International Journal of Advance Research in Science and Engineering
Vol. No. 5, Issue No. 08 , August 2016
www.ijarse.com
IJARSE
ISSN 2319 - 8354

CONSTRUCTED WETLANDS: A COST EFFECTIVE SOLUTION FOR WASTE WATER TREATMENT FOR RURAL AREAS

Mona Khosla[1], Satish Kumar[2]

[1]Assistant Professor, Deptt. of Civil Engg, IIMT College of Engg, Greater Noida

[2]Associate Professor, Deptt. of Civil Engg, IIMT College of Engg, Greater Noida

ABSTRACT

The population of almost all rural areas has rapidly increased over the past few decades. Unfortunately most of the rural areas lack in well planned sewage disposal and waste water treatment systems. The natural village ponds which were once used for bathing of humans and cattles are no longer fit for their traditional uses. The great pressure on natural resources combined with lack of awareness has resulted in degradation of the environment. In rural areas, insufficient wastewater treatment often causes serious environmental problems, especially for human health. Due to this problem, new wastewater treatment plants should be constructed or upgraded. When considering economic and maintenance factors, constructed wetlands are more desirable processes.

Constructed wetland system are among the recently proven efficient technologies for wastewater treatment. Compared to conventional treatment systems, constructed wetland systems are low cost, are easily operated and maintained and have a strong potential for application in developing countries, particularly by small rural communities. However, these systems have not found widespread use, due to lack of awareness and local expertise in developing the technology on a local basis.[1]

Constructed wetlands for wastewater treatment are a decentralized, low-tech solution for rural communities. They are easy to build, only require little maintenance and are also less cost intensive compared to central treatment plants in areas where large distances between villages or even single houses have to be covered.[1]

This paper will summarizes the state of the technology, effectiveness of the different plant species, advantages[8,9] and disadvantages[8,9] of constructed wetland systems and briefly gives basic information on wetlands.

I. INTRODUCTION

Constructed wetlands can mimic the filtration processes of natural wetlands, effectively removing contaminants from wastewater. A better understanding of the benefits that natural wetlands provide has led to the use of constructed wetlands to mimic the filtration processes that take place in the fragile ecosystem of a natural wetland. Constructed wetlands simulate natural waste water treatment systems, using flow beds to support water loving plants. The roots of these plants provide an aerobic environment to aggressively break down contaminants.[2]

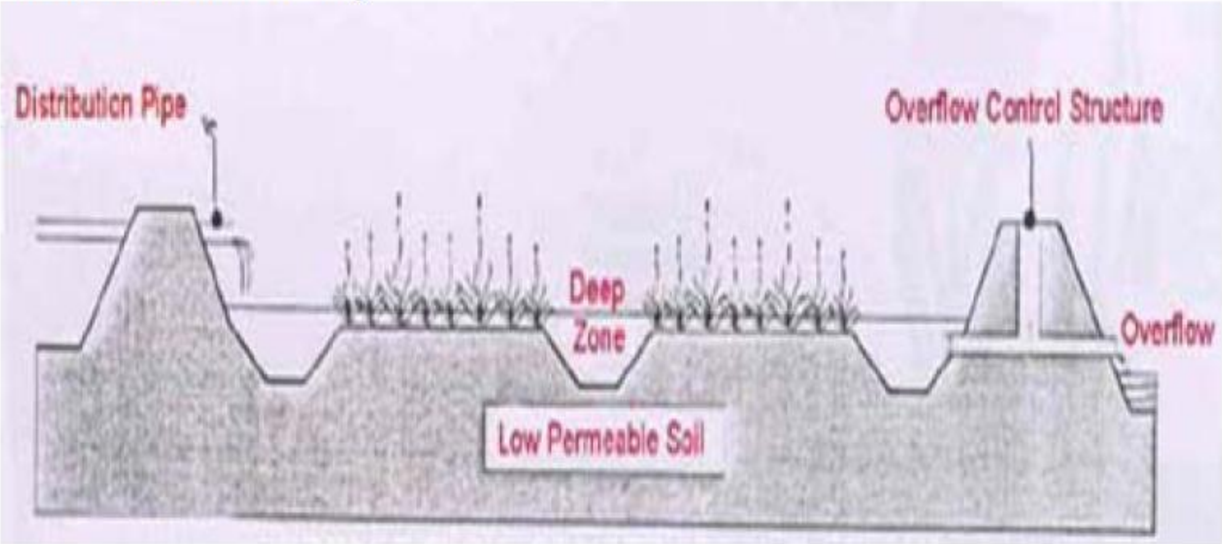
II. CLASSIFICATION OF WETLANDS

Constructed wetlands for waste water treatment can be classified as follows:

