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An Overview on Wetland Engineering and Its Significance

Dr. Krishnappa Venkatesharaju
Assistant Professor, Department of Environmental Science And Engineering, Presidency University, Bangalore, India,
Email Id-venkateshraju.k@presidencyuniversity.in

ABSTRACT:
The wetlands that are currently built for remediation purposes as surface flow systems for the removal of contaminants from liquid effluents like sewage and petroleum wastes are known as engineered wetlands. Microbial communities, which develop as biofilms in the plant root zone, are the main source of energy for the systems. Understanding the interrelationships between soil, hydrology, grading/site preparation, and installation techniques is essential for their construction. Understanding the different scientific, legal, and technical aspects of wetland ecology is necessary for building wetlands. Similar to a natural marsh, a constructed wetland has patches with open water. Lagoons are frequently incorporated into these systems to assist the establishment of emergent wetland vegetation.

KEYWORDS:

Built Wetlands, Constructed Wetlands, Flow Wetlands, Surface Flow, Wetland Engineering.

I. INTRODUCTION

As surface flow systems for the removal of contaminants from liquid effluents such sewage and petroleum wastes, engineered wetlands are those now built for remediation purposes. Microbial communities, which develop as biofilms in the plant root zone, are the main source of energy for the systems. Understanding the interrelationships between soil, hydrology, grading/site preparation, and installation techniques is essential for their construction. Understanding the different scientific, legal, and technical aspects of wetland ecology is necessary for building wetlands. Similar to a natural marsh, a constructed wetland has patches with open water. Lagoons are frequently incorporated into these systems to assist the establishment of emergent wetland vegetation. These surface flow systems support greater biodiversity than subsurface flow water treatment systems and are more tolerant of wastewaters with high suspended solid concentrations than gravel-bed systems. Natural habitats including salt scrub, pine savannahs, estuary tidal marshes, wooded wetlands, shrub-scrub wetlands, emergent wetlands, freshwater tidal wetlands, brackish tidal wetlands, and open marshes are all modelled in terms of their ecology.

Understanding the connections between the selection of plant species and soil, hydrology, grading/site preparation, and installation techniques is necessary for construction. The management approach uses an ecological justification to keep pollution clearance rates high. With the help of organic physical, chemical, and biological processes, wetlands purify water. Wetland engineering was created with the goal of using our knowledge of these processes to create wetlands that function as natural treatment systems. Geoff has spent his whole career working with the science of constructing wetlands for specific treatment objectives and has immersed himself in more different kinds of impure water than you can possibly conceive. The type of contaminants and the volume of water that needs to be cleaned will be taken into consideration while designing a treatment wetland. Different wetland mechanisms remove various toxins; some are better eliminated when there is a lot of oxygen present, while others are best removed when there is little to no oxygen. The effectiveness of a wetland might vary depending on its composition and design [1], [2].

Wetland Treatment Types

The design of wetland treatment systems varies based on the location, the kind of wastewater, and the required level of treatment. Sometimes treating the water only requires one wetland. Sometimes it is best to treat wastewater in stages, or to employ alternative technologies for pre- or post-treatment. Wetland design has a wide range of potential variants, and the terminology can be difficult to understand. The following is a description of a few of the key wetland design motifs.

Wetlands with Passive Treatment

Wetland treatment systems are frequently best designed to function without a power source because there is little that can go wrong and the cost of maintenance will be low. A wetland's water flow route influences the many designs that wetland designers describe.

Natural Flood Control

The technique of controlling the ground to lower the danger of flooding is known as natural flood management (NFM). We can implement numerous minor measures to store water higher up the watershed in regions that can handle and might benefit from the excess water, rather than building flood protection where the risk is greatest. These interventions may also enhance water quality and develop new wetland habitat if they are properly planned. These prospects are frequently of a scale that local communities and volunteer organizations, with the assistance of landowners and the government, can lead and create. Professional water engineers may be needed to provide input on larger schemes or the design of the overall pattern of NFM measures. Geoff has worked hands on with his local Slow the Flow group and Rivers Trust to build leaky dams and hold educational events about rivers and flooding. Wetland Engineering has helped with the design of offline ponds and infiltration basins in the Rabble catchment in Northern England.

