APPLICATION OF PLANTS IN WETLAND ECOLOGICAL ENGINEERING

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Abstract :

Wetland ecological engineering integrates natural processes with engineered systems to restore, construct, and manage wetlands for environmental sustainability. Plants play a central role in wetland ecological engineering due to their multifunctional capacity in water purification, habitat provision, soil stabilization, and nutrient cycling. This paper examines the application of wetland vegetation in engineered systems, including constructed wetlands, riparian buffer zones, and phytoremediation frameworks. Key plant species such as Typha latifolia, Phragmites australis, Scirpus validus are analyzed for their functional traits, pollutant removal efficiency, and adaptability to varying hydrological conditions. The mechanisms through which wetland plants enhance ecological performance—such as rhizofiltration, microbial symbiosis, heavy metal sequestration, and oxygen transport to the rhizosphere—are discussed. Additionally, the paper evaluates design considerations including species selection, biodiversity integration, hydraulic retention time, and climate resilience. Wetland plants thus serve as foundational biological components in sustainable ecological engineering solutions for wastewater treatment, flood mitigation, and ecosystem restoration.

Keywords : Wetland ecological engineering; Constructed wetlands; Phytoremediation; Aquatic macrophytes; Nutrient removal; Rhizofiltration; Pollutant sequestration; Wastewater treatment; Biodiversity conservation; Sustainable ecosystem design.

Introduction :

Wetland ecosystems, including constructed wetlands for wastewater treatment, are vegetated by wetland plants. Constructed wetlands (CWs) are engineered systems that have been designed and constructed to utilize the natural processes involving wetland vegetation, soils, and the associated microbial assemblages to assist in treating wastewater. The ability of wetlands to transform and store organic matter and nutrients has resulted in the widespread use of wetlands for wastewater treatment worldwide. Wetland plants are an important component of wetlands, and the plants have several roles in relation to the wastewater treatment processes. The present paper attempts to provide an overview and summarise the role of wetland plants in constructed wetlands. The greatest challenge in the water and sanitation sector over the next two decades would be the implementation of low-cost wastewater treatment that would at the same time permit the selective reuse of treated effluents for agricultural and industrial purposes. The construction cost for conventional wastewater treatment plants has been a major barrier to the implementation of conventional technologies by local authorities in many African countries. The paper is largely based on all ready published papers (Brix, 1993; Tornbjerg et al., 1994; Brix, 1994; Brix, 1997; Vymazal et al., 1998).

Types of wastewater :

Sources of wastewater include the Chemical industry, dairy, textile industries, fish farms, paper and pulp, homes, shops, offices and factories, farms, transport and fuel depots, vessels, quarries, and mines. Water used in toilets, showers, baths, kitchen sinks, and laundries in homes and offices is domestic wastewater.

Types of Wetland :

Based on the types, wetlands are classified as marsh, swamps, bogs, fens, estuaries, lakes and ponds, river floodplains and oxbow lakes:

Marsh :

The marsh type of wetland is flooded with water and has vegetation from saturated soil conditions. They are found both in inland and coastal ecosystems. Marshes are also found underground and beneath the surface.

Swamp :

Woody plants are the main characteristic of swamps. Swamps are classified as forest and shrub swaps. They are present in freshwater and saltwater.

Fen :

They are high-nutrient wetlands that are formed from precipitation. The main source is rainfall i.e. precipitations.

Lakes and Ponds :

Lakes and ponds are a diverse group of inland freshwater ecosystems found all over the world. They provide vital supplies and habitats for both terrestrial and aquatic creatures.

Plants in wetlands :

The larger aquatic plants growing in wetlands are usually called macrophytes. The term includes aquatic vascular plants (angiosperms and ferns), aquatic mosses, and some larger algae that have easily visible tissues. Wetland plants are at the base of the food chain and, as such, are a major conduit for energy flow in the system. The primary productivity of wetland plant communities varies, but some herbaceous wetlands have extremely high levels of productivity, rivaling those of rainforests. Ferns like *Salvinia* and *Azolla* and large algae like *Cladophora* are widespread in wetlands, and the flowering plants (i.e., angiosperms) dominate. Macrophytes, like all other photoautotrophic organisms, use solar energy to assimilate inorganic carbon from the atmosphere to produce organic matter, which subsequently provides the energy source for heterotrophs (animals, bacteria, and fungi Wetland plants are at the base of the food chain and, as such, are a major conduit for energy flow in the system. The primary productivity of wetland plant communities varies, but some herbaceous wetlands have extremely high levels of productivity, rivaling those of rainforests. Wetland plants provide critical habitat for other taxonomic groups, such as bacteria, epiphyton (algae that grow on the surface of plants), macroinvertebrates, fish, and birds. The composition of the plant community influences the overall diversity of the wetland community.

