NATURAL TECHNOLOGIES OF WASTEWATER MANAGEMENT

Chaithra T P[1], Thanmaya G[2], Bhavana K[3], Mohan Kumar C D[4], Lokesha M K[5]

[1]*Assistant Professor, Dept. Of Civil Engineering, C.I.T Gubbi, Tumkur, India*
[2]*Student, Dept. Of Civil Engineering, C.I.T Gubbi, Tumkur, India*
[3]*Student, Dept. Of Civil Engineering, C.I.T Gubbi, Tumkur, India*
[4]*Student, Dept. Of Civil Engineering, C.I.T Gubbi, Tumkur, India*
[5]*Student, Dept. Of Civil Engineering, C.I.T Gubbi, Tumkur, India*

---***---

Abstract - As India is a developing country, fast urbanization and economic growth led to rapid and continuous increase of solid waste production and wastewater discharged by both residents and industrial sector has increased heavily. Wastewater treatment in rural areas of India, including small towns and villages, has been paid very limited attention to so far as a centralized approach will face a lot of difficulties if it is promoted to rural areas because of e.g. lack of financial support and weakness in management. Small communities are not aware of technologies that are alternative to traditional waste water treatment methods. The treatment of wastewater as a medium to address sanitation, public health and environmental protection as a medium of promoting safe drinking water might suit semi urban and rural communities. This requires capacity building and awareness rising among mayors, local community based organizations but also governmental decision makers and ministries.

Key Words: Constructed wetlands, HSSFCW, VSSFCW

1.INTRODUCTION

Wastewater (or waste water) is any water that has been affected by human use. Wastewater is "used water from any combination of domestic, industrial, commercial or agricultural activities, surface runoff or storm water, and any sewer inflow or sewer infiltration. The treatment of wastewater is part of the overarching field of sanitation. Sanitation also includes the management of human waste and solid waste as well as storm water (drainage) management. A horizontal subsurface flow constructed wetland (HSSFCW) and vertical subsurface flow constructed wetland (VSSFCW) is a large gravel and sand-filled basin that is planted with wetland vegetation. As wastewater flows horizontally and vertically through the basin, the filter material filters out particles and microorganisms degrade the organics.

Constructed wetlands are engineered systems that use natural functions vegetation, soil, and organisms to treat wastewater. Constructed wetlands have been used to treat both centralized and on-site wastewater. Primary treatment is recommended when there is a large amount of suspended solids or soluble organic matter (measured as BOD and COD). There are two main types of constructed wetlands: subsurface flow and surface flow constructed wetlands. The planted vegetation plays an important role in contaminant removal. The filter bed, consisting usually of sand and gravel, has an equally important role to play. A combination of VF and HF systems, known as hybrid wetlands can also be employed for the treatment of wastewater. Such combinations often optimize nitrogen and organics removal due to the presence of aerobic, anaerobic and anoxic phases.

2. OBJECTIVES

- To evaluate the performance of HSSFCW & VSSFCW treatment systems.
- To know the optimum loading rate to treat the waste water by developing HSSFCW & VSSFCW.
- To evaluate the operational performance of the pilot plant setup of HSSF & VSSF CW. under different Organic load conditions in treating the wastewater.
- To Statistically analyze the obtained result.

3. ADVANTAGES OF CONSTRUCTED WETLANDS

- Wetlands can be less expensive to build than other treatment options
- Utilization of natural processes,
- Simple construction (can be constructed with local materials),
- Simple operation and maintenance,
- Cost effectiveness (low construction and operation costs),
- Process stability

3.1LIMITATION OF CONSTRUCTED WETLANDS

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

4. VEGETATION

Vegetation and its litter are necessary for successful performance of constructed wetlands and contribute aesthetically to the appearance. The vegetation to be planted in constructed wetlands should fulfill the following criteria:

- Application of locally dominating macrophytes species;
- Deep root penetration, strong rhizomes and massive fibrous root; Considerable biomass or stem densities to achieve maximum translocation of water and assimilation of nutrients;
- Maximum surface area for microbial populations;
- Efficient oxygen transport into the root zone to facilitate oxidation of reduced toxic metals and support a large rhizosphere.

