hydrilla Submerged Aquatic plants.

**KEYWORDS-** Hydrilla, Lake Water, Submerged Plants, Constructed Wetlands, Wastewater Treatment

## I. INTRODUCTION

### 1.1 OVERVIEW

Globally, most of the developing countries are geographically located in those parts of the world that are or will face water shortages in the near future. Moreover, the existing water sources are contaminated because untreated sewage and industrial wastewater is discharged into surface waters resulting in impairment of water quality. The treatment of wastewater using Constructed Wetland (CW) is one of the suitable treatment systems, used in many parts of the world. Wetlands are defined as land where the water surface is near the ground surface long enough each year to maintain saturated soil conditions, along with the related vegetation. Marshes, bogs, and swamps are all examples of naturally occurring wetlands.

*As stated by Ramsar Convention*, natural wetlands are those “areas of marsh, fen, peat-land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters.”

As stated by National Wetlands Working Group, (1988), wetland are those areas which are generally found in waterlogged condition to enhance the wetland and aquatic growth as denoted by poorly drained soils, hydrophytic flora and different types of biological activities which are conditioned to be grow in wet environment.

Natural wetlands are ecosystems that are either permanently or temporarily saturated in water, providing a natural habitat for biotic organisms and supporting conditions that promote the development of wetland soils. The structure of a natural wetland is shaped due to its surrounding abiotic conditions and these may be classified as: marshes, swamps, forested wetlands, bogs, and wet meadows, as well as coastal wetlands such as mangroves. The ability of wetlands to retain large volumes of water, which they release slowly, makes them significant for combatting extreme weather conditions such as flood control and drought mitigation, that occur more frequently as a result of climate change. Additionally, wetlands contribute to water purification, water regulation, biodiversity, aesthetics and recreation. Within the natural wetlands many biological activities occur, therefore these are known to be as “biological supermarkets”. Natural wetlands endowed shelter to many species by providing huge quantity of food for their survival. The life cycle in the natural wetland ecosystem shows similarity as in other ecosystems. For example, in wetlands, bacteria degrade the dead decay matter of plants and animals into organic form as they do in other ecosystems.

A “constructed wetland” is defined as a wetland specifically constructed for the purpose of pollution control and waste management, at a location other than existing natural wetlands. Wetlands can be used for primary, secondary, and tertiary treatments of domestic wastewater, storm wastewater, combined sewer overflows (CSF), overland runoff, and industrial wastewater such as landfill leachate and petrochemical industries wastewater. The most common systems are designed with horizontal subsurface flow (HF CWs) but vertical flow (VF CWs) systems are getting more popular at present. The most commonly used species are robust species of emergent plants, such as the common reed, cattail and bulrush.

In this paper the inlet and outlet wastewater physico-chemical parameters were analysed during the retention period. The parameters studied were pH, BOD, COD, DO, Total Suspended Solids, Total Dissolved Solids, Nitrogen and Phosphorus. The percentage removal of the parameters were analysed and studied until the percent removal rate gets stabilized.

#### Objectives:

- Natural Treatment of Wastewater
- Low Cost & Eco-Friendly to Environment
- Waste stabilization and nutrient removal
- Constructed wetlands and natural water treatment systems aim to control and optimize the ability of a wetland to remove or transform wastewater pollutants

**Table 1.1: Major roles of macrophytes in constructed wetlands**

Wetland plant part	Role
<b>Aerial plant tissues</b>	<ul style="list-style-type: none"> <li>➤ Light attenuation → reduced growth of phytoplanktons</li> <li>➤ Influence on microclimate → insulation during winter</li> <li>➤ Reduced wind velocity → reduced risk of resuspension of settled solids</li> <li>➤ Aesthetic appearance ➤ Nutrient storage</li> </ul>
<b>Plant tissues in water</b>	<ul style="list-style-type: none"> <li>➤ Filtering effect → filter out large debris</li> <li>➤ Reduced current velocity → increased rate of sedimentation, reduced risk of resuspension of settled solids</li> <li>➤ Surface area for attached microorganisms</li> <li>➤ Excretion of photosynthetic oxygen → increased aerobic degradation</li> <li>➤ Nutrient uptake</li> </ul>
<b>Roots and rhizomes</b>	<ul style="list-style-type: none"> <li>➤ Stabilising the sediment surface → less soil erosion</li> <li>➤ Release of oxygen increase organic degradation and nitrification</li> <li>➤ Nutrient uptake</li> <li>➤ Release of antibiotics</li> </ul>



