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Constructed Wetlands for Wastewater Treatment By Using Aquatic Plant.

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ABSTRACTS:

The first experiments using wetland macrophytes for wastewater treatment were carried out in Germany in the early 1950s. Since then, the constructed wetlands have evolved into a reliable wastewater treatment technology for various types of waste water. The classification of constructed wetlands is based on: the vegetation type (emergent, submerged, floating leaved, free-floating); hydrology (free water surface and subsurface flow); and subsurface flow wetlands can be further classified according to the flow direction (vertical or horizontal). In order to achieve better treatment performance, namely for nitrogen, various types of constructed wetlands could be combined into hybrid systems.

KEYWORDS:

Constructed Wetlands; Macrophytes; Nutrients; Organics; Wastewater.

INTRODUCTION:

A constructed wetland is an organic wastewater treatment system that mimics and Improve the effectiveness of the processes that help to purify water similar to naturally occurring wetlands. The system uses water, aquatic plants (i.e.: reeds, duckweed), naturally occurring microorganisms and a filter bed (usually of sand, soils and/or gravel). Constructed wetlands can be used for either secondary or tertiary wastewater treatment. Many different designs exist including vertical wetlands, which require less land, but more energy for operations like pumping or siphoning than horizontal wetlands, which can instead rely on gravity and topography. The extensive options in design, materials and technology allow the constructed wetland to be adapted to local conditions and land availability. Costs are dependent on the price of land and materials, but where land is cheaper and widely available, constructed wetlands are a very cost-effective method of wastewater treatment.

The general concept is that the plants, microorganisms and substrates together act as a filter and purification system. First, water is slowed as it enters the wetland, allowing for the sedimentation of solids. Through the process of water flow through the constructed wetland, plant roots and the substrate remove the larger particles present in the wastewater. Pollutants and nutrients present in the wastewater are then naturally broken down and taken up by the bacteria and plants, thereby removing them from the water. The retention time in the wetland, which varies depending on the design and desired quality level, along with UV radiation and plant secretion of antibiotics will also kill the pathogens present in wastewater. After treatment in a constructed wetland, water can be safely released into surface waters or used various purposes.

○ SALIENT FEATURES:

- Cost efficient in terms of construction, operations and maintenance
- Effectively treats wastewater from human waste, agricultural runoff, storm water and some metals or pollutants from mining and industry
- Uses technology that is simple to understand and manage
- Low energy consumption required for operations
- Prepares water for reuse
- Assists in maintaining groundwater and surface water levels
- Contributes to environmental protection by providing a habitat for plants and animals
- Acts as a means of water storage
- Pleasing natural aesthetics

○ CLASSIFICATION OF CONSTRUCTED WETLANDS:

1 . FSFCW: Free surface flow constructed wetland.