- Widely used vegetation in constructed wetlands. Phragmites karka and P. australis (Common Reed) is one of the most productive, widespread and variable wetland species in the world. Due to its climatic tolerance and rapid growth, it is the predominant species used in constructed wetland.

5. FACTORS TO BE CONSIDERED:

Three factors are considered to be key when determining the successful application of constructed wetlands to the holistic management of wastewater, namely: -

- The Ammonium-N concentration of the influent, and its effective removal through nitrification and de-nitrification.
- Phosphorus capture and retention, (which is generally considered to be the most wetland area-dependent parameter).
- Whether local soil materials are capable of providing effective protection to ground waters.

6. MATERIALS USED

S. N o	Layers	Filter media	Significance
1	Main layer	Gravel (Dia.- 6 mm)	Helps in establishing the oxygenated environment in the first stage filter bed. Grain size of the filter media play important role in its functioning ability. If the grain size is smaller clogging problem may be occur and also coarse grain size inhibit the formation of organic matter layer.
2	Transition /Intermediate Layer	Gravel (Dia.- 12 mm)	This layer helps in preventing fine particles from being washed into the drainage layer by reducing the effective porosity of the drainage layer.
3	Drainage layer	Coarse Gravel (Dia.-40 mm)	For the collection of treated water placed at the bottom of the bed.

7. METHODOLOGY

VERTICAL SUBSURFACE FLOW CONSTRUCTED WETLANDS

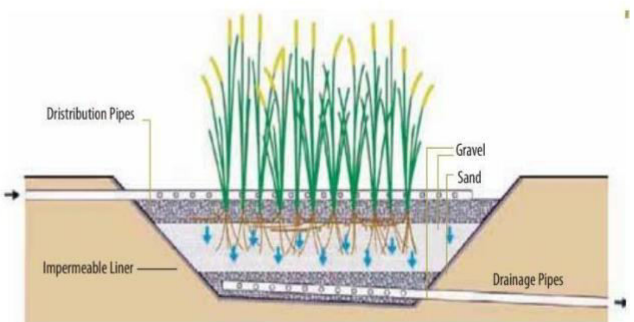

Fig 7.1.1: VSFCW

VF constructed wetland comprises a flat bed of sand/gravel topped with sand/gravel and vegetation (Figure 7.1). Wastewater is fed from the top and then gradually percolates down through the bed and is collected by a drainage network at the base. VF wetlands are fed intermittently in a large batch flooding the surface. The liquid gradually drains down through the bed and is collected by a drainage network at the base. The bed drains completely free and it allows air to refill the bed. The next dose of liquid traps this air and this together with aeration caused by the rapid dosing onto the bed leads to good oxygen transfer and hence the ability to nitrify. The oxygen diffusion from the air created by the intermittent dosing system contributes much more to the filtration bed oxygenation as compared to oxygen transfer through plant. Platzer (1998) showed that the intermittent dosing system has

a potential oxygen transfer of 23 to 64 g O2.m-2d-1 whereas Brix (1997) showed that the oxygen transfers through plant (common reed species) has a potential oxygen transfer of 2 g O2.m-2d-1 to the root zone, which mainly is utilized by the roots and rhizomes themselves. The latest generation of constructed wetlands has been developed as vertical flow system with intermittent loading. The reason for growing interest in using vertical flow systems are:

- ➢ They have much greater oxygen transfer capacity resulting in good nitrification
- ➢ They are considerably smaller than HF system
- ➢ They can efficiently remove BOD5, COD and pathogens.

WASTE WATER TREATMENT USING VERTICAL CONSTRUCTED WETLAND

➢ **Qualitative analysis of rural wastewater**

- Selection of a typical rural wastewater and analyzing the composition of wastewater
- Analysis of physical, chemical and biological parameters of selected wastewater to characterize the wastewater as per the standard methods.

➢ **Selection and development of pilot plant setup of constructed wetland system**

- Selection of Vertical constructed wetland based on the wastewater characteristics.
- Designing and developing a pilot plant setup of selected vertical constructed wetland.
- Identification and transplantation of suitable plants in the vertical constructed Wetland system.