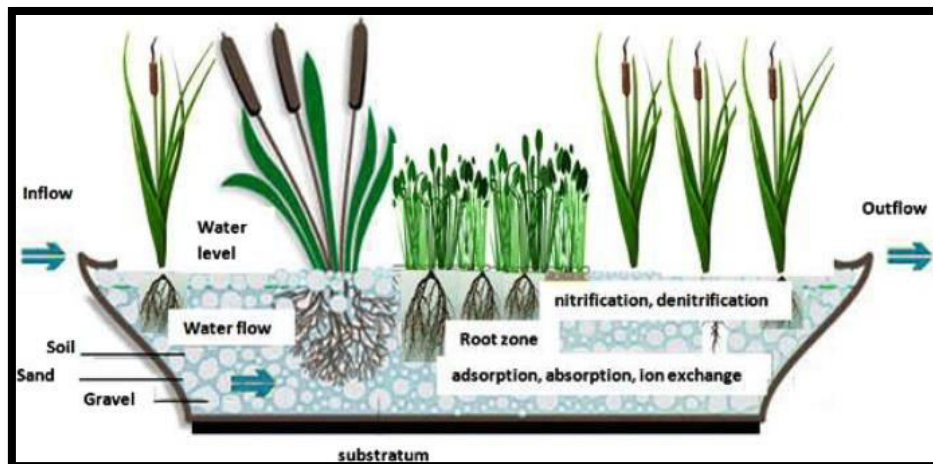
## 1.2 NATURAL WETLANDS VS. CONSTRUCTED WETLANDS

A natural wetland is an area of ground that is saturated with water, at least periodically. Plants that grow in wetlands, which are often called wetland plants or saprophyte, have to be capable of adapting to the growth in saturated soil.

Constructed wetlands, in contrast to natural wetlands, are man-made systems or engineered wetlands that are designed, built and operated to emulate functions of natural wetlands for human desires and needs. Engineered to control substrate, vegetation, hydrology and configuration. It is created from a non-wetland ecosystem or a former terrestrial environment, mainly for the purpose of contaminant or pollutant removal from wastewater.



(Figure 1.1 : Natural Wetlands)



(Figure 1.2 : Constructed Wetlands)

## 1.3 AQUATIC PLANTS

Aquatic plants predominantly grow in water. They vary greatly in type, with some being quite similar to common land plants while others are quite different. Aquatic plants are plants that have adapted to living in aquatic environments (saltwater or freshwater). They are also referred to as hydrophytes or macrophytes to distinguish them from algae and other microphytes. A macrophyte is a plant that grows in or near water and is either emergent, submergent, or floating. In lakes and rivers macrophytes provide cover for fish, substrate for aquatic invertebrates, produce oxygen, and act as food for some fish and wildlife. Aquatic plants are of two main types in working some of such plants float on water

while other live under water. Those plants which are float or above the water they work as moisture lovers and those plants which are under water they work as oxygenators.

### 1.3.1 HYDRILLA SUBMERGED SPECIES

Hydrilla (waterthyme) is a genus of aquatic plant, usually treated as containing just one species, *Hydrilla verticillata*, though some botanists divide it into several species. It is native to the cool and warm waters of the Old World in Asia, Africa and Australia, with a sparse, scattered distribution; in Australia from Northern Territory, Queensland, and New South Wales.

The stems grow up to 1–2m long. The leaves are arranged in whorls of two to eight around the stem, each leaf 5–20 mm long and 0.7–2 mm broad, with serrations or small spines along the leaf margins; the leaf midrib is often reddish when fresh. It is monoecious (sometimes dioecious), with male and female flowers produced separately on a single plant; the flowers are small, with three sepals and three petals, the petals 3–5 mm long, transparent with red streaks. It reproduces primarily vegetatively by fragmentation and by rhizomes and turions (overwintering), and flowers are rarely seen. They have air spaces to keep them upright.

