Treatment of Leachate using Hybrid Constructed Wetlands- A Review Paper

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Abstract : Constructed wetland is an engineered system that attains more attention as a feasible technology for treatment of municipal landfill leachate. This study aimed to find the efficiency of Hybrid constructed wetland system for treatment of landfill leachate. Landfill leachate taken from a landfill situated in Uttan, under Mira-Bhayander Municipal Corporation is to be treated in a laboratory scale hybrid constructed wetland (HCW) which consist of horizontal sub-surface flow constructed wetlands (HSSFCW) and vertical flow constructed wetlands (VFCW) having dimensions: length; width; height of 60,30,20 cm and 30,30,50 cm respectively. The dilution ratio for leachate is taken as 1:2 (leachate: domestic wastewater). The flow rate of leachate is calculated as 5.41 lit/day and Hydraulic retention time for HSSFCW and VFCW is 2.52 days and 3.16 days respectively. The bed slope of 1% is given to constructed wetland for ease to flow. The filter media will consist of gravels of size 16 mm, 12.5 mm,4.75-10 mm and soil. The removal efficiencies of pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), nitrates (NO_3), sulphates (SO_4), chlorides (Cl), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), oil and grease parameters are to be checked. Plants like Canna Indica, Phragmites Australis, Typha, Water Hyacinth, Cyperus Alterfolius, Duckweed, Chlorella Vulgaris, etc. are used for treating different types of waste water.In this laboratory scale study Eichhornia crassipes and Canna Indica are used in horizontal and vertical flow constructed wetland respectively.

IndexTerms **- Leachate, horizontal flow constructed wetlands, vertical flow constructed wetlands, canteen waste water, plants.**

I.INTRODUCTION

Leachate generation is a major problem for Municipal Solid Waste (MSW) Landfills and causes significant threat to surface water and ground water. Leachate can be defined as a liquid that passes through a landfill and extracts dissolved and suspended matter from it.

In India, the leachate is either disposed of on open lands or else it is allowed to mix with some water body which leads to the increase in pollution level of the surrounding. In order to treat the landfill leachate effectively, constructed wetlands are used. These constructed wetlands are artificial wetlands used to treat municipal, industrial, dairy wastewater and greywater. Constructed Wetland (CW) uses natural process to treat landfill leachate using soil, vegetation and substrates. The landfill leachate is very toxic so it is diluted with the domestic waste water. Soil and gravels are used as filter media in the constructed wetland.

CW has two types Free water surface constructed wetland and Subsurface flow constructed wetland which includes Horizontal flow constructed wetland (HFCW) and Vertical flow constructed wetland (VFCW). CW removes impurities by absorption, filtration and microbial actions which makes water free from harmful impurities. The absorption process involves absorption of heavy metals present in landfill leachate by plant roots. The substrates that are soil and aggregates acts like a filter media to treat leachate effectively**.** Canna Indica supply oxygen to the soil in the root zone. Using this oxygen, soil bacteria breakdown organic compounds in the diluted leachate and makes the water clean. Water hyacinth shows the efficiency to remove nitrates and particulate matter present in wastewater and the roots absorb the pollutants and organic matter present in the wastewater.

In this study Hybrid Constructed Wetland is used which includes HFCW followed by VFCW. The plants used are Canna Indica and Water hyacinth which has ability to absorb pollutants and other harmful nutrients from the waste water.

II. LITERATURE REVIEW

The idea behind this project is basically from various research papers related to environment, CWs, types of plants, waste water like leachate etc. which when combined together to execute this project.

