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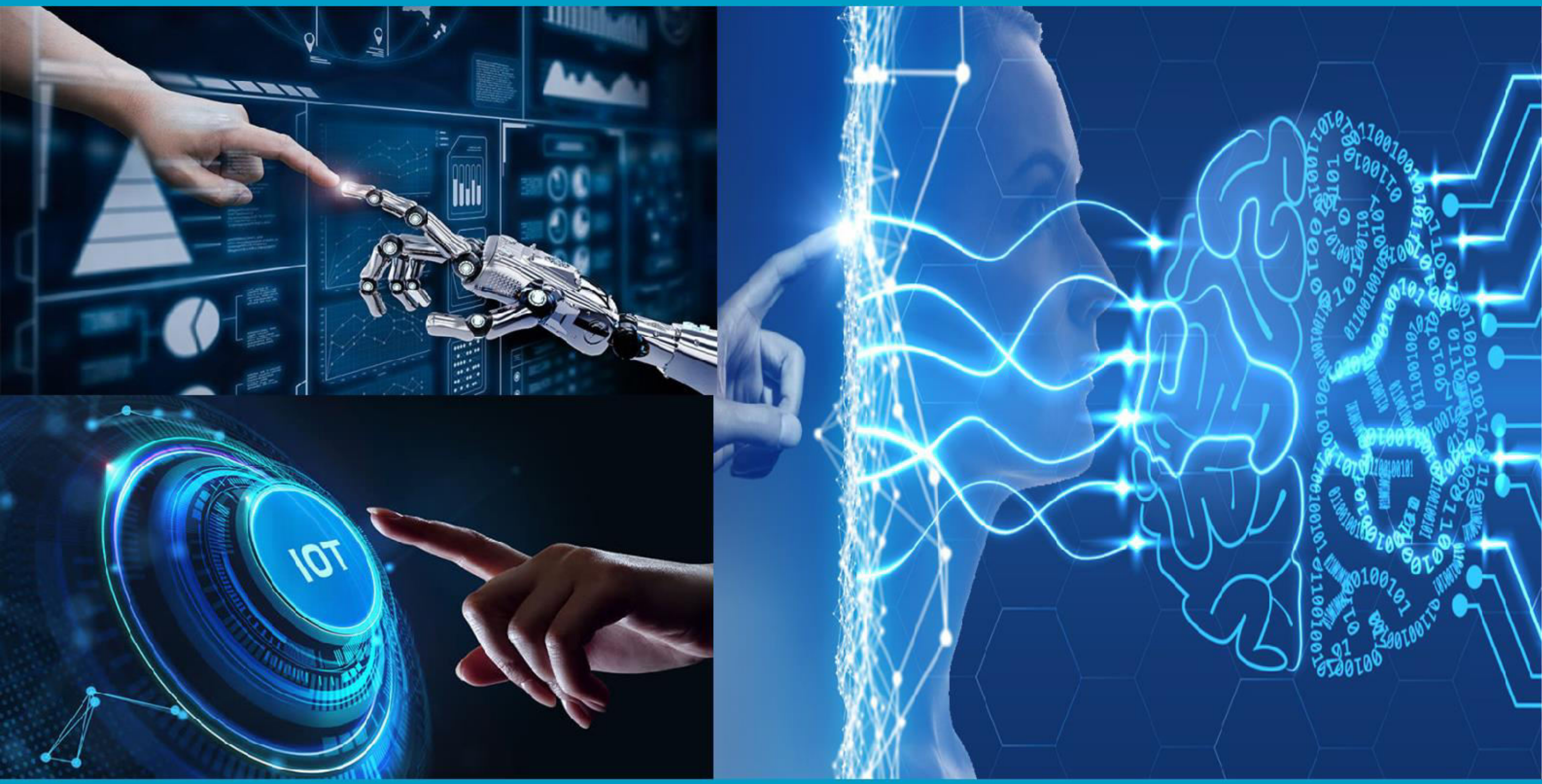

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A Review on Application and Characteristics of Aquatic Plants in Wastewater Treatment