Hydrilla is a hardy, fast-growing, herbaceous perennial with long, slender stems that can grow to some 7 metres (23 feet) in length. The leaves grow in pairs or in whorls of three to eight and are small, lance-shaped or oblong, and distinctly toothed. It has a high resistance to salinity compared to many other freshwater associated aquatic plants.

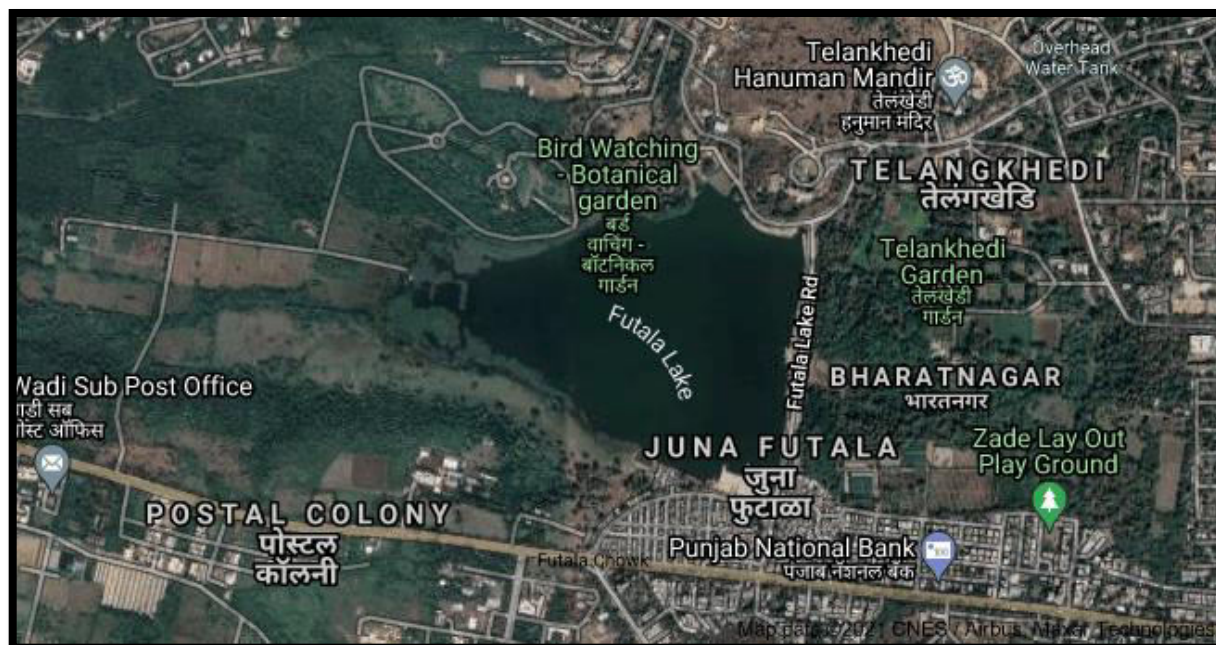


(Figure 1.3: Hydrilla Submerged Aquatic Plants)

### 1.4 SAMPLING LOCATIONS

According to a survey by ABP News-Ipsos, Nagpur has been identified as the best city in India by topping the liveability, greenery, public transport, and health care indices. It is famous for the Nagpur Orange and is known as the “Orange City” for being a major trade center of oranges cultivated in the region. Nagpur city with coordinates of 21°8'55" and 79°4'46"E is second capital of Maharashtra state. Nagpur city is popularly known as orange city, also city of lakes. The city had 10 lakes in the past, but unfortunately only 7 of them are there now. The Futala Lake with a coordinate of 21°8'44"N and 79°03' 48"E is closed water body. The Futala Lake is spread over 60 acres. The Futala Lake is located at the western side of the Nagpur city. The catchment area of dam is 6.475 sq. km. The length of west weir is 8.0m. Futala Lake is having capacity to irrigate an area of 34.42 hectares of cultivated agriculture land and Telenkhedi Garden. The initial purpose for irrigating nearby agricultural land was prominent amongst the utilization of Futala Lake.