➢ **Treatability study of the pilot plant setup**

- Periodic analysis of physical, chemical and biological parameters of the vertical constructed wetland treatment system as per the standard methods for the evaluation of operational performance of the constructed wetland system to treat the rural wastewater for one season.

Fig7.1.2 : showing the bottom layer filled with 40mm aggregates

Fig7.1.3: showing the bottom second layer filled with 12 mm aggregate

Fig7.1.4: Filled with 6mm aggregates .

Fig7.1.5: Filled with sand

Fig 7.1.6: Figure showing the plantation

Fig 7.1.7: Figure showing the filling water

HORIZONTAL SUBSURFACE FLOW CONSTRUCTED WETLANDS

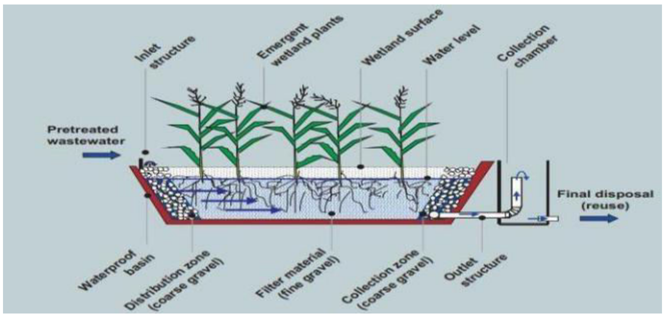

Fig 7.2.1: HSFCW

Figure 7.2.1 shows schematic cross section of a horizontal flow constructed wetland. It is called HF wetland because the wastewater is fed in at the inlet and flow slowly through the porous substrate under the surface of the bed in a more or less horizontal path until it reaches the outlet zone. During this passage the wastewater will come into contact with a network of aerobic, anoxic and anaerobic zones. The aerobic zones will be around the roots and rhizomes of the wetland vegetation that leak oxygen into the substrate. During the passage of wastewater through the rhizosphere, the wastewater is cleaned by microbiological degradation and by physical and chemical processes. HF wetland can effectively remove the organic pollutants (TSS, BOD and COD) from the wastewater. Due to the limited oxygen transfer inside the wetland, the removal of nutrients (especially nitrogen) is limited, however, HF wetlands remove the nitrates in the wastewater.

WASTE WATER TREATMENT USING HORIZONTAL CONSTRUCTED WETLAND

- **Qualitative analysis of rural wastewater**
  - Selection of a typical rural wastewater and analyzing the composition of wastewater
  - Analysis of physical, chemical and biological parameters of selected wastewater to characterize the wastewater as per the standard methods.
- **Selection and development of pilot plant setup of constructed wetland system**
  - Selection of horizontal constructed wetland based on the wastewater characteristics.
  - Designing and developing a pilot plant setup of selected horizontal constructed wetland.
  - Identification and transplantation of suitable plants in the horizontal constructed wetland system.
- **Treatability study of the pilot plant setup**
  - Periodic analysis of physical, chemical and biological parameters of the horizontal constructed wetland treatment system as per the standard methods for the evaluation of operational performance of the constructed wetland system to treat the rural wastewater for one season

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 04 Issue: 06 | June -2020 ISSN: 2582-3930

Fig7.2.2 &7.2.3: Showing the base arrangement

Fig7.2.4 &7.2.5 : Showing inlet and outlet Portion 40mm aggregates, middle portion filling fine aggregates

Fig7.2.6: Showing the plantation

8. RESULTS AND DISCUSSION

This chapter mainly deals with the parameters with their quantities which is responsible is the waste water with the results and with the reactor development.

PARAMETERS FOR INFLUENT AND EFFLUENT FROM THE HORIZONTAL CCONSTRUCTED WETLAND SYSTEM

Table-8.1 Water quality data before the treatment.

PARAMETERS	QUANTITY (mg/l)
BOD	133
COD	213
Ph	8.5
AMMONIA	16
PHOSPHORUS	8.0
TP	6.0

Table-8.2 Water quality data before and after the treatment.