2 SSFCW: Subsurface flow constructe wetland.

3 HFSSCW: Horizontal flow Subsurface constructed wetland

4 VFSSCW: Vertical flow Subsurface

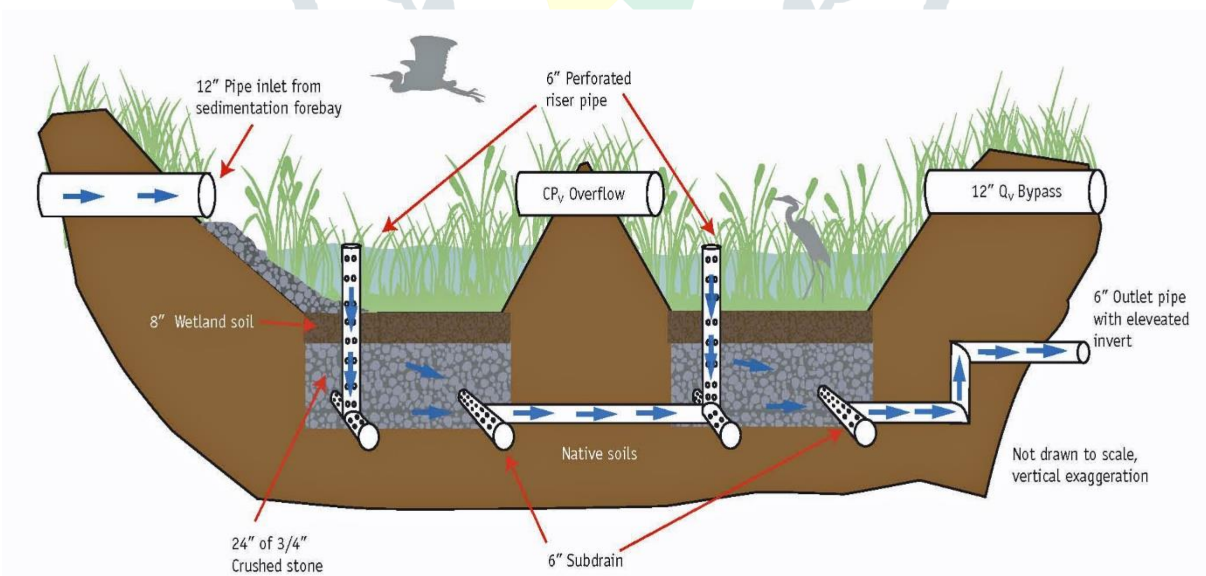


Fig1. Constructed Wetland

Components of Constructed Wetlands:

These components can be manipulated in constructing a wetland:

1.Water
2.Substrates, Sediments And Litter
3.Vegetation
4.Aesthetics And Landscape Enhanceme5.Microorganisms
6.Animals

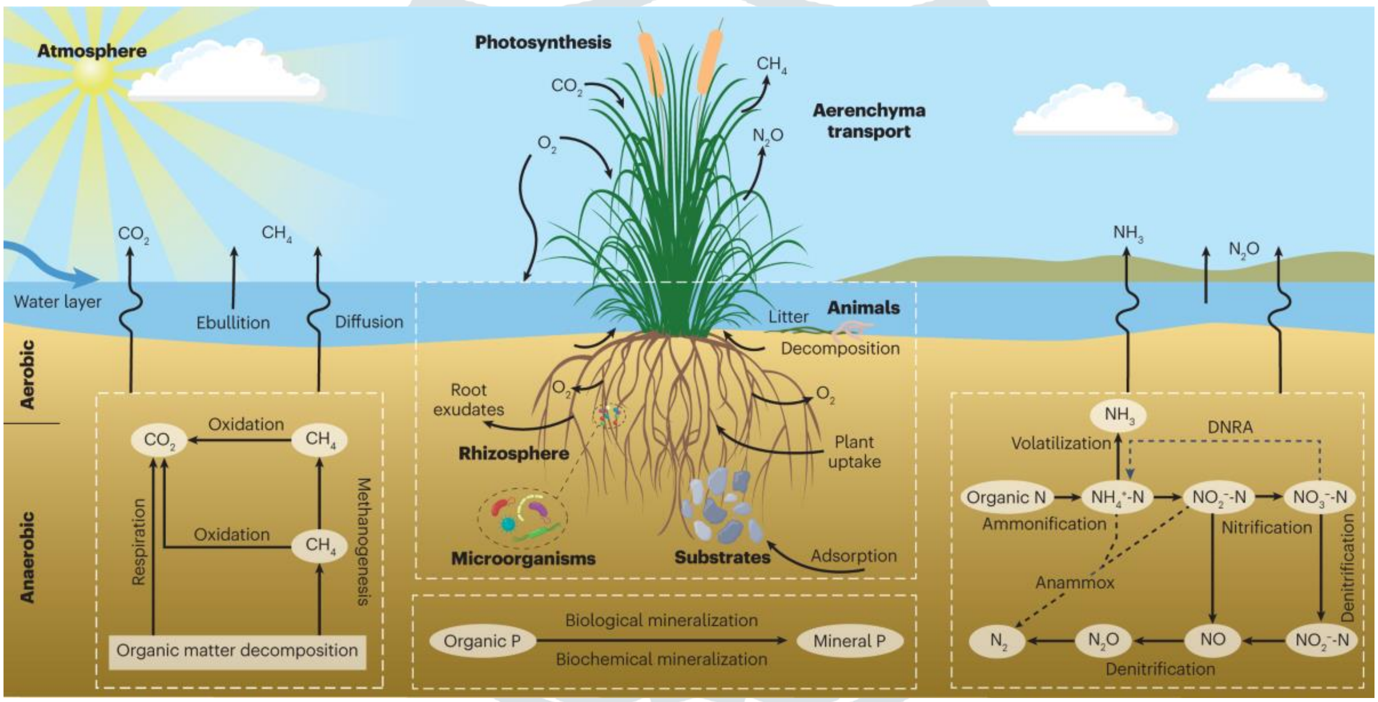


Fig 2. Planting Technique

PLANTING TECHNIQUES:

1. Plants Can Be Introduced To A Wetland By Transplanting Roots, Rhizomes, Tubers, Seedling Or Mature Plants;

2. By Importing Substrate And Seed Bank from Nearby Wetlands

3. By Relying Completely On Seed Bank Ofthe Original Site

4. Choosing Plants From Wild Stock Is More Desirable Than Nurseries As They Are Better Adapted To Environmental Conditions In Constructed Wetlands;

5. 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; 6. If Seed Are Used, They Should Be Evaluated For The Species Present Andtheir Viability.

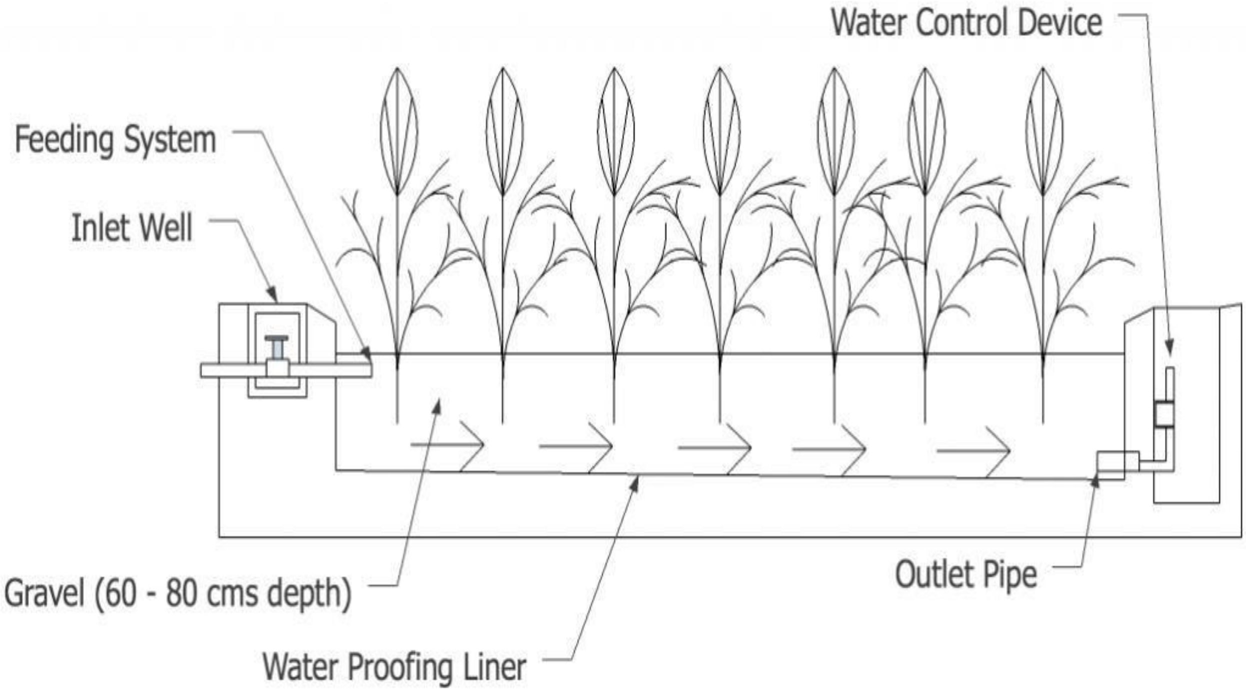


Fig.3 Planting Technique

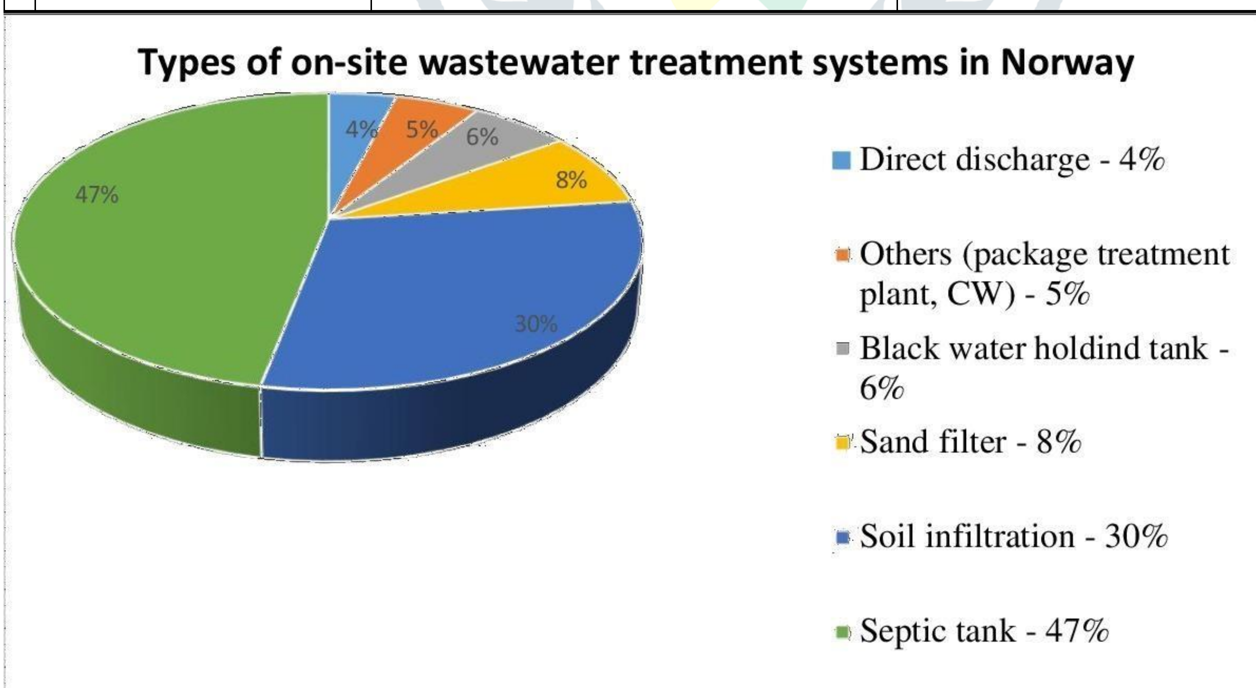
Fig4- project model

CONSTRUCTED WETLAND UNIT:

The dimension of the pilot scale unit of constructed wetland is 150x150x50cm with a slope of 0.01 (1 %). The wetland model of cross section 22500 cm2 has been designed with hydraulic loading of 225 ltrs. The retention time provided is 7 and 14 days. The wetland media consisted of a gravel bed in an impermeable plastic. The bed is filled to a height of 10cm with coarse aggregates of size between 1620mm. The top portion of the wetland unit is filled with fine aggregates up to height 10 cm to support vegetation. The soil used for the growth of plants is Garden soil. Plant used in the treatment elephant ear.