(Figure 1.4: Satellite Image of Futala Lake)

### 1.4.1 Problem on hand

The Futala lake water is unpotable and now-a-days used for irrigation purpose and for commercial fisheries. It doesn't have self cleaning capacity; hence continuous addition of nutrients through many polluting sources is leading. The watershed of Futala lake is a part of Nag river watershed. Nag River is completely polluted on account of incoming sewage into it. The Four streams are prominent within catchment. The Futala Lake and its environs near Telankhedi Garden on Amravati road, Nagpur, is a picnic spot. It is rainwater impoundment with an area of 26.3 hectares and 5-6 meters deep during monsoon. Futala Lake, too, is facing the threat of eutrophication with weeds covering almost half the lake area already. The sewage is released into Futala Lake without treatment therefore the Futala lake water is polluted at moderate level. In Futala Lake, eutrophication was first seen in some portion towards west, but, almost half of the lake area is covered by weeds, especially on south and north side. Species inside the water start to diminish due to lack of sunlight, even oxygen level in lake water already drastically dropped. Another worry for the lake was, collapse of large portion of embankment towards the bund embankment, constructed with black stone in some time ago, raising the needs for inspection of remaining portion of the embankment. Futala Lake was chosen in this study, since it is heavily influence by human actions leading to domestic and partially agricultural pollution sources. The basic objective of present study is to treatment of Futala lake water using submerged aquatic plants.

## II. LITERATURE REVIEW

### 2.1 Constructed Wetlands

#### *History of CWs –*

The scientific studies on the use of CWs for wastewater treatment began in the middle of the last century. The first experiments were undertaken by Käthe Seidel in Germany in the early 1950s at the Max Planck Institute in Plön (Seidel, 1955). In her report, she discussed the possibility “of lessening the overfertilization, pollution and silting up of inland waters through appropriate plants, thereby allowing the contaminated waters to support life once more” (Seidel, Happel, & Graue, 1978, p. 2). She opines that macrophytes (e.g., *Schoenoplectus lacustris*) are capable of removing large quantities of organic and inorganic substances from polluted water. Moreover, *Schoenoplectus* spp. (bulrush) not only enriches the soil on which it grows in bacteria and humus but apparently exudes antibiotics. Bacteria and heavy metals in the polluted water are eliminated and removed by passing through the macrophytes.

Seidel's discoveries gave birth to modern CWs and stimulated the following research and applications of engineered treatment wetlands in the Western world. However, most of her studies focused on the subsurface flow (SSF) CW. The

first fullscale CW was built with a FWS system in the Netherlands in 1967 (De Jong, 1976). This treatment facility was designed to clean the wastewater from a camping site with 6000 summer visitors per day.

In North American, the experimentation with FWS wetlands started with the observation of assimilative capacity in natural wetlands at the end of the 1960s and beginning of 1970s (Spangler, Sloey, & Fetter, 1976; Wolverton, 1987). Between 1967 and 1972, researchers in Chapel Hill, North Carolina began a five year study using a combination of constructed coastal ponds and natural salt marshes for the recycling and reuse of municipal wastewater (Odum, Ewel, Mitsch, & Ordway, 1977). In 1973, the first fully CW consisting of a series of constructed marshes, ponds and meadows was built in Brookhaven, New York (Kadlec & Knight, 1996). About the same time, an interdisciplinary research team at the University of Michigan began the Houghton Lake project. This is the first application of a treatment wetland in a cold climate area (Kadlec, Richardson, & Kadlec, 1975; Kadlec & Tilton, 1979). Since then, FWS CWs have been broadly used in the United States for various types of wastewater treatment.

## 2.2 Wetland Hydrology

Hydrology is probably the single most important determinant of the establishment and maintenance of specific types of wetlands and wetland process (Mitsch & Gosselink, 2007, p. 108). Wetland design is affected by the volume of water, its reliability and extremes, and its movement through the site (U.S. EPA, 1999). Wetland hydrology describes the input and output of water in wetland systems. It affects the composition of vegetation and species communities by acting as the main pathway via which energy and nutrients are transported. Water enters wetlands via surface flow, precipitation, and groundwater discharge, while it flows out via surface flow, ground water recharge, and evapotranspiration (ET).