• Wetlands with surface flow/over land flow or free water surface

• Wetlands with subsurface flow

Surface flow system: Systems with such flows are designed based on constructing of long narrow and shallow canals with planted wetland plants. The waste water inlet is at one end of the canals and the effluent outlet is at the opposite end. The wastewater treatment is carried out by aerobic and anaerobic microorganisms present as epiphytes on the above ground part of the stem and dead plants. Oxygen is transported through the green stem parts. This method gives satisfactory results only in the regard of total suspended solids (TSS) and biological oxygen demand (BOD), whereas the results in removing nitrogen and phosphorus are not satisfactory.[3]

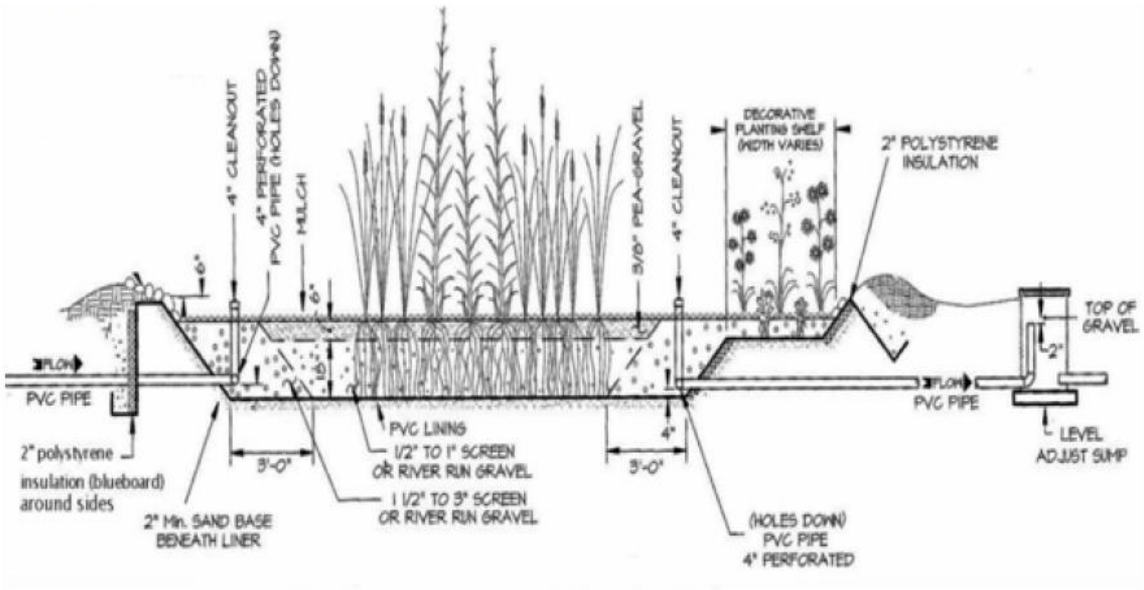


Surface flow constructed Wetland

Subsurface Horizontal Flow System: These systems are constructed in the form of rectangular lagoons, planted mostly with reeds (Phragmites australis), with the walls covered with some impermeable membrane. The role of reed in wastewater treatment is to support the process by its underground part of the root zone. Oxygen from atmosphere is transported through the hollow reed stem to the root zone, from where it partly penetrates to the microzone around the root (the rhisosphere) populated with aerobic microorganisms that decompose organic matter. Also the root and the rhizome by their growth create macropores in the soil and thus maintain its hydraulic conductivity.[3] A shortcoming of this system appears in the case of using soil as substrate, whereby the hydraulic conductivity is insufficient because of poor porosity. Hence, the water flows fast over the surface, shortening thus the residence time of wastewater and lowering the possibility of its purification. Also, the amount of oxygen is insufficient, so that percentage of nitrogen removed is not satisfactory. This system too exhibits good effects in removing TSS and BOD, whereas the removal of nitrogen and phosphorus is not satisfactory.[3]

Subsurface Vertical Flow System: In this system the natural substrate is replaced by gravel in which microphytes, mostly reeds, are planted. Wastewaters are treated by filtration through this medium and collected in the drainage pipes placed at the bottom and thus conducted to the outflow canal. The systems functions as follows: the rhizomes and reed roots grow intensively through the gavel and enable high hydraulic conductivity; in the richly branched root zone there are high populations of aerobic bacteria; oxygen transport is significantly enhanced and aeration in general is far more efficient. Thus, the purification process is accelerated.[4]

The use of this type of constructed wetlands ensures satisfactory results in the removal of TSS, BOD and nitrogen, whereas the results for phosphorus are not satisfactory, as the adsorption of this element is low because of insufficient residence time and large size of gravel particles.