Table 1. Characteristics Of Municipal Waste Water

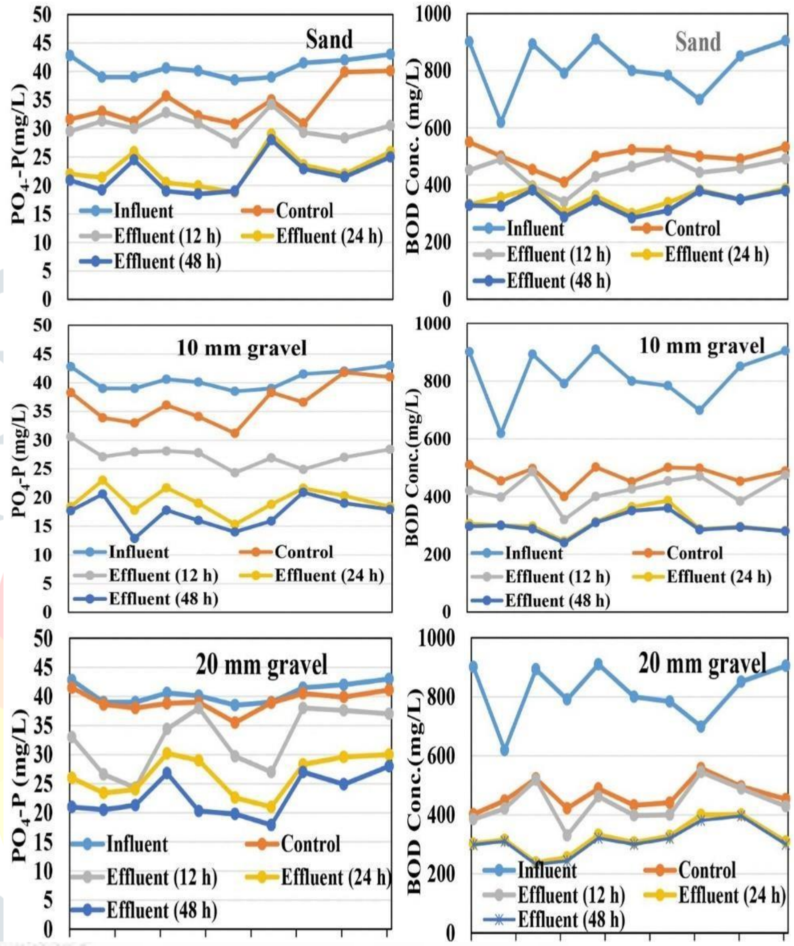
No.	Parameter's	Value
1.	PH	5.5-9
2.	TDS	250-900
3.	TOTAL NITROGEN	20-85
4.	PHOSPHORUS	6-20
5.	POTASSIUM	10-20
6.	SODIUM	6-20
7.	BOD	100-300
8.	COD	200-500

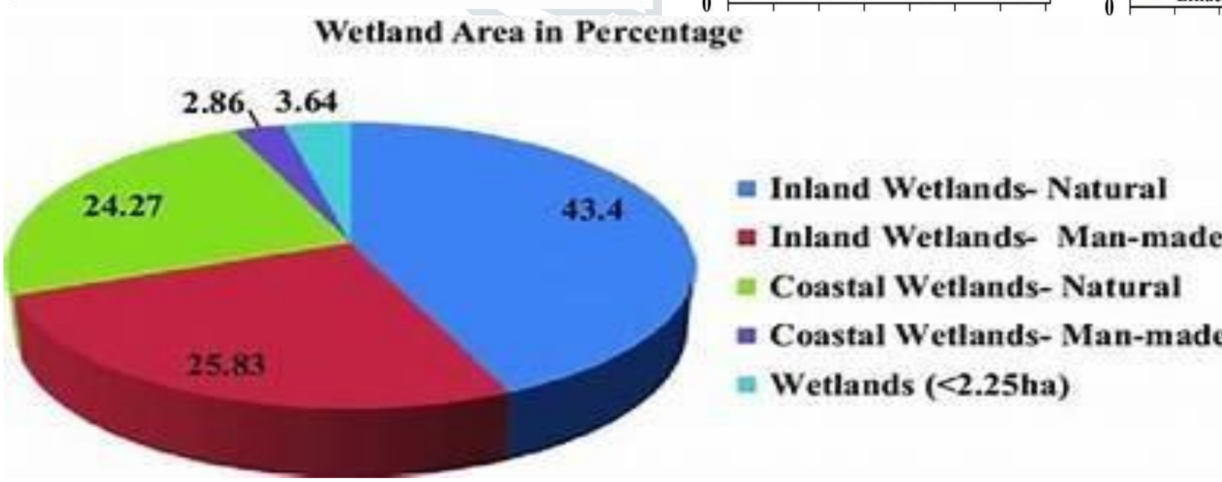


Testing Of Municipal Waste Water

Removal Mechanism: The wastewater constituents are getting removed by using the following removal mechanism.