Habitat Creation and Wetland Restoration

Wetlands are fantastic for a variety of reasons. Here, we have ecosystems that enhance the quality of our water, safeguard us from flooding, sequester carbon, offer a remarkably diverse habitat for a wide range of species, and are stunning and gorgeous. Yet, in recent decades, they have experienced a terrible decrease. I won't waste your time with statistics; instead, click on a few of the links below. Geoff is very happy that Wetland Engineering has contributed in some tiny way to the fight to protect and restore wetland ecosystems, which has received a lot of attention from governments and NGOs. In order to mimic natural systems as closely as possible, Geoff always aims to create botanically diverse wetlands. He also routinely consults with local experts to determine the best ecosystem design for the region's conditions, making sure the new wetland will complement any existing wetland areas. Geoff makes sure his project teams understand the origin of new plants and manage the risk of unintentionally introducing undesirable seeds with imported compost or nursery plants since controlling invasive species is vital.

Mine-Water Purification

Air is now allowed where Mother Nature never intended it to be thanks to mines! When the mine eventually fills with groundwater due to the effects of this air, the altered rock chemistry has an impact on the groundwater, which can become extremely acidic or contaminated with heavy metals. When this mine water rises from the ground, it may harm the ecosystem by causing streams to turn a distinctive orange color from ferric hydroxide (ochre) particles. Wetlands are frequently a viable option for purifying mine water because they require no power and little upkeep, making them suitable for isolated regions. The UK Coal Authority has constructed numerous reed bed treatment systems to get rid of iron from coal mine water, and it's starting to think about getting rid of water from our ancient metal mines as well [3], [4].

II. DISCUSSION

In order to treat sewage, greater, storm water runoff, or industrial wastewater, a built wetland is a wetland that has been intentionally created. It can also be used to reclaim land after mining or as a step in the mitigation of the loss of natural areas due to land development. Constructed wetlands are constructed systems that treat wastewater secondarily by utilizing the natural processes of vegetation, soil, and organisms. The type of wastewater to be treated must be taken into account when designing the created wetland. Both centralized and decentralized wastewater systems have utilised constructed wetlands. When there is a significant amount of soluble organic matter or suspended solids as determined by the biochemical and chemical oxygen demands, first treatment is advised.

Similar to natural wetlands, artificial wetlands function as a bio filter and/or have the ability to remove a variety of contaminants from water, including organic debris, fertilizers, pathogens, and heavy metals. A created wetland is supposed to eliminate some pathogens, such as bacteria, viruses, protozoans, and helminths, to some level. Created wetlands are intended to remove water pollutants such suspended particles, organic debris, and nutrients nitrogen and phosphorus. More pathogens are removed by subsurface wetlands than by surface wetlands. Subsurface flow and surface flow constitute the two basic categories of artificial wetlands. In order to remove contaminants, cultivated vegetation is crucial. The filter bed, which is often made of sand and gravel, has an equally crucial duty to play. Although it is not their primary function, some manmade wetlands may also act as a habitat for native and migratory wildlife. Water in subsurface flow-built wetlands is intended to move vertically or horizontally through the gravel and sand bed. Less area is needed for vertical flow systems than for horizontal flow systems.

Terminology

A bio filter shares some similarities with a built wetland, but is often devoid of vegetation. built wetlands are referred to by a variety of names, including reed beds, soil infiltration beds, treated wetlands, engineering wetlands, and man-made or artificial wetlands. The phrase constructed wetlands can also refer to land that has been repaired and replanted after being previously damaged by mining, draining, and conversion to farmland.

Overview

Sewage from a built wetland used to treat greater at an environmentally friendly housing development in Hamburg-Allergome, Germany construction of a wetland for the treatment of domestic wastewater in Begawan City, Philippines an engineered series of water bodies intended to remediate storm water runoff or wastewater constitutes a built wetland. The roots, stems, and leaves of the vegetation in a wetland act as a substrate for the growth of microbes that decompose organic matter. The term periphyton refers to this group of bacteria. Approximately 90% of pollution removal and waste breakdown is carried out by periphyton and natural chemical processes. Plants remove 7% to 10% of pollutants and serve as a carbon source for bacteria as they decompose. The choice of plants for a built wetland used for water treatment should take into account the varied rates at which various aquatic plant species absorb heavy metals. Subsurface flow and surface flow wetlands are the two main categories of constructed wetlands. One example of a natural-based approach and of phytoremediation is constructed wetlands. In order to help cleanse wastewater, constructed wetland systems are highly regulated settings that try to replicate the soil, flora, and microbes found in natural wetlands. For the most effective treatment procedure, they are built with flow regimes, micro-biotic composition, and suitable plants [5], [6].