Conclusion :

The application of plants in wetland ecological engineering proves crucial for sustainable water management, biodiversity conservation, and pollutant removal. These plants play a key role in stabilizing wetland ecosystems, enhancing water quality, and providing water habitat for various species. Their utilization in engineered wetlands showcases a promising approach to addressing environmental challenges and promoting ecological balance. The Constructed Wetland with hydrophytes (water hyacinth plant) is capable of removing pollutants and the hydrophytes have shown their ability to survive in high concentrations of nutrients with significant nutrient removal. It has reliable nutrient stripping value for the removal of the trace elements tested for in the study. The use of a water hyacinth plant aquatic system can help reduce eutrophication effects in receiving streams and also improve water quality. All types of constructed wetlands are very effective in removing organics and suspended solids, whereas the removal of nitrogen is lower but could be enhanced by using a combination of various types. Constructed wetlands require very low or zero energy input and, therefore, the operation and maintenance costs are much lower compared to conventional treatment systems.

Acknowledgment :

Acknowledging the provital role of plants in wetland ecological engineering, we express gratitude to nature for providing these green allies. Their contribution to water purification, habitat creation, and ecosystem resilience is invaluable. Special thanks to researchers and environmentalists for advising the understanding and implementation of plant-based solutions in wetland restoration, fostering a harmonious coexistence between human activities and the delicate wetland ecosystems.

References :

- Hans Brix *Department of Plant Ecology, Institute of Biological Sciences, University of Aarhus, Nordlandsvej 68, 8240 Risskov, Denmark*
- David O. Olukanni and Kola O. Kokumo *Department of Civil Engineering, Covenant University, P.M.B. 1023, Ota, Ogun State, Nigeria*

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- P. S. Navaraj, Anaerobic Waste Stabilization Ponds: A Low-cost Contribution to a Sustainable Wastewater Reuse Cycle. 2005 navaraj678@sify.com
- A. Yasar, Rehabilitation by constructed wetlands of available wastewater treatment plant in Salkhnin, Ecological Engineering. 29, 2007, 27-32.
- M. A. Maine, Nutrient and metal removal in constructed wetland for wastewater treatment from metallurgical industry. Ecological Engineering, 26 (4), 2006, 341-347.
- Kadlec, R.H.; Wallace, S.D. *Treatment Wetlands*, 2nd ed.; CRC Press: Boca Raton, FL, USA, 2008.
- Kadlec, R.H. Overview: Surface Flow Constructed Wetlands. In *Proceedings of the 4th International Conference Wetland Systems for Water Pollution Control*; ICWS Secretariat: Guangzhou, China, 1994; pp. 1-12.
- De Jong, J. The Purification of Wastewater with the Aid of Rush or Reed Ponds. In *Biological Control of Water Pollution*; Tourbier, J., Pierson, R.W., Eds.; Pennsylvania University Press: Philadelphia, PA, USA, 1976; pp. 133-139.
- Pontier, H.; Williams, J.B.; May, E. Progressive changes in water and sediment quality in awetland system for control of highway runoff. *Sci. Tot. Environ.* **2004**, *319*, 215-224.
- O´Sullivan, A.D.; Moran, B.M.; Otte, M.L. Accumulation and fate of contaminants (Zn, Pb, Feand S) in substrates of wetlands constructed for treating mine wastewater. *Water Air Soil Pollut.* **2004**, *157*, 345-364.
- Lakatos, G. Hungary. In *Constructed Wetlands for Wastewater Treatment in Europe;* Vymazal, J., Brix, H., Cooper, P.F., Green, M.B., Haberl, R., Eds.; Backhuys Publishers: Leiden, The Netherlands, 1998; pp. 191-206