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ABSTRACT- Increasing urbanization, industrialization and over population are the factors mainly responsible for adding hazardous components in lake water, which mainly constitutes heavy metals and chemicals etc. Water bodies are the main targets for disposing the pollutants directly or indirectly. In this review paper illustrating the role of plants to assist the treatment of wastewater. The prevailing purification technologies used to remove the contaminants are too costly and sometimes non-ecofriendly also. Therefore, the research is oriented towards low cost and eco-friendly technology for waste water purification, which will be beneficial for community. The review paper discusses the potential of different process and utilization of terrestrial and submerged aquatic plants (Hydrilla) in purifying water and wastewater from different sources. Present study was conducted by off-site experiment, where Hydrilla verticillata Casp was cultured in a tub for subsequent seven days over one year. Second one of the tub was used as control. The quality of domestic wastewater was assessed before and after the experiment by analyzing physicochemical parameters. The results of the present experiment revealed the significant improvement in the quality of municipal wastewater, as indicated by the decrease in values of most physicochemical parameters studied. That showed efficiency and potentiality of aquatic plant for the purpose.

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

I. INTRODUCTION

1. GENERAL INTRODUCTION

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. 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.

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.”

The review paper described include systems involving both constructed and natural wetlands, habitat creation and restoration, and the improvement of municipal effluent, urban storm water and river water quality. Aquatic plant system has been accounted as one of the processes for wastewater recovery and recycling. The main purposes of using this system have focused on waste stabilization and nutrient removal. The principal removal mechanisms are physical sedimentation and bacterial metabolic activity as in the conventional activated sludge and trickling filter (USEPA, 1991). Plant assimilation of nutrients and its subsequent harvesting are another mechanism for pollutant removal. Low cost and easy maintenance make the aquatic plant system attractive to use. Thus, constructed ponds with submerged aquatic plants are increasingly applied as a viable treatment for municipal wastewater. However, there are some constraints with using submerged aquatic plants such as the requirement for large area of land, the reliability for pathogen destruction, and the types and end-uses of aquatic plants. In this review 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.

1.2 CONSTRUCTED WETLANDS

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.

1.2.1 ADVANTAGES OF CONSTRUCTED WETLANDS

1. Wetlands can be less expensive to build than other treatment options
2. Utilization of natural processes,
3. Simple construction (can be constructed with local materials),
4. Simple operation and maintenance,
5. cost effectiveness (low construction and operation costs),
6. Process stability.
7. Low energy demand.
8. Low environmental impact

1.2.2 LIMITATIONS OF CONSTRUCTED WETLANDS

1. Large area requirement
2. Wetland treatment may be economical relative to other options only where land is available and affordable.
3. Design criteria have yet to be developed for different types of wastewater and climates.

1.2.3 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.

(Figure1.1: Natural Wetlands)

(Figure1.2: Constructed Wetlands)

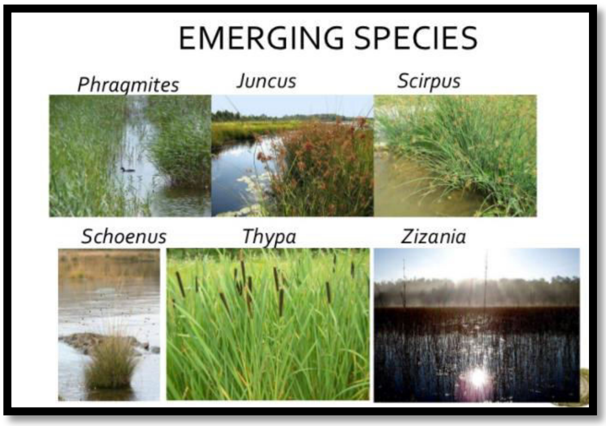
1.3 AQUATIC PLANTS

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 TYPES OF AQUATIC PLANTS

1. EMERGENT PLANTS:

The plants which have their roots fixed in soil And the leaves and stem of these plants are come out of surface of water. Juncus, Scirpus, Thypa, Phraqmites, Moss, Bulrush , Sedge , Arrowhead ,etc are the examples of Emergent plants.