Uses

Built-in wetlands can be utilised to treat industrial, agricultural, and storm water as well as raw sewage. Built-in wetlands replicate natural wetlands' capacities to collect runoff, lessen nutrient loads, and produce a variety of wildlife habitats. Greater and wastewater are both treated in constructed wetlands. Treatment wetlands are considered by many regulatory bodies as one of the best management practices for reducing urban runoff Wetlands use a combination of physical, chemical, and biological processes to purge toxins from wastewater. Understanding these processes is essential for developing wetland systems as well as for comprehending what happens to chemicals once they reach wetlands.

Theoretically, wastewater treatment happens when it moves through the rhizosphere of the plants and the wetland substrate in a manmade wetland. Due to oxygen leaking from the rhizomes, roots, and rootlets, a thin layer around each root hair is aerobic. Both aerobic and anaerobic microorganisms aid in the breakdown of organic materials. Nitrogen is released to the atmosphere as gas as a result of microbial nitrification and subsequent DE nitrification. Phosphorus is co-precipitated with calcium, iron, and aluminum compounds found in the root-bed media. In surface flow wetlands, suspended particles filter out when they settle in the water column, but in subsurface flow wetlands, the medium physically filters them out. In subterranean flow and vertical flow systems, biofilms on the gravel or sand media filter and adsorb harmful bacteria, fungi, and viruses.

Removing Nitrogen

In wetlands, organic nitrogen, ammonia, ammonium, nitrate, and nitrite are the predominant types of nitrogen that are significant for wastewater treatment. All nitrogen species are included in total nitrogen. Because ammonia is hazardous to fish when released into watercourses, it is crucial to remove the nitrogen from wastewater. It is believed that excessive nitrates in drinking water cause methemoglobinemia in babies, which reduces the blood's capacity to transport oxygen. Additionally, too much nitrogen (N) entering surface waters from point and non-point sources encourages eutrophication in rivers, lakes, estuaries, and coastal oceans. Eutrophication affects aquatic ecosystems negatively by causing toxic algal blooms, water oxygen depletion, fish mortality, and a decline in aquatic biodiversity. If constructed wetlands are intended to achieve biological nutrient removal, ammonia removal occurs there similarly to sewage treatment plants, with the exception that there is no need for an external, energy-intensive addition of air. It is a two-step process that involves nitrification and DE nitrification. The aerobic bacteria Nitrosamines sp. converts ammonia in wastewater to ammonium ions, completing the nitrogen cycle. Nitrite by oxidizing ammonium; the bacterium Nitrobacteria sp. after which turns nitrite into nitrate. Nitrate is converted into the relatively innocuous nitrogen gas that enters the atmosphere when anaerobic conditions are present.

Removing Phosphorus

In nature, phosphorus can be found in both organic and inorganic forms. Soluble reactive phosphorus (SR-P) is the analytical metric for physiologically active orthophosphates. Until they are converted into soluble inorganic forms, dissolved organic phosphorus and insoluble forms of organic and inorganic phosphorus are typically not physiologically available. The main limiting nutrient in freshwater aquatic environments is often phosphorus. Phosphorus is scarce in the natural world when left alone. The rapid growth of algae in water receiving massive discharges of phosphorus-rich wastes illustrates the natural shortage of phosphorus. Contrary to nitrogen, phosphorus does not have an atmospheric component, making the phosphorus cycle a closed system. The created wetland is the sole place where phosphorus from wastewater can be removed and stored. Within a system of wetlands, phosphorus can be sequestered by:

1. Phosphorus’s binding to organic materials as a result of being incorporated into living biomass.
2. Ferrous iron, calcium, and aluminum precipitate with insoluble phosphates in wetland soils.