PARAMETERS	INFLUENT (mg/l)	EFFLUENT(mg/l)				
		E-1	E-2	E-3	E-4	AVERAGE
BOD	133	16	21	19	15	18
COD	213	23	32	27	22	26
Ph	8.5	8	7.9	7.5	7.2	7.6
AMMONIA	16	7	10	16	3	9
PHOSPHORUS	8	3	6	5	2	4
TP	6	2	4	3	1	3

PARAMETERS FOR INFLUENT AND EFFLUENT FROM THE VERTICAL CONSTRUCTED WETLAND SYSTEM

Tables -8.3 Water quality data before the treatment

PARAMETERS	QUANTITY
BOD(mg/l)	361
COD(mg/l)	583
Ph(mg/l)	9.1
AMMONIA (mg/l)	38
PHOSPHORUS (mg/l)	8.2
TP(mg/l)	9.1

Table-8.4 Water quality data before and after the treatment.

PARAMETERS	INFLUENT	EFFLUENT(mg/l)				AVERAGE
		E-1	E-2	E-3	E-4	
BOD	361	54	80	72	51	64
COD	583	76	110	93	64	86
Ph	9.1	7.8	7.1	7.2	7	7.2
AMMONIA	38	24	27	10	16	19
PHOSPHOROUS	8.2	4	6	6	4	5
TOTAL PHOSPHATE	9.1	5	7	6	5	6

DISCUSSION

By comparing the results of both Horizontal Constructed wet lands (HCWL) and Vertical Constructed wetlands (VCWL) Method there is high reduction of BOD ,COD ,Suspended solids and pathogens .In our observation about 18% of BOD in VCWL and 65% of BOD in HCWL,COD of 86% in VCWL,26% of COD in HCWL. Ph has reduced from 9.2 to 7.2 which is fit for domestic usage. Then Ammonia, TP, Phosphorous has reduced about 86% in both methods. VCWL require less space than a HCWL and also vertical constructed wetlands has an ability to nitrify due to good oxygen transfer.

9. CONCLUSION

In constructed wetland technology, the most efficient removal of pollutants present in wastewater is taking place majorly through processes such as Sedimentation, Absorption, Adsorption, Ammonification, Nitrification, Denitrification, Microbial Degradation & Plant uptake. Horizontal subsurface flow (HSSF) constructed wetland is a large gravel and sand filled basin that is planted with wetland vegetation. As wastewater flows horizontally through the basin, the filter material filters out particles and microorganisms attached to the plant roots and filter media degrade the organics. The subsurface vertical-flow constructed wetlands (SSVF CW) are designed for the treatment of wastewater coming from rural areas. In this system the wastewater enters through the surface and flows in a vertical direction slowly through the supporting filter material and the plant roots, until reaching the bottom outlet zone.

REFERENCES

1) Begg, J. S., Lavigne, R. L., & Veneman, P. L. (2001). Reed beds: Constructed wetlands for municipal wastewater treatment plant sludge dewatering. Water Science and Technology: A Journal of the International Association on Water Pollution Research, 44(11-12), 393-398.

2) Barrett, E. C., Sobsey, M. D., House, C. H., & White, K. D. (2001). Microbial indicator removal in onsite constructed wetlands for wastewater treatment in the southeastern U.S. Water Science and Technology: A Journal of the International Association on Water Pollution Research, 44(11-12), 177-182.

3) American Public Health Association Inc. Axler, R., Henneck, J., & McCarthy, B. (2001). Residential subsurface flow treatment wetlands in northern Minnesota. Water Science and Technology, 44(11-12), 345-352.

4) Allen, W. C., Hook, P. B., Biederman, J. A., & Stein, O. R. (2002). Temperature and wetland plant species effects on wastewater treatment and root zone oxidation. Journal of Environmental Quality, 31(3), 1010-1016.

5) Al-Omari, A., & Fayyad, M. (2003). Treatment of domestic wastewater by subsurface flow constructed wetlands in Jordan. Desalination, 155(1), 27-39. American Public Health Association. (1995). Standard methods for the examination of water and wastewater (19th ed.). Washington, D.C.

6) Bayley, M. L., Davison, L., & Headley, T. R. (2003). Nitrogen removal from domestic effluent using subsurface flow constructed wetlands: Influence of depth, hydraulic residence time 66 and pre-nitrification. Water Science and Technology: A Journal of the International Association on Water Pollution Research, 48(5), 175- 182.