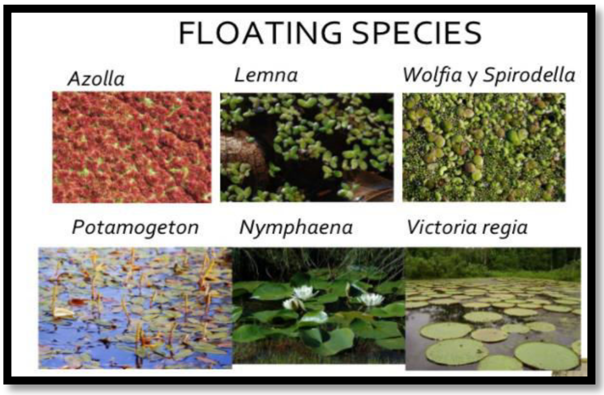
(Figure1.3: Emerging Species)

2. FIXED AQUATIC PLANTS:

Such types of plants attached to pond bed, They have stems with holes and their leaves are broad.
Lotus , Water lilies, etc are the examples of fixed aquatic plants.

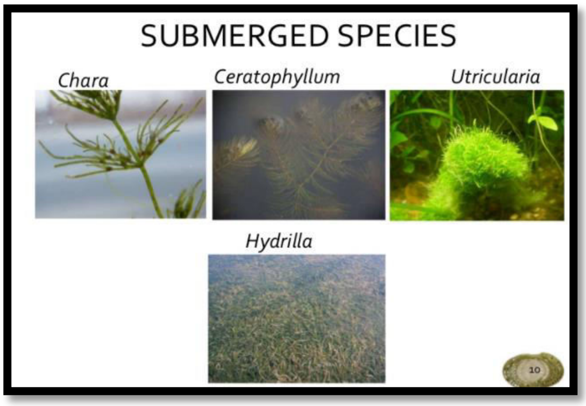
(Figure1.4: Fixed Aquatic Species)

3. FLOATING AQUATIC PLANTS:
They ae found floating freely on water, they are not attached to any surface. They have air filled cavities in their leaves and stem, these cavities makes them light and help them to easily float on water. Azolla, Lemna, Potamogeton, Nymphaena, Water lettuce, Water hyacinth, Duckweed, etc are the examples of floating aquatic plants.



(Figure1.5: Floating Species)

4. SUBMERGED AQUATIC PLANTS:
They are present in under water, roots are fixed in the soil. They require the water for physical support of the plants structure. It so gives beautiful view under water. Hydrilla, Pond Weed, Demersum, tape grass, etc are the examples of submerged aquatic plants.



(Figure1.6: Submerged Species)

1.3.1.1 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.

(Figure1.7: Hydrilla Submerged Aquatic Plants)

1.4 SCOPE & OBJECTIVE

- To evaluate the effectiveness and potential of Hydrilla verticillata Casp (a submerged aquatic plant of family hydrocharitaceae), in removing nutrients from domestic wastewater.
- To examine the Hydrilla plant ability to remove the physical, chemical wastewater parameters from lake water.
- To study different case studies related to constructed wetlands helps to understand the importance of aquatic plants.

II. LITERATURE REVIEW

2.1 Wastewater

"Wastewater" Definition

The term "wastewater" refers any water that has been used or polluted, and contains waste products. Wastewater is approximately 99% water; only 1% is a mixture of suspended and dissolved organic solids, detergent, and cleaning chemicals. "Sewage" is one kind of wastewater. It includes household waste liquid from toilets, baths, showers, kitchens, sinks and so forth that is disposed of via sewers. Sewage treatment, or municipal wastewater treatment, is the process of removing contaminants from wastewater and household sewage. It includes physical, chemical, and biological processes to remove organic, inorganic and biological contaminants. The typical composition of municipal wastewater (after pretreatment) most often treated in CWs contains suspended solids, organic matter, and in some instances, nutrients (especially total nitrogen) and heavy metals, as shown in Table 2 **(Tchobanoglous & Burton, 1991**). Domestic sewage wastewater typically contains 200 mg of suspended solids, 200 mg biochemical oxygen demands, 35 mg nitrogen, and 7 mg phosphorus per liter **(Volodymyr, Sirajuddin, & Viktor, 2007).**

