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Abstract : Constructed wetlands have been used for treatment of various waste waters for the last over six decades. Different researches have been using various kinds of CWs like surface flow, horizontal subsurface flow and vertical subsurface flow with different types of plant species. In the present study vertical up-flow and down-flow constructed wetlands were prepared and used to determine their pollutant removal efficiency from simulated dumpsite leachate using Canna – Typha macrophytes in mixed culture with soil and gravel as substrate at different hydraulic retention time (HRT) of 4, 8 and 12 days. The present study revealed maximum removal of 87.2% of COD at 12d HRT, which gradually increased from approximately 55% at 4d HRT, in both the up-flow and down-flow CWs. Maximum removal of 79.8% of phosphate, 72.2% of ammonia nitrogen and 67.7% of total nitrogen could be achieved in the up-flow vertical CWs at 8d HRT while the down-flow vertical CWs showed maximum removal efficiency of 85.9%, 63.1% and 74.3% for phosphate, ammonia nitrogen, total nitrogen, respectively at 12d HRT.

Keywords: - constructed wetland; up-flow; down-flow; leachate; macrophyte; HRT

1 Introduction

Landfills have been recognized as one of the major threats to groundwater resources. At landfills physical, chemical and microbiological changes occurred in waste after disposing. Contamination of water around municipal landfills by microbiological and physico-chemical analysis of leachate and ground water were reported by many researchers [1, 2, 3]. Liquid that percolates downward through a landfill extracting components of the landfill materials is known as “landfill leachate”. Leachate characteristics vary with differences in waste composition, waste age, and climate [4]. Leachate contains mainly four main groups of pollutants: dissolved organic matter, inorganic macro-components, heavy metals, and xenobiotic organic compounds [5]. There are different types of biological and physicochemical technologies which are used for leachate treatment: UASB, stabilization ponds, activated sludge, trickling filters, bio-discs and SBR [6,7], coagulation, flocculation, sedimentation, reverse osmosis, membrane processes, ammonia stripping and advanced oxidation processes [8,9,10] Each of the above mentioned alternatives has its own advantages and disadvantages. Combination of biological, physical and chemical processes is being considered as the most appropriate technology for treatment of high strength effluents. Constructed wetlands are complex ecosystems that include physical, chemical and biological processes. Constructed wetlands are engineered system which uses saturated substrates, emerged and submerged vegetation, and water [11]. Different types of CWs; surface flow [12], subsurface flow, horizontal subsurface flow [13], vertical subsurface flow [14] with different substrates (soil, sand, gravel, fly ash, lime stone) and macrophytes (Phragmites, Cyperus, Typha, Eichhornia) were studied for treatment of various industrial wastewaters, domestic wastewater, acid mine drainage, agricultural and urban runoff, landfill leachate, dairy wastewater etc. The purpose of this investigation is to study and compare the treatment efficacy of down-flow and up-flow vertical constructed wetland system using Canna – Typha macrophytes in mixed combination for simulated dumpsite leachate.
2 Experimental setup

Two types of wetland reactors having up-flow and down-flow were prepared using normal washing buckets (15L capacity with working volume of 3L). In up-flow wetlands, wastewater was loaded through a tube at the bottom of bucket and collected through an outlet fixed about 2” below the top whereas in case of down-flow wetlands, wastewater was loaded at the surface of bucket and collected through an outlet fixed at a height of about 2” above the base of the reactor. These CWs were fed with simulated dumpsite leachate (SDL) with flow rates of 0.52 ml, 0.26 ml & 0.17 ml per minute for HRT of 4, 8 & 12 days using peristaltic pumps. Canna (C) and Typha (T) plant species in mixed culture condition were used as the wetland plants, with soil + gravel as substrate.

3.1 Removal of COD

Initial COD concentration of influent SDL ranged from 5000 - 5560 mg/L. The per cent removal of COD was 54.1%, 71.2%, 87.2% for down-flow CWs and 55.6%, 69.8%, 87.2% for up-flow CWs at 4d, 8d and 12d HRT, respectively (Fig. 1). The results reveal that removal rate increased with increasing HRT and there was no significant difference in removal of COD in both types of studied CWs.

3.2 Removal of ammonical nitrogen (AN) and total nitrogen (TN)

Removal of ammonical nitrogen in down-flow and up-flow CWs was 52.3%, 44%, 63.1% and 64.7%, 72.2%, 53.3% at 4d, 8d and 12d HRT, respectively (Fig. 2). It was observed that at 8d HRT there was maximum removal of ammonical nitrogen in the up-flow CWs, while down-flow CWs showed maximum removal of ammonical nitrogen at 12d HRT, which may be due to the fact that higher vegetation influences interaction between plants-wastewater-microorganism, provides microbial attachment sites, sufficient wastewater resident time, trapping and settlement for wastewater components, surface area for pollutant adsorption, uptake and storage in plants, diffusion of oxygen from rhizosphere.

Table 1. Characteristics of simulated dumpsite leachate

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Parameter</th>
<th>Parameter value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pH</td>
<td>7.7 - 7.84</td>
</tr>
<tr>
<td>3</td>
<td>Phosphate (mg/L)</td>
<td>158 - 166</td>
</tr>
<tr>
<td>4</td>
<td>Ammonical Nitrogen (mg/L)</td>
<td>462.5 - 470.5</td>
</tr>
<tr>
<td>5</td>
<td>Total Nitrogen (mg/L)</td>
<td>394.4 - 405</td>
</tr>
<tr>
<td>6</td>
<td>COD (mg/L)</td>
<td>5000 - 5560</td>
</tr>
</tbody>
</table>
Similar trend for total nitrogen was also observed in this study with higher removal of 67.7% in up-flow constructed wetland reactor at 8d HRT which remained almost the same at 12d HRT, while down-flow CWs showed maximum removal of 74.3% at 12d HRT as shown in Fig. 3.

Fig.4 depicts the percent removal of phosphate in down-flow and up-flow CWs at 4d, 8d and 12d HRT. It was observed that like ammonical nitrogen and total nitrogen there was maximum removal of about 80% at 8d and 12d HRT for up-flow CWs, while 12d HRT showed maximum removal of 85.9% of phosphate in the down-flow CWs.

3.3 Changes in pH

Initial pH of simulated dumpsite leachate ranged from 7 to 7.8, which was slightly alkaline. After 4d, 8d and 12days (HRT) of treatment, pH of the simulated dumpsite leachate at outlet of both the CW systems was 8.56, 7.9, 7.7 in down-flow and 8.17, 8.48, 8.29 in the up-flow CWs, respectively. The results indicated that in the up-flow CWs, pH of the SDL changed to more alkaline in comparison to down-flow CWs.

4 Conclusion

From the study it is concluded that both types i.e., down-flow and up-flow vertical constructed wetland systems showed good removal efficiency for organic matter and nutrients. Maximum removal of 87.2% of COD at 12d HRT which gradually increased from approximately 55% at 4d HRT in both the up-flow and down-flow CWs was observed. Maximum removal efficiency of phosphate of 79.8%, ammonia nitrogen of 72.2%, total nitrogen of 67.7% could be achieved at 8d HRT in the up-flow vertical CW, while in the down-flow vertical CWs the maximum removal efficiency of 85.9%, 63.1% and 74.3% for phosphate, ammonia nitrogen, total nitrogen, respectively, was achieved at 12d HRT.

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