Subsurface flow Wetlands

Hybrid Systems: These systems represent a combination of constructed wetlands with vertical and horizontal flow, using advantages of the both systems. They enable more efficient removal of TSS, BOD, nitrogen and phosphorus. Various combinations and types of solutions are possible, which are adjusted to all the conditions on the terrain.

2.1 Purification Process

What we find in constructed wetlands is an interaction of different purification processes.[5]

- **Biological** process: microorganisms settled in the pore system of the reed body.
- **Mechanical** process: soil surface acting as filter.
- **Physical** process: adsorption on substrate particles.
- **Chemical** Process: precipitation in the soil.

Plans only play a minor role in the purification process. They

- provide along their rootsystem for the transfer of oxygen.
- help decompose organic matter.
- can prevent the filter medium from clogging.
- function as a temporary storage of nutrients.

2.2 Design Criteria

According to the ATV guideline A262 domestic waste water (without small trade in catchment area) averages 100 / per head and day, municipal waste water (including small trade in catchment area) 150 / head and day.

To treat the wastewater in constructed wetlands the following design parameters have to be calculated:[6]

2.3 Horizontal Flow Wetlands

surface ≥ 5 m^2 / inhabitant

depth ≥ 0.5m

max. hydraulic loading 40 mm/d (= 1/(m^{2*} d))

2.4 Vertical Flow Wetlands

Surface ≥ 2.5 m^2 /inhabitant

Depth ≥ 0.8m

Max. hydraulic loading 60 mm/d (= 1/(m^{2*} d))

III. EFFECTIVENESS OF DIFFERENT PLANT SPECIES

In our country, the use of constructed wetlands to treat domestic waste water is rapidly emerging as a viable alternative. The country's first constructed wetland was installed at Sanik School, Bhubneshwar, Orissa. National Environmental Engineering Research Institute (NEERI) Mumbai have conducted study to examine the feasibility of constructed wetlands using locally available plants.[7]

Plants species were collected from naturally occurring wetland region and transferred in the filled system and initially treated with tap water. Bed 1 is planted with Elephant grasses (Pennisetum purpureum) and Cattail (Typha latifolia) and bed 2 with Canny Lily (Canna indica) and Dwarf Palm (Cyperusspp). Theoretically, hydraulic loading rate and hydraulic retention time of the constructed wetland were 0.2614m^3/m^2/day and 1.14 day respectively for both the beds. The samples of influent were collected for a period of eight month, two samples a month and analyzed.

The performance of both constructed wetland beds are mentioned in Table 1 and Table 2 respectively.

Table-1: Efficiency of Constructed Wetland (Bed 1)

Parameters	Average concentration Influent Effluent	Efficiency(%)
TSS (mg/l)	144 25.00	83.00
BOD (mg/l)	152 23.00	85.00
N (mg/l)	24.0 9.40	60.00
P (mg/l)	2.80 1.50	46.00
FC(colonies/100ml)	$4.5x10^{7}$ $1.7x10^{6}$	96.00

Table-2: Efficiency of Constructed Wetland (Bed 2)

Parameters	Average concentration Influent Effluent	Efficiency(%)
TSS(mg/l)	152 38.00	75.00
BOD (mg/l)	198 45.00	77.00
N (mg/l)	32.0 15.00	53.00
P (mg/l)	3.80 2.10	44.00
FC (colonies/100ml)	$3.3x10^{6}$ $5.9x10^{5}$	82.00

TSS concentrations were quite high in the influent wastewater and were dramatically reduced in the effluent water due to filtering action of both the constructed wetland. BOD removal of Bed 1 is high as compare to bed 2 due to the microbial population and bacteria present on the root structure of the plant species. Similarly, nitrogen and phosphorus of bed 2 shows lower reduction as compare to the bed 1. FC shows the higher removal efficiency due to the plants species in bed 1. Overall, it is observed that the plants species (elephant grasses and cattails) present in bed 1 shows higher removal efficiency as compared to bed 2 (canny lily and draft palm). Hence, the plants of bed 1 are more effective for treatment of municipal wastewaters.