## 2.3 Pollutant removal

Raw sewage consists of a combination of domestic and commercial wastewaters. The pollutant parameters commonly present are BOD, TSS, organic compounds, pathogens, nutrients (especially nitrogen) and heavy metals. CWs are very efficient in reducing the level of these pollutants in municipal wastewater effluents. In FWS wetlands, the removal mechanisms include flocculation, sedimentation, absorption, oxidation and anaerobic reaction. In a properly operating CW system, the concentration of in the effluent should be less than 30mg/L, TSS are less than 25 mg/L, and fecal coliform bacteria concentration is less than 10,000 colony-forming units (cfu)/100 mL (David, James, Christopherson, & Axler, 2002)

**Biochemical Oxygen Demand (BOD5) Removal.** BOD5 is a measure of the mass of oxygen required by aerobic organisms to decompose organic matter in the water. The standard BOD value is commonly expressed in milligrams of oxygen consumed per liter of sample during 5 days of incubation at 20 °C. In FWS wetlands, removal of the soluble BOD5 is due to microbial growth attached to plant roots, stems, and leaf litter that have fallen into the water. Because algae are not present with the complete plant coverage, water surface reaeration provides the major sources of oxygen for these reactions in addition to plant translocation of oxygen from the leaves to the rhizosphere (U.S. EPA, 1980). BOD5 removal often approximates first-order kinetics. Based on the First Order–Reaction Kinetics–Plug Flow Approach, Reed’s method is used to estimate BOD removal efficiency. This method is a research-based design method based on the firstorder plug flow assumption for those pollutants that are removed primarily via biological processes (i.e., BOD, ammonia, and nitrate) (Knight, Ruble, Kadlec, & Reed, 1993).

**TSS Removal.** The “total solid” refers to the suspended or dissolved matter. TSS are solids that can be retained by a filter. The removal of TSS from water to the wetland sediment bed is essential for both the improvement of water quality and the function of the wetland ecosystem. TSS are predominantly removed via flocculation/sedimentation and filtration/interception mechanisms (U.S. EPA, 1999). Suspended solids can also be produced within the wetland. This occurs due to the death of invertebrates, fragmentation of detritus from plants, production of plankton and microbes within the water column or attached to plant surfaces, and formation of chemical precipitates. TSS removal processes are related to filtration and retention times. The slow flowing water allows the physical separation of TSS.

**Nitrogen Removal.** Nitrogen is a serious concern in wastewater because of its role in eutrophication and toxicity to aquatic. Numerous biological and physiochemical processes in wetlands are particularly important in the transformations of nitrogen into varying biologically useful forms. Additionally, plants that require nitrogen for their growth play an active role in removing it from the wastewater. Nitrogen removal occurs through nitrification, denitrification, ammonification, volatilization and plant uptake. The removal rate in a wetland is 61% through denitrification and 14% through plant biomass, and the remainder is stored in the soil (Matheson, Nguyen, Cooper,

**Burt, & Bull, 2002).** Hence, the nitrification and denitrification processes occurring within the wetland are the major mechanisms for nitrogen removal (**Vymazal, Brix, Cooper, Green, & Haberl, 1998**). Vegetated zones are anaerobic, because oxygen released by hydrophytic plants is trivial compared to the oxygen demands. Therefore, nitrification unlikely to happen in VSB wetlands and highly dense vegetated zones of FWS wetlands, but can be accomplished in open-water zones. To increase the efficiency of nitrification and denitrification, a well aerated condition must be followed by the vegetated zones.

**Total Phosphorus Removal.** Phosphorus is one of the important nutrients that cause eutrophication in the lakes. Plants uptake phosphorus during the growing season, but the phosphorus is released back into the water during decomposition when plants die. Phosphorus can also be released in varying proportions at different times throughout the year and is cycled throughout the wetland. The predominant form is orthophosphate which can be used by algae and macrophytes. Inorganic phosphorus can also be found as polyphosphates. Municipal wastewaters may contain from 5 to 20 mg/L of total phosphorous, of which 1 to 5 mg/L is organic and the rest is inorganic. The per capita phosphorous contribution per inhabitant per day averages about 0.0048 lb/person/day (Kentucky Department of Environmental Protection, 2012). The removal of phosphorus in wetlands is achieved through physical, chemical, and biological processes (**Debusk, 1999**). The physical process includes sedimentation and entrapment within the emergent macrophyte stems and attachment to plant biofilms. Chemical methods are soil absorption and desorption. This involves soluble inorganic phosphorus moving from the pores in the soil media to the soil surface. The biological mechanism involves uptake of phosphates by microorganisms, including bacteria, fungi, and algae. The biological process is rapid but does not allow for much storage. In FWS wetlands the uptake from free floating macrophytes is more important but these plants must be harvested and replaced to maximize phosphorus removal. Typical phosphorus removal is in the 40% to 60% range (**Vymazal, 2006**).