The feasibility of baffled constructed wetland for treating landfill leachate with granular packing media, toxicity and hyper salinity conditions. Bed materials used were gravels and sand. Plant used was Phragmites Australis but it couldn't tolerate extreme toxicity and salinity condition [1]. The Pilot scale constructed wetland was built to treat the waste water from tool industry. Typha domingensis displaced the other species and proved to be highly efficient for treatment of wastewater [2]. Sludge treatment beds are widely used due to low energy consumption, low operating and maintenance cost. Penetration, evaporation and transpiration are the main process of sludge dewatering in STBs. The leachate was treated in subsurface flow constructed wetland at different hydraulic retention time (HRT) like 3,4 and 6 days but the best performance was observed on HRT of 4 days. Canna Indica was used as vegetation [3]. A synthetic wastewater was treated in a VFCW followed by HFCW which had Phragmites Australis planted in different types of media gravel, organic wood mulch and mixture of gravel-wood mulch. VFCW indicated high removal efficiencies of pollutant with organic mulch substrate. It was seen that use of organic media in VFCW enhance pollutant degradation [4]. CW is a method of purifying waste water by passing it through soil filters on which natural wetland species are grown. Typha was planted in CW having dimensions 60×40×30 cm with bed slope of 1% between inlet and outlet. Leachate is very toxic so it was diluted with a sewage water in ratio 1:2 and then used in CW. Reduction in BOD & COD up to 70% was found [5]. Landfill leachate was treated in a Vertical flow constructed wetland at different flow rates and recirculation ratios Phragmites Australis was planted in a CW. Both flow rate and recirculation ratio should be taken into account for proper design of VFCW [6]. Treatment of landfill leachate is very important because when it is saturated with water it can percolate into ground and can contaminate the groundwater which is very harmful for environment and human health. Three set-ups horizontal, vertical and

integrated constructed wetland using typha sp. as vegetation were constructed. The dilution ratio of 1:2 (leachate:domestic water) was adopted and it was found that integrated set up was more efficient [7] .To determine the efficiency of HCW for treating landfill leachate, industrial, domestic, hospital and agricultural wastewater was studied. The HCW are effective in removing BOD, COD and suspended solids. It is very useful system to remove heavy metals and pharmaceuticals pollutants from different wastewater. While in terms of nutrient removal such as N and P components, the removal efficiencies were depending on system properties and operational condition [8]. Pilot scale subsurface flow constructed wetland was constructed for treating landfill leachate planted with Cyperus haspan with sand and gravel used as substrate media.The retention time for the experiment was about of 3 weeks.High removal efficiencies of BOD, COD, TSS, TP, TN was observed [9]. Vertical flow constructed wetland and horizontal flow constructed wetland were constructed to treat the landfill leachate. HFCW shown poor performance due to the limiting anaerobic conditions and the slowing of microbial process under cold temperatures. The filter media consisted of sand and coarse gravels. PVC pipes of 2.5 cm diameter were used. Cattail plants (typha sp.) and common reeds (phragmites sp) were planted in each unit at ration of 3:1. Successful removal of BOD and ammonia-nitrogen was observed [10].

III.RESEARCH METHODOLOGY

The methodology section outline the plan and method that how the study is conducted. This includes Universe of the study, sample of the study,Data and Sources of Data, study's variables and analytical framework. The detailsare as follows;

3.1 Collection of leachate and waste water

The leachate was collected from Mira Bhayander Municipal Corporation (MBMC), Uttan and the water was collected from the canteen of the Vidyavardhini's college of engineering, Vasai. Canteen wastewater was used for the dilution instead of plain water as this wastewater is drained directly into the drainage system and using it could be economical.

3.2 Collection of materials:

The aggregates and soil were collected and passed through the sieve of required size. The size of coarse aggregates taken were 16 mm and 12.5 mm other aggregates ranging from 4.75 mm-10 mm were used. The soil of size greater than 30 microns was used. Plants like Eichhornia Crssipes commonly named Water Hyacinth for horizontal constructed Wetlands and Canna Indica for vertical constructed wetlands were used. These are the plants which sustain in waste water. Other plants like Typa, Cyprus can be used.