Integration of Biomass Plants

When harvested, aquatic vegetation can prolong the life of a system by delaying the phosphorus saturation of the sediments. Plants generate a special habitat at the biofilm's attachment surface. Certain plants move oxygen, which is then released at the biofilm/root contact, supplying the wetland system with more oxygen. Plants also improve the hydraulic conductivity of the soil or other root-bed media. Growing roots and rhizomes are believed to disrupt and loosen the soil, which increases porosity and may facilitate more efficient fluid transport in the rhizosphere. Macrospores, which are useful in directing water through the soil, are ports and channels left behind as roots decompose.

Removing Metals

Metalloids and dissolved metals have been effectively removed by the usage of constructed wetlands. Although these toxins are frequently found in mine drainage, treatment wetlands have been built for rainfall, landfill leachate, and other sources such as leachate or FDG wash water at coal-fired power plants.

Eradication of Pathogens

Rather than being designed to eliminate pathogens, constructed wetlands are intended to remove other elements that affect water quality, such as suspended particles, organic matter which has a biochemical and chemical oxygen requirement, and nutrients nitrogen and phosphorus. In a built wetland, all kinds of pathogens are anticipated to be eliminated; however, a subsurface wetland is anticipated to remove pathogens more thoroughly. One can anticipate a 1 to 2 log10 reduction in pathogens in a free water surface flow wetland, but in systems with dense vegetation, bacteria and virus removal may be less than 1 log10 reduction. This is because constructed wetlands frequently have vegetation, which helps remove other pollutants like nitrogen and phosphorus. As a result, these systems minimize the value of sunlight exposure for killing bacteria and viruses.

Types and Factors Influencing Design

Diagram of the sewage treatment plant's process flow showing built wetlands with subsurface flow. However, typical free water surface systems are typically constructed with emergent saprophytes. Subsurface flow-constructed wetlands with a vertical or a horizontal flow regime are also common and can be integrated into urban areas as they require relatively little space. Constructed wetland systems can be surface flow systems with only free-floating saprophytes, floating-leaved saprophytes, or submerged saprophytes. The following are the primary three types of built wetlands. Construction of a wetland with subsurface flow is possible with either vertical or horizontal flow the effluent goes horizontally, parallel to the surface from the planted layer down through the substrate and out. Built wetland with surface flow this wetland has horizontal flow. While the latter relies on a flooded treatment basin upon which aquatic plants are held in flotation until they develop a thick mat of roots and rhizomes upon which biofilms form, the former types are placed in a basin with a substrate to provide a surface area upon which significant amounts of waste degrading biofilms form.

To safeguard the water table and surrounding grounds, the bottom is typically lined with either a polymer geomembrane, concrete, or clay where the right type of clay is available. Sand, a combination of different-sized media, or gravel typically limestone or pumice or volcanic rock, depending on local availability can serve as the substrate for vertical flow-built wetlands. To separate the particles from the liquid effluent following a septic tank for primary treatment or other types of systems, constructed wetlands can be employed. However, some manmade wetland designs may not employ initial primary treatment. A vertical subsurface flow created wetland is depicted schematically as the effluent flows through pipes on the grounds subsurface through the root zone to the ground. Effluent runs horizontally across the bed. There is no water surfacing it is maintained below gravel and wastewater flows between the plant roots in subsurface flow-built wetlands. The system is consequently more effective, repels mosquitoes, smells better, and is less susceptible to winter weather [7], [8].

The space needed to cleanse water is also reduced. The system's intakes can clog or biology easily, though this issue is frequently resolved by adding some larger-sized pebbles. Vertical flow or horizontal flow-built wetlands are subclasses of subsurface flow wetlands. With no surface water, the effluent in the horizontal flow constructed wetland moves horizontally via gravity, parallel to the surface, preventing mosquito breeding. In the vertical flow constructed wetland, the effluent moves vertically from the planted layer down through the substrate and out. When compared to horizontal flow constructed wetlands, vertical flow constructed wetlands are thought to be more effective and require less space. While horizontal flow-built wetlands can accept wastewater continually and are simpler to construct, they must be interval-loaded, and their design requires more expertise. A vertical flow subsurface created wetland only needs roughly 3 square meters (32 sq. ft.) of space per person equivalent, and in warmer regions, just 1.5 square meters. This is because to the enhanced efficiency. The French System treats raw wastewater using both primary and secondary processes. The wastewater travels through a number of filter beds with grain sizes ranging from gravel to sand.