Wastewater constituent	Removal mechanism
Suspended solids	• Sedimentation • Filtration
Soluble organics	• Aerobic microbial degradation • Anaerobic microbial degradation
Nitrogen	• Ammonification followed by microbial nitrification • Denitrification • Plant uptake • adsorption
Metals	• Adsorption and cation exchange • Complexation • Precipitation • Plant uptake • Microbial oxidation/ reduction
Pathogens	• Sedimentation • Filtration • Natural die off





- **LITERATURE REVIEWS:**

The wetland was constructed using the dimensions of 3.5 m wide 7.8 m in length and 1.8 m in depth. There are various types of layers used in the wetland as the filtration bed unit for the organic matter to get settled around the substrate media which is gravel bed ranging from 6 to 25 mm diameter and 0.75 m in depth. The wastewater is allowed to flow here using the perforated pipes and under the ground. Typha Latifolia, Phragmatis Australis, Colocasia Esculenta, Polygonum Hydropiper, Alternenthera Sissilis,

Pistia Stratoitis are the plants used in here. The reduction percentage of BOD, TSS, TDS, NO_3 N, PO_4-P &

NH_4- N are 90%, 65%, 78%, 84%, 76% & 86% resp.(U.N Rai et al.)

The constructed wetland also has the media layer of the depth of 15 mm coarse gravel at the bottom at bottom 5 cm to avoid clogging. The second and third layers are around 10 mm and 5 mm size and having a depth of 10 cm and 15 cm respectively. The gravels occupy around 2.7 l out of 8.5 l of working volume of the wetland. Also, here 250 gm of fresh iron scraps is placed as one of its layers with very lower degree of oxidation. Eichhornia crassipes is planted here. NH_4+ -N, TN, NO_2- -N, NO_3- -N, SO_4^2- , and $PO_4$3- removal efficiency in the Is83.60%, 82.43%, 15.61%, 48.93%, 80.45%, and 78.94% respectively.

(Manoj Kumar et al.)

There are various layers of the filler materials present in which gravel and clag is used of various sizes ranging from 50-100 mm and from depth range of 15 cm to 65 cm. (Shibao Lu et al.)

The upper container, which acts as the VFCW bed, was perforated at the bottom with 8 mm holes and filled with a 5 cm layer of lime pebbles followed by a 40 cm layer of high-porosity (ε ~0.8) and high surface area (860m2m-3) plastic beads. Juncus alpigenus and Cyperus haspen have been planted and the systems were found to reduce TSS, on average, by approximately 90%, from 90 to 10 mg L-1 , BOD5 by 95%, on average, from 120 to 5 mg L-1 and COD by an average of 84%, from 270 to 40 mg L-1 .The ratio of COD to BOD5 increased from 2.25 to 8 apparently due to favoured removal of biodegradable organic matter (indicated by BOD5) in comparison to less degradable organic matter.(M.Y. Sklarz et al)

The wetland designed here is in such a way that the plants used are cypres rotundus and Pennisetum pedicellatum. The layers here are used are gravel ranging from 8 to 32 mm and they have been distributed according to their sizes in to layers of 0.15 inches to 0.35 inches. Also, there is a presence of soil layer of 0.10 mm. Here the BOD removal of VFCW is 83% as compared to HFCW at 77%, COD at 65% & 60%, NH_4 + –N, at 84.47% and 67 %, Nitrogen at 66.75% and 69%, P at 90% & 85%. (Arun Kumar Thalla et al.)

To treat the effluents from GIDC Common treatment plant (NEPL-Naroda Enviro Projects Ltd.) in constructed wetlands DF system beds. The chemical oxygen demand of Complex effluent was reduced significantly after treatment. The Cyperus Rotundus. based treatment system was the most efficient in removing the pollutants from the effluent. So, in conclusion, Cyperus species were more efficient than the constructed wetland technology. The wetland bed size was 80x80x60mm. and Coras, fine send then the media was filled in the middle of the bed. Sets of constructed wetland systems were set up. Each constructed wetland set consisted of one Downflow (DF) system to complete a system were used as the wastewater top inlet and bottom side in outlet. Results from the study should be COD degradation further implemented at the selected cooperatives. Very good performance achieved by this experiment and also can be used for any type of industrial effluents by no chemical use and very less maintenance.

(Satish S. Patel et al.)