### III. PROPOSED METHODOLOGY

#### 3.1 Experimental technique

Constructed wetlands (CW's) are efficient wastewater treatment systems consisting of shallow (usually less than 1 m deep) ponds or channels which have been planted with aquatic plants, and which rely upon natural microbial, biological, physical and chemical processes to treat wastewater (EPA, 2000; Vymazal, 2007). Wastewater treatment using through engineered wetlands (constructed wetlands: CW) has emerged as a sustainable, environmentally friendly solution in many countries across the world (Kadlec and Wallace, 2009), due to the ability of CW's to recycle, transfer and/or immobilize a wide range of potential contaminants (Greenway and Wolley, 1999). Indeed, besides domestic and municipal application, the use of constructed wetlands has wide applications including treatment of industrial effluent, special wastewater (e.g. from hospitals, acid mine drainage), agricultural effluent, landfill leachate, road runoff and sludge consolidation (Vymazal, 1998). Compared to high-cost conventional mechanical treatment systems, constructed wetland technology is economical, easy operation and maintenance. Moreover, minimal fossil-fuel is required; and without any chemical energy (Kadlec and Knight, 1996). The use of low cost option for water purification is particularly valuable and exploitable for the protection of water quality in aquatic ecosystem catchments in developing countries (Denny, 1997).

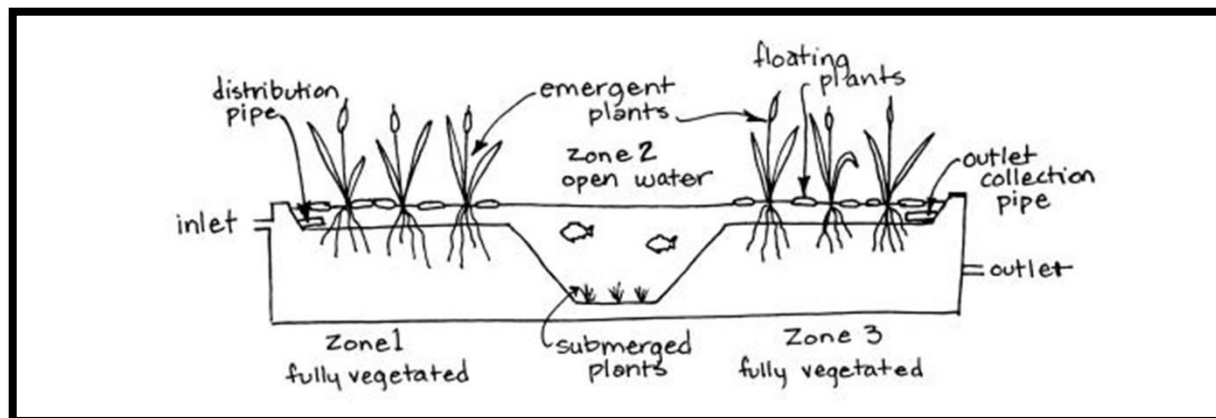
#### Planting techniques:

- Plants can be introduced to a wetland by transplanting roots, rhizomes, tubers, seedling or mature plants;
- by importing substrate and seed bank from nearby wetlands or;
- by relying completely on seed bank of the original site;
- choosing plants from wild stock is more desirable than nurseries as they are better adapted to environmental conditions in constructed wetlands;
- plants collected from nearby area must be planted within 36 hrs. If nursery plants are used, they should be from similar climatic conditions & should be shipped rapidly to minimize losses;
- if seed are used, they should be evaluated for the species present and their viability.

Experimental aquatic plant (*Hydrilla verticillata* Casp.) is a submerged aquatic plant, native of Africa, Australia and parts of Asia, which can quickly overcome other plant species because of the ability to grow with less light and more efficiently take-up nutrients from aquatic system.