Table 2.1 : Contaminations Concentration in the Typical Untreated Domestic Wastewater

Parameter	Unit	Weak (Concentration)	Medium (Concentration)	Strong (Concentration)
TS	Mg/L	350	720	1200

TDS	Mg/L	250	500	850
TSS	Mg/L	100	220	350
BOD	Mg/L	110	220	400
COD	Mg/L	250	500	1000
TN	Mg/L	20	40	85
TP	Mg/L	4	8	15
Total Coliform	No/100mL	10^6-10^7	10^7 ~ 10^8	10^7 ~ 10^9

2.2 Wastewater Reuse and Reclamation

During the last century, the increasing demands for freshwater coupled with environmental concerns about the discharge of wastewater into ecosystems and the high cost and technology requirements of wastewater treatment have spurred processes in water reclamation and reuse. Early development stems from the land application for the disposal of wastewater, following the admonition of Sir Edwin Chadwick—"the rain to the river and the sewage to the soil" **(National Research Council of the National Academies, 1996, p. 17).** Such land disposal schemes were widely adopted by large cities in Europe and the United States in the 1900s. With the development of sewerage systems, domestic wastewater was firstly considered to be reused by farms. California was the pioneer in wastewater reuse and has the most comprehensive regulations pertaining to the public health aspects of reuse. By 1910, 35 California communities were using sewer water for irrigation (Recycled Water Task Force, 2003). In 1918, the California State Board of Public Health promulgated the initial Regulation Governing Use of Sewage for Irrigation Purpose, pertaining to irrigation of crops with sewage effluents. In 1929, the city of Pomona, California, initiated a project using reclaimed wastewater for the domestic irrigation of lawns and gardens **(Ongerth & Harmon, 1959)**. In 1965, the Santee, California recreational lakes, supplied with reused wastewater, were opened for swimming. Today, as more advanced technologies are applied for water reclamation, the quality of reclaimed water can exceed conventional drinking water quality based on most conventional parameters. Water reclamation or water purification processes could technically provide water of almost any quality desired **(Asano, 1998).**

2.3 Conventional Wastewater Treatment

The conventional wastewater treatment process consists of a series of physical, chemical and biological processes. Typically, treatment involves three stages, called primary, secondary and tertiary treatment.

2.3.1 ***Primary treatment*** is used to separate and remove the inorganic materials and suspended solids that would clog or damage the pipes. Primary treatment consists of screening, grit removal, and primary sedimentation. Screening and grit removal may also be called "preliminary treatment." Large debris, such as plastics, rags, branches, and cans are removed by the screens, while smaller coarse solids, such as sand and gravel, are settled by a grit chamber system. Then wastewater is moved into a quiescent basin, with a temporarily retention; the heavy solids settle to the bottom while the lighter solids, grease and oil float to the surface. The settled and floating pollutants are removed by sedimentation and skimming, with the remaining liquid then discharged to undergo secondary treatment. Typically, about 50% of total suspended solids (TSS) and 30% to 40% of BOD are removed in the primary treatment stage **(Nelson, Bishay, Van Roodselaar, Ikonomou, & Law, 2007).**

2.3.2 Secondary treatment removes dissolved and suspended biological matter. Typically, up to 90% of the organic matter in the wastewater can be removed through secondary treatment by a biological treatment process **(U.S. EPA, 2004b).** The two most common conventional methods used to achieve secondary treatment are attached growth processes and suspended growth processes. In attached growth (or fixed-film) processes, the bacteria, algae and microorganisms grow on a surface and form a biomass. Attached growth process units include trickling filters, biotowers, and rotating biological contactors. In suspended growth processes, the microbial growth is suspended in an aerated water mixture. The most common of this type of process is called "activated sludge." This process grows a biomass of aerobic bacteria and other microorganisms that will breakdown the organic waste.