Applications

Subsurface flow wetlands are capable of treating a wide range of wastewaters, including residential, agricultural, paper mill, mining, tannery, or meat processing wastes, as well as storm water. The design will influence the effluent's quality, and it should be tailored to the disposal technique or intended reuse application such as irrigation or toilet flushing.

Considerations for Design

Depending on the type of constructed wetlands, wastewater passes through a gravel and, less frequently, a sand medium on which plants are rooted. A gravel medium typically composed of limestone or volcanic rock lava stone can also be used; however, doing so will result in a surface reduction of about 20% over limestone. It is primarily used in horizontal flow systems, where it is less effective than sand but more likely to clog. Constructed subsurface flow wetlands are secondary treatment systems, thus the effluent must first pass through an effective primary treatment that eliminates solids. As an example of primary treatment, sand and grit removal, grease traps, compost filters, septic tanks, Inhofe tanks, anaerobic baffled reactors, or up flow anaerobic sludge blanket (UASB) reactors may be used. The subsequent treatment is based on various biological and physical processes such as filtration, adsorption, or nitrification. The biological filtration through a biofilm of facultative or aerobic bacteria is crucial. The adsorption and filtering processes are supported by coarse sand in the filter bed, which also serves as a surface for microbial growth.

These microbes require a significant amount of oxygen to survive. The impacts of evapotranspiration and precipitation are important, particularly in warm and arid areas. Although vertical flow systems are more reliant on an external energy source, in circumstances of water loss, a vertical flow created wetland is better to a horizontal one due to an unsaturated upper layer and a shorter retention duration. A horizontal flow system is designed with evapotranspiration and rainfall in mind. In the event that residential wastewater or backwater is treated, the effluent may be yellowish or brownish in hue. Greater that has been treated typically lacks color. According to pathogen requirements for safe release to surface water, treated greater is pathogen-free. Depending on the intended reuse application, treated residential wastewater may require tertiary treatment. Although at least 20 different plant species are suitable, plantings of reed beds are common in subsurface flow wetlands that have been built in Europe. There are many fast-growing timer plants that can be utilised, including sedges, cattails [9], [10].

Operations and Upkeep

Peak overloading shouldn't affect performance, but ongoing overloading reduces treatment capacity due to an excess of suspended particles, sludge, or fats. The following maintenance procedures are necessary for subsurface flow wetlands: routine inspections of the pretreatment procedure, use of pumps, influent loads, and distribution on the filter bed.

Comparisons to other Categories

Because there is no water that is exposed to the surface, subsurface wetlands are less conducive to mosquito breeding than surface flow wetlands. In wetlands with surface flow construction, mosquitoes can be a concern. Systems with subsurface flow have the benefit of requiring less acreage for water treatment than systems with surface flow. Surface flow wetlands, however, might make better habitat for wildlife. When compared to typical municipal wastewater treatment facilities, the area needs of a subsurface flow-built wetland may be a limiting factor for urban applications. Less area is needed for high-rate aerobic treatment processes such membrane bioreactor plants, trickling filters, spinning discs, submerged aerated filters, and activated sludge plants. Subsurface flow-built wetlands have one advantage over previous technologies: they are more operationally reliable, which is crucial in developing nations. Another benefit is that there is no need for sewage sludge treatment because engineered wetlands do not produce secondary sludge. However, primary sludge from primary settling tanks does produce and needs to be removed and treated.

Costs

The price of the sand required to fill the bed determines the costs of subsurface flow created wetlands, along with the price of the surrounding land.

