Abstract: Performance of constructed Wetlands to treat leachate was studied by using a pilot scale subsurface vertical batch flow wetland systems for Sri Lankan environment conditions. The specific task was to study the effect of plantation and media for removal of pollutants in wetland systems. Three wetlands were constructed and planted with typha with a medium of coir fibre and gravel. Leachate was introduced to the system with 10% and 20% dilution. 500 l of diluted leachate was feed in a batch and treated for five days. During the experiment, the influent and effluent samples were tested for chemical oxygen demand (COD), biological oxygen demand (BOD), Ammonia-Nitrogen, Nitrate-Nitrogen. The wetlands showed more than 70% removal for BOD and COD in all wetland units and treatment of BOD and COD among the wetlands was found comparable. Ammonia–nitrogen removal efficiency was varied 54.4%–97.8% and variation is not significant among the units. Nitrate–Nitrogen removal in planted wetlands was not significant at the initial runs but it increased after the introduction of 20% leachate in to the systems. The study revealed that the sub surface vertical batch flow wetland system can be used for leachate treatment and effect of plantation and coir media is not significant to treat leachate.

Keywords: Leachate, Wetland

1. INTRODUCTION

Wetlands are natural systems comprising dense vegetation, water and earth. Wetland systems act as a biological and chemical treatment element for wastewater. Constructed wetlands are developed to have the same characteristics and environment to treat wastewater. These wetland systems are simple and less costly compared with other techniques available for treating wastewater. Since, constructed wetlands are very popular all over the world. Now, constructed wetlands are used to treat municipal, mine drainage, urban and agricultural storm water, sludge, leachate and various industrial effluents.

Wetlands are not very commonly used to treat wastewater in Sri Lanka. But the climatic conditions are more favourable to use Constructed wetlands for wastewater treatment.

When considering the solid waste treatment, sanitary landfills are common around the world. But landfill bat mature states starts to generate leachate. This landfill leachate is highly contaminated. Its composition varies with landfill composition, site condition (Hydrology), age of landfill and weather condition. Thus, treatment is essentially required for leachate before discharging into the environment.

1.1 Objectives

To investigate the applicability of constructed Wetland for Leachate treatment in tropical developing country context.

Specific Objectives

To investigate the performance of Constructed Wetlands (CW) for leachate treatment using vertical flow CW system with different media
In Sri Lanka Wetlands are not commonly used for leachate treatment. The project mainly focuses on the behaviour of Wetland to treat leachate. For this, the main target falls on how the Wetland media and Wetland plantation affect the treatment process. Considering the Wetland media, the previous studies and current practices carry out on treating leachate can be analyzed. In Nuwara Eliya Landfill site, coir brush is being used to treat leachate. Thus coir media was selected to use in Wetland. Normally gravel is used in Wetland. So a comparison of media was done using coir and gravel.

2. LITERATURE REVIEW

2.1 Landfill leachate

Leachate is formed when water passes through the waste in the landfill. The precipitation can be from rain and the waste itself. As the liquid moves through the landfill many organic and inorganic compounds are transported via the leachate and it moves to the base of the landfill.

2.1.1 Composition of landfill leachate

1. Dissolved organic matters (Alcohols, acids, aldehyes, short chain sugar and etc.)
2. Inorganic macro components (Sulfate, chlorides, iron, nitrogen compounds, phosphorus compounds and etc.)
3. Heavy metals (Pb, C, Ni, Hg, Fe)
4. Xenobiotic organic compounds (Polychlorinated biphenol, dioxins)

This components and composition can be varying with age of landfill, type of waste, disposal method, climate and seasonal conditions.

2.2 Constructed wetlands

Manmade or Engineered systems to treat domestic and municipal waste. Constructed wetlands act as biochemical filter, removing sediments and pollutants such as nitrogen, heavy metal from wastewater.

2.2.1 Performance of wetlands

Vegetation in a wetland provides a substrate (roots, stem and leaves) upon which microorganisms can grow as they break down organic material. This microorganism and natural chemical process remove 90% of pollutant and 10% of pollutant are removed by plants. Physical, chemical and biological processes are combined to remove contaminants from waste water in wetland. Aerobic and Anaerobic microorganism are facilitate decomposition of organic matter. Microbial nitrification and subsequent denitrification releases nitrogen as gas to atmosphere. Phosphorus is co-precipitated with iron, aluminum and calcium compound located in the root bed medium. Suspended solids are filter out from soil and gravel media. Harmful bacteria and viruses are reduced by filtration and adsorption by bio filter on rock media.

2.2.2. Pollution removal process in wetland system

Table 1 shows the pollution removal processes in wetland systems.

<table>
<thead>
<tr>
<th>Pollutants</th>
<th>Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic material (measured as BOD)</td>
<td>Biological degradation, sedimentation, microbial uptake</td>
</tr>
<tr>
<td>Organic contaminants</td>
<td>Adsorption, volatilization</td>
</tr>
</tbody>
</table>
### Suspended solids
<table>
<thead>
<tr>
<th>Nitrogen</th>
<th>Sedimentation, filtration, nitrification/denitrification, microbial uptake</th>
</tr>
</thead>
<tbody>
<tr>
<td>phosphorus</td>
<td>Sedimentation, filtration, adsorption, plant and microbial uptake</td>
</tr>
<tr>
<td>Pathogens</td>
<td>Natural die-off, sedimentation, filtration, UV degradation, adsorption</td>
</tr>
<tr>
<td>Heavy metals</td>
<td>Sedimentation, adsorption, plant uptake</td>
</tr>
</tbody>
</table>
3.2 Sampling

Samples were collected from the inlets and outlets of all three wetland units. Sample at inlet was collected during the feeding and effluent samples were collected after the five days of treatment. The testing was carried out on the same day of sampling or samples were preserved for later testing.