2.3.3 Tertiary treatment is sometimes defined as advanced treatment; it produces a higher-quality effluent than do primary and secondary treatment in order to allow discharge into a highly sensitive or fragile ecosystem (estuaries, low-flow rivers, coral reefs, and others). The purpose of tertiary treatment is to provide a final treatment stage to raise the effluent quality to the desired level. This advanced treatment can be accomplished by a variety of methods such as coagulation sedimentation, filtration, reverse osmosis, and extending secondary biological treatment to further stabilize oxygen-demanding substances or remove nutrients. As wastewater is purified to higher and higher degrees through such advanced treatment processes, the treated effluent can then be safely and appropriately reused. Before the treated wastewater is discharged, ***a disinfection process*** is sometimes required. Water systems add disinfectants to kill pathogenic microorganisms. The purpose of disinfection in the treatment of wastewater is to substantially reduce the number of microorganisms in the water to be discharged back into the environment, and it is almost always the final step in the treatment process regardless of the level or type of treatment used. Common methods of disinfection include chlorine, and ultraviolet light. The treated water can be discharged into a stream, river, lagoon, or wetlands, or it can be used for landscape irrigation. If it is sufficiently clean, it can also be used for groundwater recharge or agricultural purposes.

2.4 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.

ATIF MUSTAFA(2013) conducted treatment performance of a pilot-scale constructed wetland (CW) commissioned in in Karachi, NED University of Engineering & Technology, was evaluated for removal efficiency of biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), ammonia-nitrogen (NH_4-N), ortho-phosphate (PO_4-P), total coliforms (TC) and faecal coliforms (FC) from pretreated domestic wastewater. Monitoring of wetland influent and effluent was carried out for a period of 8 months. NED wastewater treatment plant (WWTP) treats wastewater from campus and staff colony. The wastewater contains domestic sewage and low flows from laboratories of various university departments. The constructed wetland is planted with common wetland plant (*Phragmites karka*). The key features of this CW are horizontal surface flow. Treatment effectiveness was evaluated which indicated good mean removal efficiencies; BOD (50%), COD (44%), TSS (78%), NH4-N (49%), PO4-P (52%), TC (93%) and FC (98%).

YADAV and **JADHAV (2011)** construct wetland unit combined with surface flow and planted with *Eichhornia crassipes* was built near Technology Department, Shivaji University, Kolhapur (Latitude 160 40' N, Longitude 740 15' S). Maharashtra situated in Western part of India. The campus wastewater was let into the constructed wetland intermittently over 30 days.The study was performed in two sets A and B which were run in the months of December and January respectively. The parameters analysed for the study were pH, Dissolved Oxygen, Biochemical Oxygen Demand, Chemical Oxygen Demand, Total Suspended Solids, Total Dissolved Solids, Nitrogen and Phosphorus. Only quality of wastewater was analysed during the study period of 2 months i.e. December and January. The sampling took place daily at both inlet and outlet of constructed wetland system. Treatment effectiveness was evaluated which indicated good mean removal efficiencies; BOD (95%), COD (97%), TSS (82%), NH4-N (43%), PO4-P (49%).

2.5 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).

2.6 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. PROBLEMS STATEMENT

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 hectors 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.

IV. PROPOSED METHODOLOGY

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 21º8'55" and 79º4'46"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 21º8`44``N and 79º03` 48``E is closed water body. The Fulata 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 hectors of cultivated agriculture land and Telenkhedi Garden. The initial purpose for irrigating nearby agricultural land was prominent amongst the utilization of Futala lake.

(Figure4.1: Satellite Image of Futala Lake)

4.2 U.S. EPA Guidelines

There are no federal regulations governing reclaimed water use, but the U.S. EPA (2004b) has established guidelines to encourage states to develop their own regulations. The primary purpose of federal guidelines and state regulations is to protect human health and water quality. To reduce disease risks to acceptable levels, reclaimed water must meet certain disinfection standards by either reducing the concentrations of constituents that may affect public health and/or limiting human contact with reclaimed water.