Two large scale subsurface wetlands are designed and operated for around a time span of 3 years for the treatment of municipal wastewater. The HFCW had a area of 654.5 m² and the VFCW had a total area of around 457.6 m². The plant species used here are canna, phragmatis australis and cypres papyrus were planted. The removal rate of COD & BOD in HFCW is 91% and 92.8% respectively and that in VFCW is around 92.9% & 93.6%. TSS is reduced in HFCW is around 92.3% & that in VFCW is around 94%. TKN removal in HFCW is 60% and in VFCW is 62.5%. The average nitrogen concentration in the wastewater applied to both HFCW & VFCW had a concentration level of 0.2 mg/l and 0.44 mg/l . (Abou-

Elela et al.)

The constructed wetland in Turkey Ankara is used for the treatment of domestic wastewater by using Australis Phragmattis as its plant for the wetland bed. Other material which is used here for checking its efficiency is the blast furnace slag which will be used as a material for filter bed in the layers a long with gravels. The total efficiency for slag and gravel are COD- 47 & 44%, NH4 - N 88 & 53%, Total Nitrogen – 44 & 39%, Total phosphorus – 44% & 4%. This concludes that treatment using the blast furnace slag is more efficient. So, this treatment is useful for application in the fields and making it more beneficial to the environment as the blast furnace slag is always neglected (E Asuman Korkusuz et al.)

Presented in this paper is an integrated cost and efficiency analysis of a pilot vertical subsurface flow constructed wetland (CW) built up near the Longdao River in Beijing, China. The CW has been monitored over one year and proved to be a good solution to treat the polluted water and restored the ecosystem health of the Longdao River. The modified CW system in accordance with local conditions costs less in construction, operation and maintenance than traditional wastewater treatment system and occupies less land than conventional CW. Also, derived from the efficiency analysis, the Longdao River CW provides better elimination effects for nutrient substances in the polluted river water and has stable performances in cold seasons. (Z.M. Chen, et al.)

Three lab-scale vertical-flow constructed wetlands (VFCWs), including the non-aerated, intermittently aerated and continuously aerated ones, were operated at different hydraulic loading rates to evaluate the effect of artificial aeration on the treatment efficiency of heavily polluted river water. Results indicated that artificial aeration increased the dissolved oxygenconcentrations in intermittently aerated and continually aerated, which significantly favoured the removal of organic matter. The DO grads caused by intermittent aeration formed aerobic and anoxic regions in intermittently aerated and thus promoted the removal of total nitrogen. The removal COD removal efficiency of all three models decreased due to increase in HLR. The artificial aeration enhanced the reactor resistance to the fluctuations of pollutant loadings. At 19 cm/day HLR in CA the COD removal efficiency was observed at around 81%. This study has demonstrated the feasibility of applying artificial aeration to VFCWs treating polluted river water, particularly at a high HLR. (Huiyu Dong, et al)

Two pilot-scale integrated vertical-flow constructed wetlands (IVCWs) in parallel were employed to evaluate domestic wastewater treatment performance at a loading rate of 250 mm/d, and each was planted with two different plant species: Typha orientalis and Arundo donax var. versicolor (Plot 1), and Canna indica and Pontederia cordata (Plot 2). The results showed that different plant combinations offered no significant improvement in pollutant removal efficiencies). The mean removal efficiencies associated with Plot 1 and Plot 2 were 59.9% vs. 62.8% for COD. Dissolved oxygen (DO) in the wetland beds was a factor of dependence for the removals of organic matter and nitrogen, and it could be used to predict removal rates of chemical oxygen demand (COD). Low temperatures had a negative impact on nutrient removals. (Jun-jun Chang, et al) In this article it was found that the vertical flow constructed wetlands provide more oxygenated environment and significantly reduce the organic matter as well as microbial species from wastewater. In this study vertical up-flow constructed wetlands were constructed and used as bio-filter to improve the water quality of secondary treated effluent. The reduction pattern is studied in this research and related with plant species and presence of plant. The plant species used in the constructed wetlands were canna indica and phragmitis australis. The fibrous rooting system of canna indicahelps in causing high aerobic conditions throughout the treatment bed which in turn facilitates higher removal in comparison to phragmitis australis planted wetland. COD removal was ranges from 38 to 47% while treating domestic wastewater through vertical flow system. The author also observed lower COD removal in one case of non-planted wetland than planted one. Size and distribution of gravel in all units were same as 8-12mm gravel were placed at the top and 16-20mm gravel at the bottom. A total of 20 water samples were collected on weekly basis for constructed wetland units which are planted with canna (with and without sand layer incorporation). pH values range from 8.19 to 8.38 in influent and effluents of all the units. (Gargi Sharma et al.)