Advantages

- Energy and material inputs in to wetlands are low.
- A wide range of treatment processes are available in wetlands.
- Wetlands can tolerate a wide range of pollutants and toxicants.
- Wetlands are a natural and sustainable approach to waste water treatment.
- Wetlands can have multiple beneficial uses. Under some circumstances constructed wetlands for wastewater treatment may act as useful wild life habitats
- The cost of both seed treatment and wetlands is very low, in most cases negligible.
- These technologies are traditional, rudimentary, and easy to implement, ideal for rural areas.

- Wetland systems are easy to build, simple to operate, and require little or no maintenance
- Most small scale wetland treatment systems require relatively small land areas.
- Wetland technologies reduce nutrient contamination of natural systems.
- Heavy metals absorbed by the plants in wetland treatment systems are not returned to the water.
- Water-hyacinth based and other wetland systems produce plant biomass that can be used as a fertilizer, animal feed supplement, or source of methane.

Disadvantages

• Wetland capital cost are medium to high.

• Wetland requirements are high.

• Operational control over treatment processes is limited in wetlands.

• Wetlands will accumulate toxic substances in the sediments and may become contaminated sites.

• Wetlands are natural ecosystems and typically have seasonally activity patterns which may result in seasonal variations in performance.

• Under some circumstances wetland beneficial uses may be conflicting. Attracting some wildlife to wetlands constructed for waste water treatment may result in decreased treatment performance through secondary contamination of water or through physical damage of wetland vegetation by wildlife. Depending on the particular site, the use of trees and shrubs can interrupt flight paths and sight lines and reduce the systems habitat value for certain species.

• Excessive amounts of sediments can reduce function overtime.

• In some places plant seeds may not be readily available.

• Temperature (climate) is a major limitation, since effective treatment is linked to the active growth phase of the emersed (surface and above) vegetation.

• Plants die rapidly when the water temperature approaches the freezing point; therefore, greenhouse structures may be necessary in cooler climates.

• Water hyacinth plants may create small pools of stagnant surface water which can serve as mosquito breeding habitat; this problem can generally be avoided by maintaining mosquitofish or similar fishes in the system.

• The spread of water hyacinth must be closely controlled by barriers, since the plant can spread rapidly and clog previously unaffected waterways.

• Evapotranspiration in wetland treatment systems can be 2 to 7 times greater than evaporation alone.

IV. CONCLUSION

Constructed wetlands are an effective option for on-site wastewater treatment when properly designed, installed and maintained. Sub surface flow constructed wetlands are found to be a viable tertiary treatment alternative for municipal wastewater. These systems are potentially good, low-cost, appropriate technology treatment for domestic wastewater in rural areas where land is inexpensive.

REFERENCES

1. G.Lakatos, Hungry, Constructed Wetlands for Wastewater Treatment in Europe, 191- 206 (1998).
2. Gray Kenneth Roy and Biddlestone Anthony Joseph; The University of Birmingham,"Engineered Reed Bed System for Wastewater Treatment" Trends of Biotechnology, pp 248-252, 1995.
3. H. Brix, Constructed Wetlands for Municipal Wastewater Treatment in Europe, Global Wetlands: Old World and New, Elsevien Science B.V., 325-333, (1994).
4. Luise Davis; "A Handbook of Constructed Wetlands: A Guide of Creating Wetlands for Agricultuira Wastewater, Domestic Wastewater, Coalmine Drainage and storm water in the Mid Atlantic Region", Vol.1 General Considerations, 1994.
5. United States Environment Protection Agency; "Constructed Wetlands Treatment of Municipal Wastewater", EPA/625/R-99/010, Sep. 2000.
6. Cooper P.F., "European Design and operating guidelines for Reed Bed Treatment Systems", Presented at conference on Use of Constructed Wetlands in Water Pollution Control, Cambridge, UK. 1990.
7. Sandeep T, Tayade; Ajay R. Ojha *et al.*. Feasibility Study of Constructed Wetland for Treatment of Municipal Wastewater, Sep. 2005.
8. AQUAREC- Integrated Concepts for Reuse Upgraded Wastewater, "Constructed Wetlands for Water Reclamation", Barcelona, 1-3 Feb, 2006.
9. Amelia K Kivaisi, Ecological Engg., "The Potential for Constructed Wetlands for Wastewater Treatment and Reuse in Developing Countries: A review", pp 545-560 Vol. 16, issue 4, Feb. 2001.