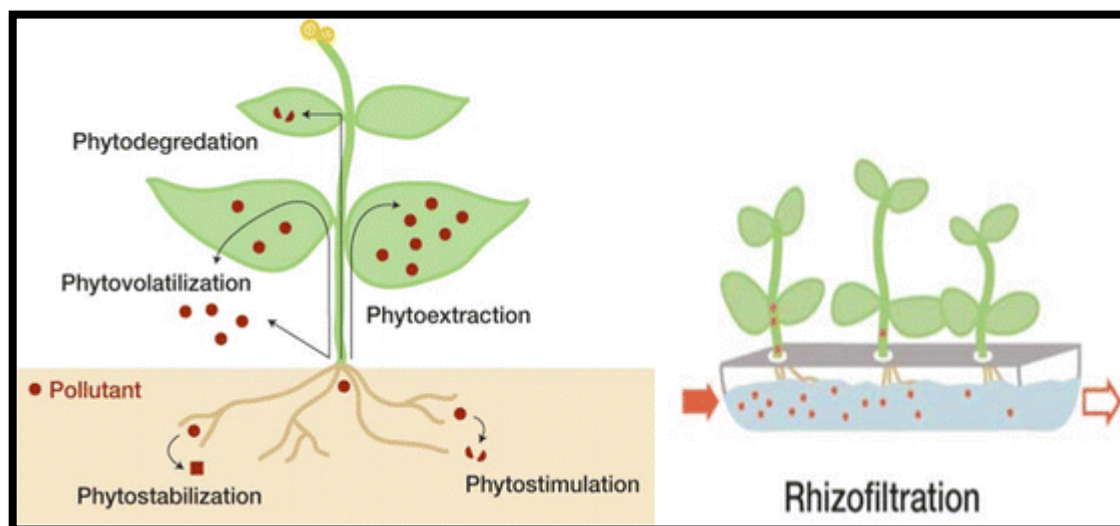
Remediation of nutrients from lake water (wastewater) was studied by using a *Hydrilla verticillata* Casp. A fixed amount of 100gms of this aquatic plant was cultured in a plastic tub of 0.173 m diameter, six inches deep and 20 Liter capacities containing domestic wastewater, for a week interval.



(Figure 3.1: Constructed Wetland Process)

### 3.1.1 Rhizofiltration Technique

A rhizofiltration system planted with *Hydrilla* was constructed with the sample of Futala lake Nagpur, Maharashtra, and evaluated for its efficiency in removing physical, chemical parameters and enteric pathogens from wastewater. The utilisation of wetlands for remediation of polluted soils and waters via rhizofiltration, phytostabilisation and phytoextraction has been increasing steadily over the past decades. The use of wetlands for quality improvement of wastewater, referred to as rhizofiltration, is the best known and most researched application of constructed wetlands. Rhizofiltration is the process of absorption of contaminants present in the rhizosphere into the root system of plants. This remediation process is used to decontaminate aquatic ecosystems using aquatic or land plants. During the utilization of this process, plants are grown on the contaminated site (in situ) or in an ex situ environment. Contaminants are absorbed through plant roots until saturation is reached, and finally, the plants are harvested with their roots. As the accumulation of contaminants occurs in the roots without any translocation to the shoots, there is an extremely low chance of atmospheric contamination.



(Figure 3.2: Rhizofiltration Technique)

## IV. RESULTS AND DISCUSSION

## 4.1 Physico-chemical examination of Futala Lake Water

Macrophytes / aquatic plants grow normally in water bodies polluted by nutrients of varied sources and utilized the nutrients to produce large amount of biomass. The results of physico-chemical analysis of lake water before & after the remediation by using a submerged aquatic plant *Hydrillaverticillata* Casp. Physical parameter Temperature plays an important role in change of various chemical parameters and physiological process of aquatic plant. pH Value was recorded around 7.0 before culture but after the culture (ending of the experiment) little increase was noticed due to reaction of aquatic plant in water. Turbidity and Salinity values were decreased after the culture during the entire study period.