Based on the U.S. EPA inventory, current regulations can be divided into the following reuse categories: unrestricted urban reuse (irrigation of areas with unrestricted public access), restricted urban reuse (irrigation of areas with controllable access), agricultural reuse on food crops, agricultural reuse on non-food crops, unrestricted recreational reuse, restricted recreational reuse, environmental reuse (wetland or sustain stream flows), industrial reuse, groundwater recharge, and indirect potable reuse. Based on the study objectives, the regulations on "unrestricted urban reuse" and "agricultural reuse on food crops" should be considered in this research. Table 1 lists the U.S. EPA guidelines for urban reuse and agricultural reuse water quality.

Table 4.1 U.S. EPA Guidelines for Water Reuse

Reuse types	Treatment	Reclaimed water quality	Setback distance	Monitoring
Urban reuse (landscape irrigation, vehicle washing, fire protection, commercial air conditioners, etc.)	Secondary Filtration Disinfection	pH=6-9, BOD≤10mg/L, ≤2 NTU, No detectable fecal coli/100mL, 1 mg/L CL2 residual(minimum)	50 feet to potable water wells	pH: weekly, BOD: weekly, Turbidity: continuous, Coliform: daily, Cl2 residualcontinuous
Agricultural reuse on food crop	Secondary Disinfection	pH=6-9, BOD ≤30mg/L, TSS ≤30mg/L, < 200 fecal coli/100ml, 1mg/L CL2 residual(minimum)	300 feet to potable water wells 100 feet to areas accessible to the public (if spray irrigation)	pH: weekly, BOD: weekly, TSS: daily, Coliform: daily, Cl2 residualcontinuous
Agricultural reuse nonfood crop	Secondary Filtration Disinfection	pH=6-9, BOD≤10mg/L, ≤2 NTU, No detectable fecal coli/100mL, 1 mg/L CL2 residual(minimum)	50 ft (15 m) to potable water wells	pH: weekly, BOD: weekly, Turbidity: continuous, Coliform: daily, Cl2 residualcontinuous

4.3 MATERIALS AND METHODS

4.3.1 Materials

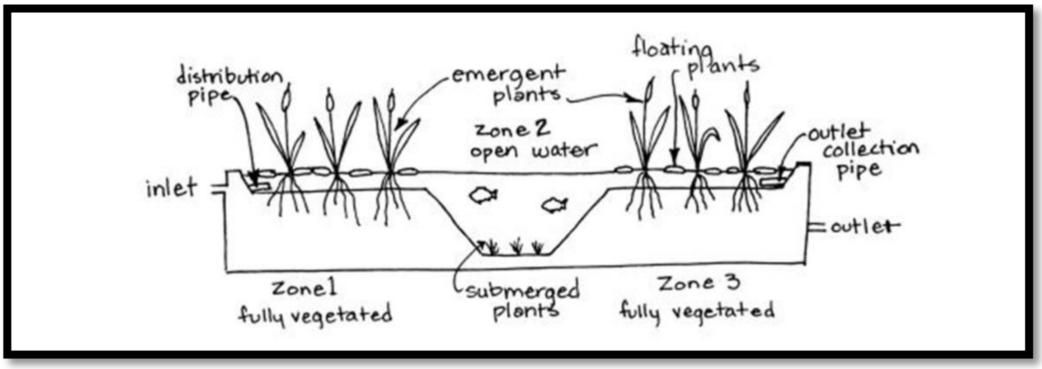
1. Submerged Aquatic Plants (Hydrilla)
2. Wastewater Sample
3. Tube
4. PVC Pipe
5. Valve

(Figure4.2: Collection of Submerged Aquatic plants)

(Figure4.3: Wastewater Sample and Hydrilla plants)

4.3.2 Experimental technique

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.



(Figure4.4: Constructed Wetland Process)

4.3.3 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.

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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