In the Official guidelines for the on-site treatment of domestic sewage have been published by the Danish Ministry of Environment as a consequence of new treatment requirements for single houses and present in the rural areas of Denmark. This paper shows the guidelines for vertical constructed wetland systems (planted filter beds) that has capacity to fulfil demands of 95% removal of BOD and 90% nitrification. The system can be extended with chemical precipitation of phosphorus with aluminium polychloride in the sedimentation tank to meet requirements of 90% phosphorus removal. The sewage is, after sedimentation, pulse-loaded onto the surface of the bed using pumping and a network of distribution pipes. The drainage layer in the bottom of the bed is aerated through vertical pipes extending into the atmosphere in order to improve oxygen transfer to the bed media. Half of the nitrified effluent from the filter is recirculated to the first chamber of the sedimentation tank or to the pumping well in order to enhance denitrification and to stabilise the treatment performance of the system. A phosphorus removal system is installed in the sedimentation tank using a small dosing pump. The mixing of chemicals is obtained by a simple airlift pump, which also circulates water in the sedimentation tank. The VFCW system is an attractive alternative to the common practice of soil infiltration and provides efficient treatment of sewage for discharge into the aquatic environment. (Hans Brix et al.)

In the use of VFCW was to treat municipal wastewater reduces energy consumption and therefore economic costs, as well as reduces environmental pollution. The purpose of this study was to compare the purification capacity of domestic wastewater using two species of plants sown in subsurface constructed wetlands with vertical flow built on a small scale that received municipal wastewater with primary treatment. The species used were Phragmites Australis and Cyperus Papyrus. For such purpose, a constant flow of 0.6 m^3 day^{-1} was given from the primary lagoon to each of the two wetlands built on a pilot scale with continuous flow. Each unit was filled with granite gravel in the lower part and with silica sand in the upper part of different granular, the porosity of the medium was 0.34, with a retention time of 1.12 days and a hydraulic load rate of 0.2 m day^{-1}. To analyse the purification capacity of wastewater, physical, chemical and biological parameters were monitored during three months. Samples were taken at the inlet and treated water outlet in each experimental unit. The results obtained in the experimental tests for the two species of plants, showed that the Cyperus Papyrus present in a greater capacity of pollutants removal as BOD (80.69%), COD (69.87%). In the case of Phragmites Australis retains more solids. The species with greater efficiency in the treatment of domestic wastewater for this study was Cyperus Papyrus. (Fernando García-Ávila, et al.)

➢ Result:-

Testing of waste water (municipal waste water):

Parameters	Initial values	Final values	Permissive levels
pH	9.80	8.33	5.5-9.0
Turbidity (NTU) (Nephelometric Turbidity)	1)58.2(NTU) 2)41.6(NTU) 3)36.32(NTU)	1)41.6(NTU) 2)36.32(NTU) 3)29.98(NTU) Final -35.96(NTU)	0-10
COD(mg/lit)	1)428(mg/lit) 2)368(mg/lit) 3)295(mg/lit)	1)368(mg/lit) 2)295(mg/lit) 3)225(mg/lit) Final-296(mg/lit)	<250 (mg/lit)
Chlorides(mg/lit)	1)451.21(mg/lit)	1)335.46(mg/lit)	<1000 (mg/lit)

	2)335.46(mg/lit) **3)268.98(mg/lit)**	**2)268.98(mg/lit)** **3)172.66(mg/lit)** **Final-259.03(mg/lit)**	

CONCLUSION:

1.Constructed wetlands are designed systems that use a combination of plants, soil, and microorganisms to treat wastewater.

2. The soil in the wetland acts as a filter, trapping and breaking down pollutants through various biological and chemical processes.

3. Microorganisms, including bacteria and fungi, play a crucial role in breaking down organic matter and converting harmful substances into less harmful forms.

4. This project is eco-friendly.

5.This treated water can be used for irrigation in agriculture, reducing the demand for freshwater resources.

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