3.3 Design of constructed wetland

The model consists of various tanks, one for horizontal constructed wetland, second for vertical constructed wetland and lastly a collection tank. The leachate and waste water is collected and is diluted in the ratio 1:2 (leachate: wastewater) and stored the tank. An inclined pipe connects the tank to the Horizontal Subsurface Flow Constructed Wetland(HSSFCW).The horizontal to vertical ratio should be between 1:1 to 4:1.The HSSF (Horizontal Subsurface Flow) wetland consists of aggregates at the sides and soil in the middle up to a depth of 15 cm as shown in figure below and have dimensions 60×30×20 cm. The diluted leachate is passed through it and has retention time of 2.52 days.

Length-to-width ratio for secondary wetlands generally fall between 2:1 and 4:1 to avoid hydraulic problems. And depth is generally between 15 to 60 cm and taking slope of 1%.

Dimensions of constructed wetland:
For Horizontal Flow Constructed Wetland:
Length=60 cm, Width=30 cm, Height=20 cm
For Vertical Flow Constructed Wetland:
Length=30 cm, Width=30 cm, Height=50 cm
Filter Media:
Gravels of size 20-25 mm and 4.75 mm and Soil
Hydraulic Design Theory:
HRT= 2.52 days for HSSFCW
HRT= 3.16 days for VFCW

The effluent from HSSFCW is the passed through the Vertical Flow Constructed Wetland (VFCW). The horizontal to vertical ratio is taken as 1:1. The aggregates and soil layers are kept as shown in figure 1. The dimensions of the VFCW finalised are 30×30×50 cm. The bottom 10cm consists of aggregates of size 20-25mm and the upper 10cm consists of 4.75 and there is a 20cm layer of soil provided for the plants. The effluent from HSSFCW is then retained in the container for 3.16 days. After 3.16 days the effluent is collected in the collection tank and sent for further testing. Aggregates are placed on both sides of the container in an inclined manner and the space in between is filled by the soil and water hyacinth in Horizontal Subsurface Flow Constructed Wetlands (HSFCW). In Vertical Subsurface Constructed Wetllands (VSFCW), the larger aggregates are placed at the bottom with depth 10cm, the middle layer is of smaller aggregates with depth 10cm and the soil layer on top is in the range of 20cm-25cm, the plants species used are Canna Indica. Figure1 indicates the arrangement of Hybrid Constructed Wetlands.