3.3 Testing and testing methods

The following tests were carried during the study.

- BOD₅, COD, Ammonium and Nitrate tested.
- Nitrogen ammonia test – Salicylate method
- Nitrogen nitrate test - Cadmium reduction method using powder pillows
- Chemical oxygen demand test - Reactor digestion method (USEPA approved for reporting wastewater analysis)
- Biological oxygen demand – Dissolved Oxygen test

4. RESULTS AND DISCUSSION

4.1. Treatment for 10% leachate

Table 2 shows the variation of parameters for 10% leachate.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Influent (mg/l)</th>
<th>Effluents (mg/l)</th>
<th>Removal Efficiency/%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wt1 (Control)</td>
<td>Wt2 (Gravel)</td>
<td>Wt3 (Coir)</td>
</tr>
<tr>
<td>BOD₅</td>
<td>346.2±141.7</td>
<td>81.05±46.2</td>
<td>89.75±63.8</td>
</tr>
<tr>
<td>COD</td>
<td>2082±1114</td>
<td>366±65</td>
<td>348±144</td>
</tr>
<tr>
<td>NH₄⁺-N</td>
<td>201.6±156.6</td>
<td>33±17.0</td>
<td>26.5±15.0</td>
</tr>
<tr>
<td>NO₃⁻-N</td>
<td>18.3±3.7</td>
<td>16.3±21.7</td>
<td>49.13±22.2</td>
</tr>
</tbody>
</table>

Although the plantation and media do not show significant role on removing BOD, COD and Ammonia constructed wetland are viable solution for leachate treatment.

Wetland 1(Control Wetland) only shows minor removal of Nitrate. This cause may due to nitrification process. Nitrification process converts Ammonia in to Nitrate. It consists of two steps. They are oxidation of ammonia (NH₄⁺) to nitrite (NO₂⁻) and subsequent oxidation of nitrite to nitrate (NO₃⁻):

\[
\text{NH}_4^+ + 1.5\text{O}_2 \rightarrow \text{NO}_2^- + 2\text{H}^+ + \text{H}_2\text{O}
\]

\[
\text{NO}_2^- + 0.5\text{O}_2 \rightarrow \text{NO}_3^-
\]

The total reaction of nitrification is

\[
\text{NH}_4^+ + 2\text{O}_2 \rightarrow \text{NO}_3^- + 2\text{H}^+ + \text{H}_2\text{O}
\]

Thus, Nitrate concentration is high compare with the influent concentration. After the nitrification, Nitrate convert to Nitrogen gas in Denitrification process. Denitrification is the reduction of oxidized nitrogen compounds. The final product of complete denitrification process is nitrogen gas (N₂). Denitrification runs stepwise, from the most oxidized to the most reduced compound:

\[
\text{NO}_3^- \rightarrow \text{NO}_2 \rightarrow \text{NO} \rightarrow \text{N}_2\text{O} \rightarrow \text{N}_2
\]

The resulting reaction of denitrification:

\[
2\text{NO}_3^- + \text{H}^+ + \text{organic matter} \rightarrow \text{N}_2 + \text{HCO}_3^-
\]
Denitrification is performed by heterotrophic bacteria, which use organic material as carbon source. Reduction occurs under strict anoxic conditions, so, dissolved oxygen concentration should be as low as possible. The process is less dependent on the temperature conditions. The most favorable pH for denitrification lies between 7 and 9. (Reference- leachate treatment at filborna landfill with focus on nitrogen removal, Andrii Butkovskyi, 2009)

As above description, denitrification process increase in anoxic condition. From the observation thin film of algae form at the surface of Wetland 1 (Control Wetland). Due to this algae formation Oxygen penetration in to the system is less compare with other two Wetland system. This provides anoxic conditions in the system. Because of that wetland 1 gives somewhat removal for Nitrate.

4.2. Treatment for 20% leachate

Table 3 shows the variation of parameters for 20% leachate.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Influent (mg/l)</th>
<th>Effluents (mg/l)</th>
<th>Removal Efficiency/%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wt1 (Control)</td>
<td>Wt2 (Gravel)</td>
<td>Wt3 (Coir)</td>
</tr>
<tr>
<td>BOD₅</td>
<td>502.8±17.8</td>
<td>140.9±51.5</td>
<td>144.8±8.25</td>
</tr>
<tr>
<td>NH₄⁺-N</td>
<td>323.5±56.5</td>
<td>86.5±7.5</td>
<td>105±30</td>
</tr>
<tr>
<td>NO₃⁻-N</td>
<td>46.2</td>
<td>9.65</td>
<td>16.5</td>
</tr>
</tbody>
</table>

![Figure 2 Variation of COD](image)

Note: Wt 1-Wetland 1, Wt 2-Wetland 2, Wt 3-Wetland 3
Figure 3 Variation of BOD$_5$

Figure 4 Variation of Ammonia

Figure 5 Variation of Nitrate
Comparing the BOD removal all wetlands units show almost same removal efficiency. Thus, the effectiveness of wetland plants and the media are not very significant in removing BOD. However, all the systems showed more than 70% removal for BOD. So the Wetland System is capable to treat leachate in this regard.
After introducing 20% of leachate to the system the Ammonia, Nitrate and nitrate removal were found higher due to acclimatization of the system for leachate.

5. CONCLUSION
Considering the above discussion, plantation and the media have no significant role in removing BOD, COD and Ammonia in constructed wetlands. Nevertheless, constructed wetland can be used for Leachate treatment in tropical developing country context.

6. ACKNOWLEDGEMENT
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