Surface Current

Diagram of a manmade wetland with a free-water surface that mimics how diseases are eliminated, particles settle, and nutrients are used by living things and plants in nature. Surface flow wetlands, often referred to as free water surface engineered wetlands, can be used to treat storm water runoff and as a final step in the tertiary treatment of wastewater. Instead of vertical flow, surface flow-built wetlands always have wastewater pass over the roots of the plants. In comparison to subsurface flow-built wetlands, they need a relatively wide area to purify water, and they could smell worse and perform worse in the winter. Surface flow wetlands are not considered ponds in the technical literature, despite looking a lot like wastewater treatment ponds such as waste stabilization ponds. Since the water is exposed to direct sunlight, pathogens are destroyed by natural decay, predation by higher organisms, sedimentation, and UV radiation. The soil layer beneath the water is anaerobic, but the roots of the plants release oxygen around them, allowing complex biological and chemical reactions. Numerous soil types, such as bay mud and various salty clays, can support surface flow wetlands. Eichhornia crosses, a type of water hyacinth, and Pontederia spp. are employed everywhere, despite Typhus and Phragmites being extremely invasive.

III. CONCLUSION

In this chapter discussed about the wetland engineering. The maintenance and restoration of wetland ecosystems depend heavily on wetland engineering. Wetland engineering seeks to improve the ecological functions and values of wetlands through the use of engineering techniques such hydrological manipulation, vegetation management, and structural interventions. Wetland engineering's usefulness in tackling various environmental issues is one of the main lessons learned from the research. Wetlands offer a wide range of ecosystem services, such as carbon sequestration, flood control, water purification, and habitat provision. Wetland engineering solutions can assist biodiversity preservation, enhance water quality, lessen flood risk, and help rehabilitate degraded wetlands.

REFERENCES

[1] L. Cui et al., “Analyzing Coastal Wetland Degradation and its Key Restoration Technologies in the Coastal Area of Jiangsu, China,” Wetlands, 2018, doi: 10.1007/s13157-018-0997-6.

[2] Q. Zhou et al., “The constructed wetlands engineering cases with different plants treating domestic sewage in a subtropical climate at cold seasons,” Hupo Kexue/Journal Lake Sci., 2018, doi: 10.18307/2018.0113.

[3] W. Wu, Z. Yang, B. Tian, Y. Huang, Y. Zhou, and T. Zhang, “Impacts of coastal reclamation on wetlands: Loss, resilience, and sustainable management,” Estuar. Coast. Shelf Sci., 2018, doi: 10.1016/j.ecss.2018.06.013.

[4] R. Van Coppenolle, C. Schwarz, and S. Temmerman, “Contribution of Mangroves and Salt Marshes to Nature-Based Mitigation of Coastal Flood Risks in Major Deltas of the World,” Estuaries and Coasts, 2018, doi: 10.1007/s12237-018-0394-7.

[5] X. Huang, M. A. Rippy, A. S. Mehring, B. K. Winfrey, S. C. Jiang, and S. B. Grant, “Shifts in dissolved organic matter and microbial community composition are associated with enhanced removal of fecal pollutants in urban stormwater wetlands,” Water Res., 2018, doi: 10.1016/j.watres.2018.03.020.

[6] R. M. Saaltink, S. C. Dekker, J. Griffioen, and M. J. Wassen, “Vegetation growth and sediment dynamics in a created freshwater wetland,” Ecol. Eng., 2018, doi: 10.1016/j.ecoleng.2017.11.020.

[7] Y. An et al., “Variations in vegetative characteristics of Deyeuxia angustifolia wetlands following natural restoration

in the Sanjiang Plain, China," Ecol. Eng., 2018, doi: 10.1016/j.ecoleng.2017.12.022.

[8] T. Li, H. Hu, Z. Li, J. Zhang, and D. Li, "The Impact of Irrigation on Bacterial Community Composition and Diversity in Liaohe Estuary Wetland," J. Ocean Univ. China, 2018, doi: 10.1007/s11802-018-3391-3.

[9] X. Li et al., "Relationship between design parameters and removal efficiency for constructed wetlands in China," Ecological Engineering. 2018. doi: 10.1016/j.ecoleng.2018.08.005.

[10] A. Gracia, N. Rangel-Buitrago, J. A. Oakley, and A. T. Williams, "Use of ecosystems in coastal erosion management," Ocean and Coastal Management. 2018. doi: 10.1016/j.ocecoaman.2017.07.009.