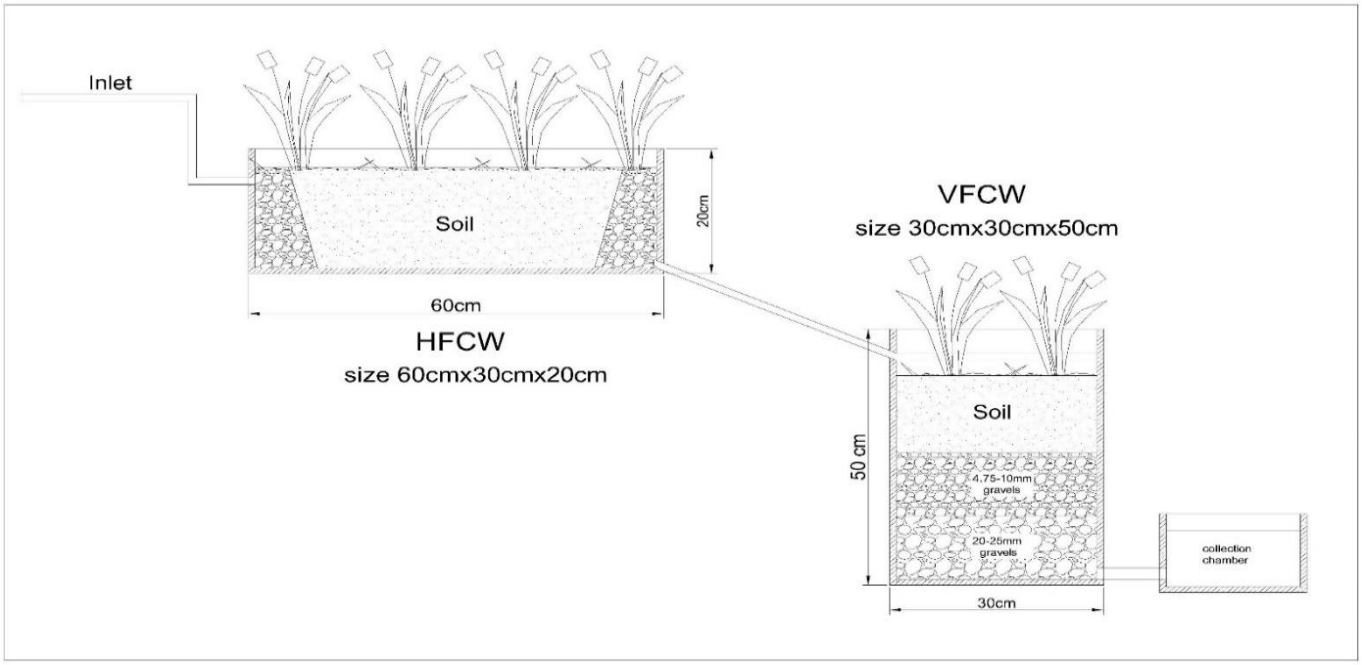

Fig 1. Diagrammatic representation of Hybrid Constructed Wetlands

IV. Results And Dicussion

The expected results should have a lower value of the parameters that can be harmful for the environment or the location where the leachate is discharged.

4.1 Results on Initial Characteristics of Leachate

Table 4.1: Initial Characteristics of Leachate

Sr No	Tests	Results	Standard Discharge limits	Units
Discipline – Chemical Testing Group - Leachate : Wastewater(1:2)				
1	pH	7.5	6 to 9	
2	COD	6867.2	400	mg/l
3	BOD	2200	50	mg/l
4	TDS	4470	…	mg/l
5	TSS	3200	50	mg/l
6	Chlorides	2127	150	mg/l
7	Sulphates	197.5	8	mg/l
8	Nitrates	2.43	0.6	mg/l
9	DO	ND<0.1	Less than 0.1	mg/l

After several trials it is expected that the total removal of COD should be around 72–76% and that of BOD is expected to be around 70–75%. The pH value is expected within the permissible range of 6.0–9.0. The leachate contains suspended solid matter consisting of particles of many different sizes which are relatively small solid particles that can cause the leachate to appear turbid. The initial concentration of TSS is efficiently more and it is expected to be reduced. The TSS concentrations can be reduced significantly in the cells with lower hydraulic retention time, but when hydraulic retention time increased, the difference between TSS concentrations in influent and effluents becomes insignificant.

V. Conclusion

Various treatment methods to treat leachate were studied and a suitable method of hybrid Constructed Wetlands was finalized to treat leachate. The different characteristics of leachate like BOD, COD, pH, TN, TP and permissible limits up to which treated leachate should be obtained were studied. The design of horizontal sub surface flow constructed wetland and vertical flow wetlands is designed on the basis of thumb rule method and regression equation. Depending on the different plant species study, the plants selected were Water Hyacinth and Canna Indica. It was found that substrate of sand, soil and various sizes of gravels are suitable. The landfill leachate cannot be directly disposed on the land or natural water bodies therefore, a low-cost technique to treat leachate is essential. Hence, Hybrid Constructed Wetland is adopted to treat leachate with dilution ratio 1:1. The treated leachate can be used for Irrigation and gardening purpose or can be directly discharged into various water bodies.

VI. Acknowledgment

The authors would like to thank the Department of Civil Engineering at Vidyavardhini's College of Engineering and Technology, Vasai Road, guided by Asst. Prof. Puja Kadam. They would also thank the Mira bhayandar municipal council (MBMC) MSW facilities for providing the leachate sample.

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