A minor variation was observed in chloride contents due to its non-utilization by the aquatic plant. In domestic wastewater Dissolved oxygen and Percentage oxygen saturation values were increased significantly, after the experiment, as *Hydrillaverticillata* Casp played a vital role in oxygen transfer in to water system. Nitrogen contents were examined as Ammonical, Nitrite and Nitrate form. As Nitrate nitrogen is the stable product of oxidation.

## 4.2 Percentage changes in physico-chemical parameters

## Physical changes:

Temperature minimized 9.89 percentage and pH shifted above of 6.58 %. Reduction in Turbidity, Salinity noticed 37.00 and 17.42 %. Due to ionic absorbing tendency of *Hydrillaverticillata* Casp in experiment, Electrical conductivity and Total dissolved solids were deducted in 15.66 and 15.80 % relatively.

## Chemical changes:

34.50 % Reduction was found for Total alkalinity. Remarkable utility of Carbon dioxide in photosynthetic activity Total and Free carbon dioxide reduced in 51.56 and 36.91 %. Because of significant release of oxygen in water by *Hydrillaverticillata* Casp Dissolved oxygen values increased to 140.1 % and Oxygen saturation 113.0 %. Little change in Chloride (4.38%) was found. Chemical oxygen demand decline average of 36.14 %. Total hardness, Calcium hardness, Calcium, Magnesium values were reduced by percentage of 28.71, 24.96, 24.39 and 37.16 individually. More than 39.00 % reduction rate was noticed for Nitrogenous and Phosphorous compounds like Ammonical – N (39.45 %), Nitrite – N ( 47.59 %), Nitrate – N ( 50.35 %) and Total ortho phosphate (52.58% ), Acid hydrolysable phosphate (42.85 %) and 44.69 % for Total phosphate. Organic phosphate reduction value in percentage was 36.41 after the experimentation in lake water with *Hydrillaverticillata* Casp.

Table 4.1: Physico-chemical characteristics of Lake water before & after the culture of "*Hydrillaverticillata*"

S.No.	Parameters	Unit	Initial Value	Final Value
1.	Temperature	Celcius	24.8	22.9
2.	pH	.	6.98	7.63
3.	Turbidity	NTU	18.1	10.1
4.	Salinity	‰ (permil).	0.553	0.469
5.	Electrical Conductivity	Mmhos	835.10	720.30
6.	Total Oxygen Demand	Ppm	538.10	468.90
7.	Total Alkalinity	mgCaCo/L	260	155
8.	Chloride	mg/L	108.45	103.10
9.	Dissolved Oxygen	mg/L	2.6	7.5
10.	Oxygen Saturation	%	33.3	82
11.	Chemical Oxygen Demand	mg/L	144	100.8
12.	Total Hardness	mg/L	335.62	256.08
13.	Calcium Hardness	mg/L	184.14	140.58
14.	Calcium	mg/L	73.80	56.34
15.	Magnesium	mg/L	36.46	27.68
16.	Ammonical -N	mg/L	12.89	6.74
17.	Nitrite-N	mg/L	0.362	0.242
18.	Nitrate-N	mg/L	57.04	29.11
19.	Total Phosphate	mg/L	1.657	1.154
20.	Organic Phosphate	Mg/L	0.795	0.593

## V. CONCLUSION

It is noted that CWs are now being increasingly used for environmental pollution control. Constructed wetlands were implemented in a wide range of applications, such as water quality improvement of polluted surface water bodies, wastewater on-site treatment and reuse in rural areas, campuses, recreational areas and green architectures, management of aquaculture water and wastewater, tertiary treatment, and miscellaneous applications.

Water monitoring results obtained from several demonstrations show that CWs could achieve acceptable wastewater treatment performances in removing major pollutants, including suspended solids, organic matters, nutrients, and indicating microorganisms, from wastewater influent. The results indicate that if constructed wetlands are appropriately designed and operated, they could be used for secondary and tertiary wastewater treatment under local conditions, successfully. Hence constructed wetlands can be used in the treatment train to upgrade the existing malfunctioning wastewater treatment plants, especially in developing countries. During hydraulic retention study, it was found that the BOD, COD was best removed in planted wetland than unplanted wetland. It is because of the oxygen diffusion from roots of the plants and the nutrient uptake and insulation of the bed surface. It is also found that the increases in the detention period of the wastewater the removal rate also increases.

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